# CROP PRODUCTION GUIDE
# AGRICULTURE
# 2020


**Directorate of Agriculture**
Chepauk, Chennai - 600 005
&
**Tamil Nadu Agricultural University**
Coimbatore - 641 003

# CONTENTS

**திரு. இரா. துரைக்கண்ணு, B.A**
மாண்புமிகு வேளாண்மைத்துறை அமைச்சர் மற்றும்
இணை வேந்தர் தமிழ்நாடு வேளாண்மைப் பல்கலைக்கழகம்,
சென்னை – 600 002

## முகவுரை

வேளாண்மையில் பயிரிடும் பரப்பு குறைந்து வரும் இக்காலத்தில் பயிரின் உற்பத்தியை பெருக்கி உழவரின் இலாபத்தை அதிகரிப்பது என்பது மத்திய மற்றும் மாநில அரசுகளின் முக்கியமான நோக்கமாக உள்ளது. இதனை அடைய புதிய தொழில் நுட்பங்கள் முக்கிய பங்கு வகிக்கின்றன. பயிர்களின் உற்பத்தியை பெருக்குவதில் தமிழகம் முதன்மை பெற்று ''கிரிஷி கருமன் விருதை'' தொடர்ந்து ஐந்து முறை பெற்று மாநிலத்திற்கு பெருமை சேர்த்து தமிழ்நாடு வேளாண்மைப்பல்கலைக் கழகமும், தமிழக வேளாண்மைத் துறையும் சாதனை படைத்துள்ளது. இத்தகைய தொழில் நுட்பங்களை உழவர்களுக்கு கொண்டு செல்வது ஒரு முக்கியமான வளர்ச்சிப் பாதையாகும். இவ்வகையில் **பயிர் உற்பத்திக் கையேடு – வேளாண்மை 2020** ஒரு உடனடி தீர்வுக்காண பார்வைக் கையேடாக உள்ளது. இதில் தொகுக்கப்பட்டுள்ள தமிழ்நாடு வேளாண்மைப் பல்கலைக்கழக வேளாண் பயிர்களின் ஆராய்ச்சி முடிவுகளை கடைப்பிடிக்கப்படும் போது பல்வேறு பயிர்களின் உற்பத்தித்திறன் அதிகரிக்கும் என்பது திண்ணமாகும்.

முக்கிய பயிரான நெல் முதற்கொண்டு அனைத்து வேளாண் பயிர்களுக்கான காலநிலை, இரகங்கள், பயிர் மேலாண்மை, பயிர் பாதுகாப்பு மற்றும் விதை உற்பத்தி குறிப்புகள் இக்கையேட்டில் குறிப்பிடப்பட்டுள்ளன. இவை தவிர காளான் உற்பத்தி, வேளாண்மை கழிவில் உர உற்பத்தி, கழிவு நீரை சுத்திகரித்து உபயோகித்தல், பட்டுப்புழு வளர்ப்பு, வேளாண் காடுகள், ஒருங்கிணைந்த பண்ணைய முறைகள், பிரச்சனைக்குரிய களை மேலாண்மை, இறுகிய நில மேலாண்மை, நீர்நுட்பங்கள், பண்ணைக்கருவி மற்றும் உபகரணங்கள், வேளாண் பதனிடும் தொழில் நுட்பங்கள் ஆகியவை இக்கையேட்டில் இடம் பெற்றுள்ளன.

இக்கையேடு வேளாண்மைத்துறை கள அலுவலர்களுக்கு பெரிதும் உதவியாக இருப்பது மட்டுமன்றி நிர்வாகத்தினர்களுக்கும், ஆராய்ச்சியாளர்களுக்கும், வேளாண் மாணாக்கர்களுக்கும் மிகவும் உதவியாக இருக்கும். இக்கையேட்டினை உருவாக்க உறுதுணையாக இருந்த அனைத்து தமிழ்நாடு வேளாண் பல்கலைக் கழக விஞ்ஞானிகளுக்கும் தொகுப்பாகிய ஆராய்ச்சி இயக்குனர் அவர்களுக்கும், வழிநடத்திய துணை வேந்தர் அவர்களுக்கும் எனது மனமார்ந்த மகிழ்ச்சியையும், நன்றியையும் தெரிவித்துக் கொள்கிறேன்.

**(இரா. துரைக்கண்ணு)**

**Shri Gagandeep Singh Bedi, IAS**
Agricultural Production Commissioner &
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# PREFACE

The Indian agriculture has taken a paradigm shift from conventional farming to precision agriculture with an intend to overcome a bundle of constraints such as shrinking arable lands, frequent droughts, declining organic matter, multi-nutrient deficiencies besides exodus of people from farming. Despite the fact that the country faces extreme weather conditions, the State of Tamil Nadu retained its glory by getting the **Krishi Karman Award 2019** for the fifth time in a row for continued enhancement of food grain and oilseed production. The data vividly indicate the successful accomplishments of both scientists of TNAU and officials in the Department of Agriculture in the past several years.

The Tamil Nadu Agricultural University, Coimbatore, is playing a pivotal role in design and development of crop varieties, technologies and farm implements to suit the prevailing situations and adapt to the climate change scenarios. In this context, there was an urgent need for standard operational protocols and technology package of practices to fit various agro-climatic zones of the state of Tamil Nadu. In this context, the TNAU under the dynamic leadership of the Vice Chancellor, Director of Research and other technical directors, the "**Crop Production Guide (CPG) – Agriculture 2020**" was revised, updated and put together as a technology capsule prescribed for adoption by the Department of Agriculture and in turn to the farmers of the State. While doing the revision, the Director of Agriculture and entire team of Department officials ensured that the field level problems are addressed.

The **CPG - Agriculture 2020** carries recommended crops and varieties, seed to seed crop management technologies, seed invigoration techniques, soil-test crop response based fertilizer prescription, drip fertigation, integrated weed management practices, technology capsule for pests and diseases management, labour saving farm machineries and post-harvest management practices.

I take this opportunity to thank and the Vice Chancellor, Director of Agriculture, Director of Research, other Technical Directors and Department officials for their assiduous efforts to orchestrate the document that serve as the base for the agricultural growth and development in the State of Tamil Nadu.

**(Gagandeep Singh Bedi)**

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Vice Chancellor
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# PREFACE

The Tamil Nadu Agricultural University, Coimbatore, is one of the best State Agricultural Universities in the country, evolving several crop varieties, technologies and farm implements to promote productivity and profitability of farms while ensuring environmental safety and rural livelihood. The TNAU has a well articulated and structured research framework to develop varieties and technologies to enable adoption by the farmers of the State.

The Research Council of TNAU identifies the field problems that are developed as research projects, monitored and evaluated during the annual crop scientists meets and the research outcomes are presented to the State level Scientific Workers Conference to take the final decision on the varieties or technologies to be recommended for adoption. Such a meticulous planning and execution help us in assembling basket of varieties and technologies that are packaged as the Crop Production Guide.

The TNAU has taken efforts to revise and update the "**Crop Production Guide (CPG) – Agriculture 2020**" involving the Directors and Deans in the university besides Department of Agriculture and Department officials. In the past one year, there was a close coordination between the Department and University in undertaking joint efforts to resolve the unresolved field problems. Such network helped us to improve the CPG as a technology package suitable for the farmers of the Tamil Nadu State. The CPG carries recommended crop varieties, improved management technologies, precision farming practices, technology capsule for the management of pests and diseases besides post-harvest management practices.

I take this opportunity to thank the Agricultural Production Commissioner & Principal Secretary to the Government, Director of Agriculture, Director of Research, other Technical Directors, Deans and Department officials for their contribution towards the publication of the CPG - Agriculture 2020.

**(N. KUMAR)**

# 1. RICE (*Oryza sativa* L.)

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 36 - 38 | 10 - 12 | 30 - 32 | 1000 - 4500 | up to 2000 |

Tropical and sub tropical hot and humid climate. Minimum temperature required for germination, flowering and grain formation is 10, 23 and 20°C, respectively. Optimum temperature for growth, flowering and grain formation is 21 - 36, 25 - 29 and 20 - 25, respectively. Short day plant.

## CROP IMPROVEMENT

## I. SEASON AND VARIETIES

| Zone District/Season | Month | Varieties |
|---|---|---|
| **I. Cauvery Delta Zone** | | |
| **a. Thanjavur/ Tiruvarur** | | |
| Kuruvai | (Jun -Jul) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| Samba | (Aug) | CR 1009 *Sub*1, TNAU Rice ADT 50, ADT 51, CR 1009, TRY 3 |
| Late Samba / Thaladi | (Sep -Oct) | VGD 1, TKM 13, CO 52, CO (R) 50, ADT 39, ADT 38, TNAU Rice ADT 49, CO 43, CO 43 sub.1, Imp.White Ponni, ADT (R) 46, TNAU Rice TRY 3*, TNAU Rice Hybrid CO 4 |
| Navarai | (Dec -Jan) | ADT 53, CO 51, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| **b. Nagapattinam** | | |
| Late Kuruvai | (July) | ADT(R)48, MDU 5, CO 51, ADT 53, ADT(R)45, ADT 37, ADT 36 |
| Samba | (Aug – Sep) | CR 1009 *Sub*1, TNAU Rice ADT 50, ADT 51, CR 1009, |
| | | CO(R)50, CO 52, ADT (R)46, TKM 13, TNAU Rice TRY 3*, ADT 39, ADT 38, CO 43 sub 1, CO 43 |
| Semi dry cultivation in Thanjavur, Thiruvarur and Nagapattinam | August | CR 1009, CR 1009 sub 1, ADT 51,TRY 3 |
| | September | ADT 38, ADT 39, ADT 46, Co 50, Co 52, TKM 13, TRY 3 |
| **c. Tiruchirapalli** | | |
| Kuruvai | (Jun -Jul) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9, TRY 2* |
| Samba / Thaladi | (Aug -Sep) | CR 1009 *Sub*1, TNAU Rice ADT 50, ADT 51, CR 1009 |

| | | |
|---|---|---|
| | | TNAU Rice TRY 3*, TRY 1*, CO 43, TKM 13, VGD 1, CO 52, CO (R) 50, ADT 39, ADT 38, TNAU Rice ADT 49, Imp.White Ponni, ADT (R) 46, TNAU Rice Hybrid CO 4 |
| Summer | (Dec.) | ADT 53, CO 51, ADT (R) 45, TPS 5, ADT 36, ADT 37, CORH 3, ASD 16, |
| d. Flood affected areas | (Aug-Sep) | CR 1009 sub1 |
| e.Salt affected areas | | TRY 1, TRY 2, TRY 3 and Co 43 |
| **II. North Eastern Zone** | | |
| **a. Kanchipuram/Tiruvallur** | | |
| Sornavari | (April -May) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| Samba/ Late Samba | (Aug- Sep) | VGD 1, TKM 13, CO 52, CO (R) 50, ADT 39, ADT 38, TNAU Rice ADT 49, CO 43, Imp.White Ponni, ADT (R) 46, TNAU Rice TRY 3*, TNAU Rice Hybrid CO 4 |
| Navarai | (Dec -Jan) | ADT 53, CO 51, ADT (R) 45, MDU 6, ADT 36, ADT 37, CORH 3, TKM 9 |
| Rainfed direct seeded and Semi-dry | (July - Aug) | Anna (R) 4, ADT 36, ADT 39, TKM 9, TKM 11 |
| **b. Vellore/Tiruvannamalai** | | |
| Sornavari | (April-May) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| Samba | (Aug) | VGD 1, TKM 13, CO 52, Imp.White Ponni, ASD 19, TNAU Rice ADT 49, CO (R) 50, ADT 39, ADT 38, CO 43, ADT (R) 46, TNAU Rice Hybrid CO 4 |
| Navarai | (Dec -Jan) | ADT 53, CO 51, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| **c. Cuddalore/ Villupuram** | | |
| Sornavari | (April -May) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5, MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| Samba | (Aug) | CR 1009 *Sub*1, TNAU Rice ADT 50, ADT 51, CR 1009, |
| | | VGD 1,TKM 13, CO 52, Imp.White Ponni,, TRY 3*, TNAU Rice Hybrid CO 4,CO (R) 50, TNAU Rice ADT 49, CO 43, TRY 1, ADT(R) 46, ADT 38 |
| Navarai | (Dec-Jan) | ADT 53, CO 51, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| **Delta regions of** Cuddalore | | |
| Samba | (Aug) | CR 1009, CR 1009 Sub 1, ADT 51 |
| Late samba/Thaladi | (Sep-Oct) | ADT 38, ADT 39, ADT 46, Co 50, Co 52, TKM 13, Improved white ponni, TRY 3 |

| | | |
|---|---|---|
| Salt affected areas (Cuddalore) | | TRY 1, TRY 2, TRY 3 and Co 43 |
| **III. Western zone** | | |
| **a. Coimbatore/Tiruppur/Erode** | | |
| Kar | (May - Jun) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16 |
| Samba /Late Samba | (Aug - Sep) | CO 52, TKM 13, VGD 1, CO 43, Imp.White Ponni, TNAU Rice Hybrid CO 4, CO (R) 50, ADT(R) 46, TNAU Rice ADT 49, ADT 39, |
| Navarai | (Dec -Jan) | ADT 53, CO 51, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16 |
| **b. Karur/Perambalur/Ariyalur** | | |
| Kuruvai | (Jun -Jul) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| Samba | (Aug) | CR 1009 *Sub*1, TNAU Rice ADT 50, ADT 51, CR 1009 |
| Late Samba / Thaladi | (Sep -Oct) | VGD 1,TKM 13, CO 52, CO (R) 50, ADT 39, ADT 38, TNAU Rice ADT 49, CO 43, Imp.White Ponni, ADT (R) 46, TNAU Rice TRY 3*, TNAU Rice Hybrid CO 4, TRY 1* |
| Navarai | (Dec -Jan) | ADT 53, CO 51, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| **Delta regions of** Karur | | |
| Late Samba | (Sep -Oct) | ADT 38, ADT 39, ADT 46, Co 50, Co 52, TKM 13, Improved white ponni, TRY 3 |
| **Delta regions of** Ariyalur | | |
| Samba | (Aug) | CR 1009, CR 1009 Sub 1, ADT 51 |
| Late samba/Thaladi | (Sep-Oct) | ADT 38, ADT 39, ADT 46, Co 50, Co 52, TKM 13, Improved white ponni, TRY 3 |
| **IV. North Western Zone** | | |
| **a. Salem/Namakkal** | | |
| Kar | (May - Jun) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| Samba | (Aug) | VGD 1,TKM 13, CO 52, Imp.White Ponni, CO 43, TRY 1*, TNAU Rice TRY 3*, CO (R) 50, TNAU Rice ADT 49, TNAU Rice Hybrid CO 4 |
| Navarai | (Dec - Jan) | ADT 53, CO 51, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| **b. Dharmapuri/ Krishnagiri** | | |
| Kar | (May -Jun) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |
| Samba/Late Samba | (Aug - Oct) | VGD 1,TKM 13, CO 52, Paiyur 1, Imp.White Ponni, TNAU Rice ADT 49, ADT 39, ASD 19, CO 43 |
| Navarai | (Dec- Jan) | ADT 53, CO 51, ADT (R) 45, TPS 5 , MDU 6, ADT 36, ADT 37, CORH 3, ASD 16, TKM 9 |

| | | |
|---|---|---|
| **V. High Altitude zone** | | |
| **a. The Nilgiris** | | |
| Samba | (Jul -Aug) | CO(R)50, CO 52, ADT 39 |
| **VI. Southern zone** | | |
| **a. Pudukottai** | | |
| Kuruvai | (Jun -Jul) | ADT 53, CO 51, ADT 43, ADT (R) 45, TPS 5 , ADT 36, ADT 37, CORH 3, ASD 16 |
| Samba | (Aug) | CR 1009 *Sub*1, TNAU Rice ADT 50, ADT 51, CR 1009 |
| Late Samba/Thaladi | (Sep - Oct) | VGD 1,TKM 13, CO 52, CO (R) 50, ADT 39, ADT 38, TNAU Rice ADT 49, CO 43, Imp.White Ponni, ADT (R) 46, TNAU Rice TRY 3*, TNAU Rice Hybrid CO 4 |
| Rainfed direct seeded/ Semi-dry | (Jul -Aug) | CR 1009 *Sub1,* CR 1009, ADT 39 |
| **Delta regions** | (Sep -Oct) | ADT 38, ADT 39, ADT 46, Co 50, Co 52, TKM 13, Improved white ponni, TRY 3 |
| Salt affected areas | | TRY 1, TRY 2, TRY 3 and Co 43 |
| **b. Madurai/Dindigul/Theni** | | |
| Kar | (May -Jun) | MDU 6, CO 51, ADT 53, ASD 16, MDU 5, ADT43, ADT(R)45 |
| Samba/ Late Samba | (Aug- Sep) | VGD 1,TKM 13, CO 52, CO (R) 50, ADT 39, ADT 38, TNAU Rice ADT 49, CO 43, Imp.White Ponni, ADT (R) 46, TNAU Rice TRY 3*, TNAU Rice Hybrid CO 4 |
| Navarai | (Dec -Jan) | MDU 6, CO 51, ADT 53, ADT 36, ADT 37, ADT(R)45, ASD 16 |
| Semi-dry | (Jul -Aug) | Anna (R) 4, MDU 5, PMK (R) 3 |
| **c. Ramanathapuram** | | |
| Samba | (Aug) | Imp.White Ponni, TNAU Rice TRY 3, TRY 1*, VGD 1,TKM 13, CO 52, TNAU Rice Hybrid CO 4, CO (R) 50, CO 43, ADT 39 |
| Rainfed direct seeded & Semidry | (Jul -Aug) | Anna (R) 4, MDU 5, MDU 6, PMK (R) 3, ADT 36, ADT 53, CO 51 |
| **d. Virudhunagar** | | |
| Samba | (Sep-Oct) | VGD 1,TKM 13, CO 52, CO (R) 50, ADT 39, ADT 38, TNAU Rice ADT 49, CO 43, Imp.White Ponni, ADT (R) 46, TNAU Rice TRY 3*, TNAU Rice Hybrid CO 4 |
| Rainfed direct seeded | (Jul -Aug) | Anna (R) 4, ADT 36, MDU 6, PMK (R) 3, ADT (R) 45 |
| **e. Sivaganga** | | |
| Semi-dry | (Jul –Aug) | ADT 36, MDU 6, PMK (R) 3, Anna (R) 4, ADT 53, CO 51, ADT 39, TKM 13, VGD 1 |
| **f. Tirunelveli, Thoothukudi** | | |
| Early kar | (Apr - May) | TPS 5 , ASD 16, ASD 18, ADT 53, CO 51, ADT 43, ADT (R) 45, ADT 36, ADT 37, CORH 3, TKM 9 |
| Kar | (May -Jun) | |
| Pishanam/Late Pishanam | (Sep-Oct.) | TPS 3, ASD 19, VGD 1, TKM 13, CO 52, CO (R) 50, ADT 39, ADT 38, TNAU Rice ADT 49, CO 43, Imp.White |

| | | |
|---|---|---|
| | | Ponni, ADT (R) 46, TRY 1, TNAU Rice Hybrid CO 4 |
| Semi dry | (July- Aug) | Anna (R) 4, PMK (R) 3 |
| Drought affected areas (Ramanathapuram, Virudhunagar, Tiruvallur& parts of Madurai) | | Anna (R) 4, PMK 3 |
| **VII. High Rainfall zone** | | |
| **a. Kanyakumari** | | |
| Kar | (May –Jun) | TPS 5, ASD 16, ADT 36, ASD 18, ADT 43,ADT(R) 45, CORH 3, ADT 53, CO 51, |
| Pishanam / Late samba | (Sep – Oct) | ASD 19, TPS 3, CR 1009 *Sub1*, CR 1009, CO 43, TRY 1*, TNAU Rice TRY 3, VGD 1,TKM 13, ADT 39, CO 52, ADT (R) 46, TNAU Rice Hybrid CO 4, CO(R) 50, Imp.White Ponni, CO 43 |
| Semi-dry | (Jul – Aug) | ADT 36, TKM 9 |

* suitable for salt affected soils

***Note of Caution of the varieties****: ADT43 is recommended for Kar, Sornavari and Kuruvai seasons and should not be grown during cold weather period. Improved white ponni is also susceptible to blast and care should be taken on plant protection measures. All samba/late samba season varieties are likely to get infected with false smut and hence prophylactic spraying has to beadopted.*

Kuruvai/Navarai/Sornavari : Short duration
late samba/thaladi : Medium duration
Samba : long duration

## II. PARTICULARS OF RICE VARIETIES
## SHORT DURATION VARIETIES

| **PARTICULARS** | **CO 51** | **MDU 6** | **TPS 5** |
|---|---|---|---|
| Year of Release | 2013 | 2015 | 2014 |
| Year of Notification | SO.268(E)/28.1.2015 (SVRC) SO.1007(E)/30.3.2017(CVRC) | SO.1379(E)/27.03.2018 | SO.1556(E)/11.06.2015 |
| Parentage | ADT 43 / RR 272-1745 | MDU 5 / ACM 96136 | ASD 16 / ADT 37 |
| Duration (Days) | 105-110 | 115-120 | 118 |
| Average Yield (kg/ha) | 6641 | 6118 | 6301 |
| 1000 grain wt (g) | 16.0 | 17.3 | 22.7 |
| Grain L/B ratio | 3.0 | 3.09 | 2.3 |
| Grain type | Medium Slender | Long Slender | Short bold |
| **Morphological Characters** | | | |
| Habit | Semi dwarf, erect | Erect ,good tillering | Erect |
| Leaf sheath | Green | Green | Green |
| Septum | - | Green | Green |
| Ligule | - | Pale green | Light green |

| | | | |
|---|---|---|---|
| Auricle | Pale Green | Pale green | Light green |
| Panicle | Intermediate, droopy | Intermediate, droopy | Well exserted panicle |
| Husk colour | Straw | Straw | Straw |
| Rice colour | White | White | White |
| Abdominal white | Occasionally present | Occasionally present | Occasionally present |
| **Grain size (mm)** | | | |
| Length | 5.5 | 6.8 | 6.1 |
| Breadth | 1.8 | 2.2 | 2.7 |
| Thickness | -- | -- | |
| Seed source | Seed centre,TNAU, Coimbatore-3 | Seed centre, TNAU, Coimbatore | Seed centre, TNAU, Coimbatore |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. |

| **PARTICULARS** | **ADT 36** | **ADT 37** | **ADT 43** |
|---|---|---|---|
| Year of Release | 1980 | 1987 | 1998 |
| Year of Notification | SO 19(E)/ 14.01.1982 | SO.280(E)/ 13.04.1989 | SO.425(E)/ 8.6.1999 |
| Parentage | Triveni/ IR 20 | BG 280-1 2/ PTB 33 | IR 50/ Imp. White Ponni |
| Duration (Days) | 110 | 105 | 110 |
| Average Yield (kg/ha) | 5500 | 6200 | 5900 |
| 1000 grain wt (g) | 20.6 | 23.4 | 15.5 |
| Grain L/B ratio | 3.1 | 1.79 | 2.81 |
| Grain type | Medium | Short bold | Medium slender |
| **Morphological Characters** | | | |
| Habit | Semi dwarf,Erect | Semi dwarf, Erect | Semi dwarf, slightly open |
| Leaf sheath | Green | Green | Light green |
| Septum | Green | White | Cream |
| Ligule | Colourless | White | White |
| Auricle | Colourless | White | - |
| Panicle | Long compact | Compact | Moderately long, Intermediate type, |

| | | | |
|---|---|---|---|
| | | | drooping |
| Husk colour | Straw | Straw | Straw |
| Rice colour | White | White | White |
| Abdominal white | Absent | White, Present | Very occasionally present |
| **Grain size (mm)** | | | |
| Length | 7.8 | 5 | 5.46 |
| Breadth | 2.5 | 2.8 | 1.94 |
| Thickness | 2.0 | 1.88 | 1.63 |
| Seed source | Seed centre, TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre Fine variety : Direct procurement centre/private traders. | Bold variety : Direct procurement centre Fine variety : Direct procurement centre/private traders. | Bold variety : Direct procurement centre Fine variety : Direct procurement centre/private traders. |

| **PARTICULARS** | **ADT (R) 45** | **ASD 16** | **ASD 18** |
|---|---|---|---|
| Year of Release | 2001 | 1986 | 1991 |
| Year of Notification | SO.1134(E)/15.11.2001 | SO.867(E)/26.11.1986 | SO.615(E)/17.8.1993 |
| Parentage | IR50 / ADT 37 | ADT 31/CO 39 | ADT 31/IR 50 |
| Duration (Days) | 110 | 110 - 115 | 105 - 110 |
| Average Yield (kg/ha) | 5400 | 5600 | 5900 |
| 1000 grain wt (g) | 17.5 | 24.2 | 21.8 |
| Grain L/B ratio | 2.98 | 2.6 | 3.2 |
| Grain type | Medium slender | Short Bold | Medium slender |
| **Morphological Characters** | | | |
| Habit | Semi dwarf, erect | Semi dwarf,erect | Semi dwarf |
| Leaf sheath | Green | Green | Pale Green |
| Septum | Cream | Green | Light green |
| Ligule | White | White | White clefted |
| Auricle | - | Colourless | Pale green |
| Panicle | Compact | Long Compact | Medium, compact exerted |

| | | | |
|---|---|---|---|
| Husk colour | Straw | Straw | Straw |
| Rice colour | White | White | White |
| Abdominal white | Absent | Present | Slightly present |
| **Grain size (mm)** | | | |
| Length | 8.00 | 7.86 | 8.64 |
| Breadth | 2.16 | 3.02 | 2.7 |
| Thickness | 1.97 | 1.96 | 2.2 |
| Seed source | Seed centre, TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. |

| **PARTICULARS** | **Anna (R) 4** | **CORH 3 (hybrid)** | **ADT 53** |
|---|---|---|---|
| Year of Release | 2009 | 2006 | 2019 |
| Year of Notification | SO.2137(E)/ 31.08.2010 | SO.1178(E)/ 20.7.2007 | SO.3220(E)/ 5.9.2019 |
| Parentage | Pantdhan 10 x IET 9911 | TNAU CMS 2A/CB 87R | ADT 43 / JGL 384 |
| Duration (Days) | 105-110 | 110-115 | 110-115 |
| Average Yield (kg/ha) | 3700 | 7500 | 6334 |
| 1000 grain wt (g) | 25.7 | 22.0 | 14.5 |
| Grain L/B ratio | 3.45 | 2.95 | 3.1 |
| Grain type | Long slender | Medium slender | Medium Slender |
| **Morphological Characters** | | | |
| Habit | Semidwarf erect | Semi dwarf | Medium tall, erect |
| Leaf sheath | Green | Green | Green |
| Septum | - | - | Cream |
| Ligule | - | - | White, Split shape |
| Auricle | Pale green | Pale green | Light green |
| Panicle | Intermediate | Long, compact, drooping | Intermediate Compact |
| Husk colour | Straw | Straw | Straw |
| Rice colour | White | White | White |
| Abdominal white | Absent | Occasionally present | Absent |

| **Grain size (mm)** | | | |
|---|---|---|---|
| Length | 6.90 | 6.2 | 5.8 |
| Breadth | 2.00 | 2.1 | 1.9 |
| Thickness | - | 1.2 | 1.02 |
| Seed source | Seed centre,TNAU, Coimbatore-3 | Seed centre, TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders. |

| **PARTICULARS** | **TKM 11** | **TRY 2** |
|---|---|---|
| Year of Release | 1998 | 2001 |
| Year of Notification | SO.425(E)/8.6.1999 | SO.1134(E)/15.11.2001 |
| Parentage | C 22/BJ 1 | IET6238/IR36 |
| Duration (Days) | 110-120 | 115-120 |
| Average Yield (kg/ha) | 3000 | 5362 |
| 1000 grain wt (g) | 21.4 | 22.8 |
| Grain L/B ratio | 3.2 | 3.5 |
| Grain type | Long slender | Long slender |
| **Morphological Characters** | | |
| Habit | Erect | Semi dwarf,erect |
| Leaf sheath | Green | Green |
| Septum | cream | Light green |
| Ligule | Colourless | Distinct |
| Auricle | Light green | Hairy light brown |
| Panicle | Long, compact, drooping | Compact |
| Husk colour | - | Straw |
| Rice colour | White | White |
| Abdominal white | - | Absent |
| **Grain size (mm)** | | |
| Length | 9.3 | 9.1 |

| | | |
|---|---|---|
| Breadth | 2.3 | 2.6 |
| Thickness | 1.6 | 1.7 |
| Seed source | Seed centre,TNAU, Coimbatore-3 | Seed centre, TNAU, Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders |

| **PARTICULARS** | **ADT (R) 48** | **MDU 5** | **PMK (R) 3** | **TKM 9** |
|---|---|---|---|---|
| Year of Release | 2005 | *1996* | 2003 | 1978 |
| Year of Notification | SO.599(E)/ 25.04.2006 | SO.662(E)/ 17.09.1997 | SO.1177(E)/ 25.08.2005 | SO.19(E)/ 14.01.1982 |
| Parentage | IET 11412/IR 64 | *O.glaberrima*/ Pokkali | UPLRI 7/CO 43 | TKM 7 / IR 8 |
| Duration(Days) | 94-99 | 95 - 100 | 110-115 | 100-105 |
| Average Yield (Kg / ha) | 4800 | 4500 | 3025 | 5019 |
| 1000 grain wt(g) | 22.0 | 21.1 | 26.10 | 25.13 |
| GrainL/B ratio | 3.25 | 3.12 | 2.64 | 2.71 |
| Grain type | Long slender | Medium slender | Long bold | Short bold |
| **Morphological characters** | | | | |
| Habit | Semidwarf erect | Erect | Erect | Dwarf |
| Leaf sheath | Green | Green | Green | - |
| Septum | Cream | - | - | Light blue |
| Ligule | Acute, prominent | Colourless | Pale green | - |
| Auricle | - | Colourless | - | - |
| Panicle | Intermediate | Intermediate | Intermediate | Compact |
| Husk colour | Straw | Straw | Gold yellow with brown streaks | Straw |
| Rice colour | White | White | White | Red |
| Abdominal white | Occassionally present | - | - | Present |
| **Grain size(mm)** | | | | |
| Length | 9.15 | 8.45 | 6.75 | 8.12 |
| Breadth | 2.54 | 2.7 | 2.38 | 2.99 |
| Thickness | 1.90 | - | 2.08 | 2.01 |
| Seed source | Seed centre, TNAU, | Seed centre,TNAU, | Seed centre, TNAU, | Seed centre, TNAU, |

| | | | | |
|---|---|---|---|---|
| | Coimbatore-3 | Coimbatore-3 | Coimbatore-3 | Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders |

## MEDIUM DURATION VARIETIES

| **PARTICULARS** | **Rice CO 52** | **TKM 13** | **TNAU Rice TRY 3** | **VGD 1** |
|---|---|---|---|---|
| Year of Release | 2017 | 2015 | 2010 | 2019 |
| Year of Notification | SO.1379(E)/27.03.2018 | SO.3540(E)/ 22.11.2016 | SO.1708(E)/26.07.2012 | SO.3220(E)/5.9.2019 |
| Parentage | BPT 5204 / CO(R) 50 | WGL 32100 / Swarna | ADT 43 / *Jeeraga Samba* | ADT 43/ Seeragasamba |
| Duration (Days) | 130-135 | 130 | 135 | 130 - 135 |
| Average Yield kg/ha | 6191 | 5938 | 5833 | 5859 |
| 1000 grain wt (g) | 14.10 | 13.8 | 23.0 | 8.8 to 8.9 |
| Grain L/B ratio | 3.0 | 2.83 | 2.58 | 2.1 |
| Grain type | Medium Slender | Medium Slender | Medium | Short bold |
| **Morphological Characters** | | | | |
| Habit | Erect, Medium Tall | Semi dwarf, erect, non- lodging | Intermediate erect | Semi dwarf, erect |
| Leaf sheath | Green | Green | Green | Green |
| Septum | -- | Cream | -- | Cream |
| Ligule | -- | Split, White | Cleft, White | White |
| Auricle | White | Present, Colourless | Light Green | light green |
| Panicle | Long, compact, Droopy | Well exerted, Compact | Intermediate, Compact | Compact and drooping at maturity |
| Husk colour | Straw | Straw | Straw | Straw |
| Rice colour | White | White | White | White |
| Abdominal white | Occasionally present | Occasionally present | Occasionally present | Absent |
| **Grain size (mm)** | | | | |
| Length | 5.5 | 5.44 | 6.2 | 3.7 |

| | | | | |
|---|---|---|---|---|
| Breadth | 1.8 | 1.92 | 2.4 | 1.8 |
| Thickness | -- | -- | 1.5 | 1.25 |
| Seed source | Seed centre,TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders |

| **PARTICULARS** | **TNAU Rice ADT 49** | **CO (R ) 50** | **ADT 39** | **ADT 38** |
|---|---|---|---|---|
| Year of Release | 2011 | 2010 | 1988 | 1987 |
| Year of Notification | SO.1708(E)/ 26.07.2012 | SO.1708(E)/ 26.07.2012 | SO.280(E)/ 13.04.1989 | SO.280(E)/ 13.04.1989 |
| Parentage | CR1009/ Jeeraga Samba | CO 43 / ADT 38 | IR 8/IR 20 | IR 1529-680-3-2/ IR 4432-52-6-4/ IR 7963-30-2 |
| Duration (Days) | 130- 135 | 130-135 | 120 - 125 | 130 - 135 |
| Average Yield kg/ha | 6173 | 6338 | 5000 | 6200 |
| 1000 grain wt (g) | 14.0 | 20.5 | 18 | 21 |
| Grain L/B ratio | 2.77 | 2.90 | 2.9 | 3.2 |
| Grain type | Medium Slender | Medium | Medium slender | Long Slender |
| **Morphological Characters** | | | | |
| Habit | Semi dwarf, Erect | Medium tall with New plant type | Semi dwarf | Semi dwarf, erect |
| Leaf sheath | Green | Green | Green | Green |
| Septum | Cream | - | Light Cream | White |
| Ligule | Split , white | - | Papery white | White Non-prominent |
| Auricle | Colourless | Pale green | Non-pigmented | White |
| Panicle | Compact | Long compact droopy | Medium, Modera-tely dense | Long moderately |
| Husk colour | Straw | Straw | Straw | dense |
| Rice colour | White | White | White | Straw |
| Abdominal white | Occasionally present | Occasionally present | Absent | White |

| Grain size (mm) | | | | Absent |
|---|---|---|---|---|
| Length | 7.36 | 6.10 | 7.6 | 6.9 |
| Breadth | 2.24 | 2.10 | 2.3 | 2.4 |
| Thickness | 1.69 | - | 1.9 | 2 |
| Seed source | Seed centre, TNAU, Coimbatore | Seed centre,TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 | Seed centre, TNAU, Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre Fine variety : Direct procurement centre/private traders |

| **PARTICULARS** | **Imp. White Ponni** | **ADT (R) 46** | **CO 43** | **Paiyur 1** |
|---|---|---|---|---|
| Year of Release | 1986 | 2002 | 1982 | 1982 |
| Year of Notification | SO.280(E)/ 13.04.1989 | SO.1177(E)/ 25.08.2005 | SO.596(E)/ 13.8.1984 | SO.596(E)/ 13.8.1984 |
| Parentage | Taichung 65/2 MayangEbos*80 | ADT38 / CO 45 | Dasal x IR 20 | IR 1721-14/IR 1330-3-3-2 |
| Duration (Days) | 135 - 140 | 135 | 135 - 140 | 135-140 |
| Average Yield kg/ha | 4500 | 6656 | 5200 | 5900 |
| 1000 grain wt (g) | 16.4 | 23.8 | 20 | - |
| Grain L/B ratio | 3.22 | 3.12 | 3.5 | - |
| Grain type | Medium slender | Long Slender | Medium slender | Medium slender |
| **Morphological Characters** | | | | |
| Habit | Medium tall | Erect, semi-dwarf | Erect | Medium tall |
| Leaf sheath | Green | Green | Green | - |
| Septum | Green | Cream | Green | - |
| Ligule | White | Long white | White, longer | - |
| Auricle | Colourless | Pale green | Colourless | - |
| Panicle | Long drooping | Intermediate | Long drooping | - |
| Husk colour | Straw | Straw | Straw | Straw |
| Rice colour | White | White | White | White |
| Abdominal white | Absent | Absent | Absent | Absent |
| **Grain size (mm)** | | | | |

| | | | | |
|---|---|---|---|---|
| Length | 8 | 9.58 | 8.1 | - |
| Breadth | 3 | 2.46 | 2.3 | - |
| Thickness | 2 | 1.95 | 1.8 | - |
| Seed source | Seed centre,TNAU, Coimbatore-3 | Seed centre, TNAU, Coimbatore-3 | Seed centre, TNAU, Coimbatore-3 | Seed centre, TNAU, Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders |

| PARTICULARS | TPS 3 | TNAU Rice hybrid CO 4 | TRY 1 | ASD 19 |
|---|---|---|---|---|
| Year of Release | 1993 | 2011 | 1995 | 1995 |
| Year of Notification | SO.360(E)/ 1.5.1997 | SO.1708(E)/ 26.07.2012 | SO.92(E)/ 2.2.2001 | SO.360(E)/ 1.5.1997 |
| Parentage | RP31-492/LMN | TNAU CMS 23 A / CB 174 R | IR578-172-2-2/ BR-1-2-B-1 | Lalnakanda/ IR 30 |
| Duration (Days) | 135-140 | 130 - 135 | 135-140 | 127 (120-132) |
| Average Yield (kg/ha) | 5253 | 7348 | 5255 | 5800 |
| 1000 grain wt (g) | 23.2 | 20.40 | 24 | 18.39 |
| Grain L/B ratio | 2.06 | 2.96 | 2.6 | 3.06 |
| Grain type | Short bold | Medium slender | Medium | Short, slender |
| **Morphological Characters** | | | | |
| Habit | Semi dwarf/erect | Semi dwarf | Erect | Semi-dwarf, erect |
| Leaf sheath | Green | Green | Green | Light green |
| Septum | Cream | - | White | Cream |
| Ligule | - | - | White | White |
| Auricle | - | Pale green | White | Palegreen |
| Panicle | Long | Long compact droopy | Long, moderately compact | Compact, dense drooping & well exerted |
| Husk colour | Straw | Straw | Straw | Straw |
| Rice colour | White | White | White | White |
| Abdominal white | Present | Occasionally present | Absent | Absent |
| **Grain size (mm)** | | | | |
| Length | 7.96 | 5.67 | 6.2 | 8.28 |
| Breadth | 3.0 | 1.91 | 2.4 | 2.32 |

| | | | | |
|---|---|---|---|---|
| Thickness | 2.0 | - | 1.8 | 1.72 |
| Seed source | Seed centre, TNAU, Coimbatore-3 | Seed centre, TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 | Seed centre,TNAU, Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders |

**LONG DURATION VARIETIES**

| **PARTICULARS** | **Rice ADT 51** | **CR 1009 *Sub* 1** | **TNAU Rice ADT 50** | **CR 1009** |
|---|---|---|---|---|
| Year of Release | 2017 | 2015 | 2012 | 1982 |
| Year of Notification | S.O. 6318(E) /26.12.2018 | SO.3540(E)/22.11.2016 | SO.268(E)/28.01.2015 | SO.499(E)/08.07.1983 |
| Parentage | BPT 5204 / I.W.Ponni | CR 1009 / FR 13 A (MAB) | BPT 5204 / CR 1009 | Pankaj/Jagannath |
| Duration (Days) | 154 | 150-155 | 149 | 155 - 160 |
| Average Yield (kg/ha) | 6587 | 5759 | 5945 | 5300 |
| 1000 grain wt (g) | 23.9 | 23.0 | 15.9 | 23.5 |
| Grain L/B ratio | 2.74 | 2.05 | 2.56 | 2.2 |
| Grain type | Medium | Short bold | Medium Slender | Short bold |
| **Morphological Characters** | | | | |
| Habit | Erect Semi dwarf | Semi dwarf tolerance to submergence | Medium tall | Erect |
| Leaf sheath | Green | Green | Green | Green |
| Septum | Cream | - | Cream | Green |
| Ligule | White | - | Split , white | White |
| Auricle | Present, Light green | Pale Green | Absent | Colourless |
| Panicle | Well exerted, compact panicle | Intermediate | Compact | Medium drooping |
| Husk colour | Straw | Straw | Straw | Straw |
| Rice colour | White | White | White | White |
| Abdominal white | Absent | Occasionally present | Occasionally present | Absent |
| **Grain size (mm)** | | | | |
| Length | 6.3 | 5.06 | 7.24 | 6.9 |
| Breadth | 2.3 | 2.46 | 3.50 | 3.1 |
| Thickness | 1.56 | -- | 1.65 | 2.1 |
| Seed source | Seed centre, TNAU, | Seed centre, TNAU, | Seed centre, | Seed centre, |

| | | | | |
|---|---|---|---|---|
| | Coimbatore-3 | Coimbatore-3 | TNAU, Coimbatore | TNAU, Coimbatore-3 |
| Marketability | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders | Bold variety : Direct procurement centre<br>Fine variety : Direct procurement centre/private traders |

## CROP MANAGEMENTSYSTEMS OF RICE CULTIVATION IN TAMIL NADU

Rice is cultivated under **puddled** and **un-puddled lowland** situations in Tamil Nadu. 'Transplanting' and 'direct wet seeding' are the two environments under puddled lowland. Whereas, un-puddled lowland cultivation undergoes different environments like, dry seeding exclusively with rainfall, locally called as 'rainfed rice', with supplemental irrigation during peak vegetative and reproductive phases by the rain water collected / harvested in tanks ('semi-dry rice') and also assured irrigation from canal after 30-45 days of dry situation (also called semi-dry rice) . They are grouped as follows:

1. **Transplanted puddled lowland rice**
2. **Direct seeded lowland rice**
   a. Wet seeded rice in puddled soil
   b. Dry seeded rice in un-puddled soil
      i) Rainfed
      ii) Semi dry - supplemental irrigation
      iii) Semi dry - canal irrigation* (contingent crop)
3. **Dry seeded upland rice** – This system of rice cultivation is there in areas with high rainfall (like Assam and NE frontiers of India) where the land is slopy and terraced and there is no possibility for bunding to stagnate the water. Grain yield is poor due to loss of nutrients and soil mainly caused by water erosion. Moisture availability is mostly at saturation or at wet range. There is very limited area in Dharmapuri district, Tamil Nadu.
4. **Deep water rice** cultivation exists in certain pockets of Nagapattinam and Tiruvarur districts particularly during NE monsoon with heavy downpour.

# 1. TRANSPLANTED PUDDLED LOWLAND RICE

## TRANSPLANTED RICE

### 1.1 Nursery management

#### 1.1.1. Wet nursery Nursery area

Select 20 cents (800 $m^2$) of land area near to water source for raising seedlings for one hectare.

**Seed rate**

30 kg for long duration
40 kg for medium duration
60 kg for short duration varieties and 20 kg for hybrids

**Seed treatment**

a. Treat the seeds in Carbendazim or Pyroquilon or Tricyclozole solution at 2 g/l of water for 1 kg of seeds. Soak the seeds in water for 10 hrs and drain excess water.
b. This wet seed treatment gives protection to the seedlings up to 40 days from seedling disease such as blast and this method is better than dry seed treatment.
c. If the seeds are required for sowing immediately, keep the soaked seed in gunny in dark and cover with extra gunnies and leave for 24hrs for sprouting.
d. **Seed treatment with *Pseudomonas fluorescens***: Treat the seeds with talc based formulation of *Pseudomonas fluorescens* 10g/kg of seed and soak in 1lit of water overnight. Decant the excess water and allow the seeds to sprout for 24hrs and then sow.
e. **Seed treatment with biofertilizers :** Five packets (1kg/ha) each of *Azospirillum* and Phosphobacteria or five packets (1kg/ha) of Azophos bioinoculants are mixed with sufficient water wherein the seeds are soaked overnight before sowing in the nursery bed (The bacterial suspension after decanting may be poured over the nursery area itself).
Carrier based formulation: Treat one hectare of seeds with 1 kg each of biofertilizers *viz., Azsopirillum,* Phosphobacteria, (or) Azophos, Silicate solubilizing bacteria (SSB) / Potash bacteria (KRB) using rice gruel, shade dry for 30 minutes before sowing.
Liquid formulation : Treat one hectare of seeds with 125 ml of each biofertilizers *viz., Azsopirillum,* Phosphobacteria (or) Azophos, Silicate solubilizing bacteria (SSB) / Potash bacteria (KRB) shade dry for 30 minutes before sowing.
   - Biocontrol agents are compatible with biofertilizers
   - Biofertilizers and biocontrol agents can be mixed together for seed soaking
   - Fungicides and biocontrol agents are incompatible

**Forming Seedbeds**

- Mark plots of 2.5m breadth with channels 30cm wide all around the seedbeds.
- Length of the seed bed may vary from 8 to 10m according to soil and slope of the land.
- Collect the puddled soil from the channel and spread on the seedbeds or drag a heavy stone along the channel to lower it, so that the seed bed is at a higher level.
- Level the surface of the seedbed, so that the water drains into the channel.

**Sowing**

- Sow the sprouted seeds uniformly on the seedbed having thin film of water in the surface.

**Water Management**

- Drain the water 18 to 24 hrs after sowing
- Care must be taken to avoid stagnation of water on the seedbed.
- Allow enough water to saturate the soil from 3$^{rd}$ to 5$^{th}$ day. From 5$^{th}$ day onwards, increase the water depth to 1.5 cm depending on the height of the seedlings.
- Thereafter maintain 2.5 cm depth of water.

**Weed Management**

- Apply any one of the pre-emergence herbicides *viz*., Pyrazosulfuron ethyl @ 20 g/ha on 3$^{rd}$ or 4$^{th}$ day after sowing to control weeds in the lowland nursery. Keep a thin film of water and allow it to disappear. Avoid drainage of water. This will control germinating weeds.
- Pre-emergence herbicide Butachlor 1.0 l/ha (or) Pendimethalin 1.0 l/ha. Herbicides should be applied on 8 DAS with thin layer of water in the field.

**Nutrient management**

- Apply 1 tonne of fully decomposed FYM or compost to 20 cents nursery and spread the manure uniformly on dry soil.
- Basal application of DAP is recommended when the seedlings are to be pulled out in 20-25 days after sowing in less fertile nursery soils.
- For that situation, before the last puddling, apply 40 kg of DAP and if not readily available, apply straight fertilizers 16 kg of urea and 120 kg of super phosphate.
- If seedlings are to be pulled out after 25 days, application of DAP is to be done 10 days prior to pulling out.
- For clayey soils where root snapping is a problem, 4 kg of gypsum and 1 kg of DAP/cent can be applied at 10 days after sowing.
- Soil application of 100 g $ZnSO_4$ /cent can be followed.

**1.1.2. Dry nursery**

- Dry ploughed field with fine tilth is required.
- Nursery area with sand and loamy soil status is more suitable for this type of nursery.

- Area 20 cents.
- Plots of 1 to 1.5 m width of beds and channels may be formed. Length may be according to the slope and soil. Raised beds are more ideal if the soil is clayey in nature.
- Seed rate and seed treatment as that of wet nursery.
- Sowing may be dry seeding. Seeds may be covered with sand and finely powdered well decomposed farm yard manure.
- Irrigation may be done to wet the soil to saturation.
- Optimum age for transplanting – 4th leaf stage
- This type of nursery is handy in times of delayed receipt of canal water.
- During transplanting seedlings may be dipped in 2% $ZnSO_4$ or ZnO for 30 min and then transplanted.

## 1.2. Main Field Management

### 1.2.1. Land preparation

- Plough the land during summer to economize the water requirement for initial preparation of land.
- Flood the field 1 or 2 days before ploughing and allow water to soak in. Keep the surface of the field covered with water.
- Keep water to a depth of 2.5cm at the time of puddling.
- Special technologies for problem soils:
  a) For fluffy paddy soils: compact the soil by passing 400kg stone roller or oil-drum with stones inside, eight times at proper moisture level (moisture level at friable condition of soil which is approximately 13 to18%) once in three years, to prevent the sinking of draught animals and workers during puddling.
  b) For sodic soils with pH values of more than 8.5, plough at optimum moisture regime, apply gypsum at 50% gypsum requirement uniformly, impound water, provide drainage for leaching out soluble salts and apply green leaf manure at 5 t/ha, 10 to 15 days before transplanting. Mix 37.5 kg of zinc sulphate per ha with sand to make a total quantity of 75 kg and spread the mixture uniformly on the leveled field. Do not incorporate the mixture in the soil. Rice under sodic soil responds well to these practices.
  c) For saline soils with EC values of more than 4 dS/m, provide lateral and main drainage channels (60cm deep and 45cm wide), apply green leaf manure at 5 t/ha at 10 to 15 days before transplanting and 25% extra dose of nitrogen in addition to recommended P and K and $ZnSO_4$
  d) For acid soils apply lime based on the soil analysis for obtaining normal rice yields. Lime is applied 2.5 t/ha before last ploughing. Apply lime at this rate to each crop up to the 5th crop.

### 1.2.2.Stand Establishment

**Optimum age of seedlings for quick establishment**

- Optimum age of the seedlings is 18-22 days for short, 25-30 days for medium and 35-40 days for long duration varieties.

**Pulling out the seedlings**

- Pull out the seedlings at the appropriate time ($4^{th}$ leaf stage).
- Pulling at $3^{rd}$ leaf stage is also possible. These seedlings can produce more tillers, provided enough care taken during the establishment phase (See section 1.8 Integrated Crop Management (ICM) - Rice-SRI) through thin film of water management and perfect leveling of main field.
- Transplanting after $5^{th}$ and higher order leaf numbers will affect the performance of the crop and grain yield. Then they are called as 'aged seedlings'. Special package is needed to minimize the grain yield loss while planting those aged seedlings.

**Root dipping**

- Prepare the slurry with 5 packets (1 kg/ha) each of *Azospirillum* and Phosphobacteria or 5 packets of (1 kg/ha) Azophos inoculant in 40 lit. of water and dip the root portion of the seedlings for 15 - 30 minutes in bacterial suspension and transplant.

**Planting seedlings in the main field**

| Soil | Medium and low fertility | | | High fertility | | |
|---|---|---|---|---|---|---|
| Duration | Short | Medium | Long | Short | Medium | Long |
| Spacing (cm) Hills / $m^2$ | 15x10<br>66 | 20x10<br>50 | 20x15<br>33 | 20x10<br>50 | 20x15<br>33 | 20x20<br>25 |

- Transplant 2-3 seedlings/hill for short duration and 2 seedlings/hill for medium and long duration varieties
- Shallow planting (3 cm) ensures quick establishment and more tillers.
- Deeper planting (> 5cm) leads to delayed establishment and reduced tillers.
- Line planting permits rotary weeding and its associated benefits.
- Allow a minimum row spacing of 20 cm to use rotary weeder.
- Fill up the gaps between $7^{th}$ and $10^{th}$ DAT.

**Management of Aged seedlings***

* **Which developed tillers / underwent node elongation in the nursery itself and About half of its leaf producing capacity may be already over.**

- Follow the spacing recommended to medium and low fertility soil
- Plant two to three seedlings per hill
- Avoid cluster planting of aged seedlings, which are hindering the formation of new tillers.
- New tillers alone are capable of producing normal harvestable panicle. Weak panicle may appear in the mother culm within three weeks after transplanting and vanishes well before harvest.
- To encourage the tiller production, enhance the basal N application by 50% from the recommended and thereafter follow the normal schedule recommended for other stages.

**Gap filling**

- Fill the gaps if any within 7 - 10 days after planting.Nutrient management Application of organic manures
- Apply 12.5 t of FYM or compost or green leaf manure @ 6.25 t/ha.

- If green manure is raised @ 50 kg seeds/ha *in situ,* incorporate it to a depth of 15 cm using a green manure trampler or tractor.
- In the place of green manure, press-mud / composted coir-pith can also be used.

### 1.2.3. Nutrient Management

**Stubble incorporation**

- Apply 10 kg N/ha (22 kg urea) at the time of first puddling while incorporating the stubbles of previous crop to compensate immobilization of N by the stubbles.
- This may be done at least 10 days prior to planting of subsequent crop. This recommendation is more suitable for double crop wetlands, wherein, the second crop is transplanted in succession with short turn around period.

**Biofertilizer application**

- Broadcast 10 kg of soil based powdered BGA flakes at 10 DAT for the dry season crop. Maintain a thin film of water for multiplication.
- Raise Azolla as a dual crop by inoculating 250 kg/ha 3 to 5 DAT and then incorporate during weeding for the wet season crop.
- Mix 2 kg each of biofertilizers *viz., Azsopirillum,* Phosphobacteria (or) Azophos, Silicate solubilizing bacteria (SSB) / Potash bacteria (KRB) with 25 kg of FYM and 25 kg of sand and broad cast uniformly before transplanting and
- *Pseudomonas fluorescens* (Pf 1) at 2.5 kg/ha mixed with 50 kg FYM and 25 kg of soil and broadcast the mixture uniformly before transplanting.

**Application of inorganic fertilizers**

- Apply fertilizer nutrients as per STCR-IPNS recommendations for desired yield target (Appendix I) (or)
- N dose may be through Leaf Color Chart (**LCC**)*
- P & K may be through Site Specific Nutrition Management by Omission plot technique**
- If the above recommendation are not able to be followed, adopt blanket recommendation a follows:

| **Nutrients** | **N** | **$P_2O_5$** | **$K_2O$** |
|---|---|---|---|
| | **(kg/ha)** | | |
| Short duration varieties (**dry season**) | | | |
| a) Cauvery delta & Coimbatore tract | 150 | 50 | 50 |
| b) For other tracts | 120 | 40 | 40 |
| Medium and long duration varieties (**wet season**) | 150 | 50 | 50 |
| Hybrid rice | 175 | 60 | 60 |
| Low N responsive cultivars (like Improved White Ponni) | 75* | 50 | 50 |

* For Ponni, N should be applied in three splits at AT, PI and H stages** in addition to GLM or FYM application.
**Phenological stages of rice (days after sowing)

| Stages | Short (105) | Medium (135) | Long (150) |
|---|---|---|---|
| Active Tillering (AT) | 35-40 | 50-55 | 55-60 |
| Panicle Initiation (PI) | 45-50 | 70-75 | 85-90 |
| Heading (H) | 70-75 | 100-105 | 115-120 |

**N management through LCC**

- Time of application is decided by LCC score
- Take observations from 14 DAT in transplanted rice or 21 DAS in direct seeded rice.
- Repeat the observations at weekly intervals up to heading
- Observe the leaf colour in the fully opened third leaf from the top as index leaf.
- Match the leaf color with the colours in the chart during morning hours (8-10 am).
- Take observation in 10 places.
- LCC critical value is 3.0 in low N response cultures like White Ponni and 4.0 in other cultivars and hybrids
- When 6/10 observations show less than the critical colour value, N can be applied as per the following recommendation : Application of 25 kg N $ha^{-1}$ (1 bag urea) at 7 DAT followed by N @ 40 kg $ha^{-1}$ each time for kuruvai/ short duration rice / 30 kg $ha^{-1}$ each time for medium & long duration rice as and when the leaf colour value falls below the critical value of 4 for varieties and hybrids and critical value of 3 for white ponni, monitored from 14 DAT.
- For aged seedlings : Basal application of 35 kg N per ha is recommended to avoid yield loss when seedlings aged 35 - 45 days are used for transplanting and the LCC based N management can be followed from 14 DAT.

****Recommendation of P&K fertilizer rates based on SSNM approach for rice growing tracts of Tamil Nadu (other than Cauvery Delta)**

| Sl. No. | Location | Calibrated SSNM fertilizer dose (kg/ha)* | |
|---|---|---|---|
| | | $P_2O_5$ | $K_2O$ |
| 1 | Cauvery delta | | |
| | (i) Old delta | **35** | **50** |
| | (ii) New delta | **35** | **80** |
| 2 | Coimbatore District | | |
| | (i) General | 30 | 40 |
| | (ii) Annamalai block | 30 | 80 |
| 3 | Killikulam | 30 | 50 |
| 4 | Trichy | 35 | 50 |
| 5 | Ambasamudram | 40 | 50 |
| 6 | Bhavanisagar | 20 | 25 |
| 7 | Paiyur | 25 | 45 |
| 8 | Yethapur | 30 | 45 |

| | | | |
|---|---|---|---|
| 9 | Aruppukottai | 20 | 30 |
| 10 | Cuddalore | 30 | 50 |

** The above SSNM based fertilizer P and K arrived based on yield response are recommended for specific soil series prevailing in different rice growing areas for adoption by farmers

**Split application of N and K**

- Apply N and K in four equal splits viz., basal, tillering, panicle initiation and heading stages.
- Tillering and Panicle initiation periods are crucial and should not be reduced with the recommended quantity.
- N management through **LCC** may be adopted wherever chart is available

**Application of P fertilizer**

- P may be applied as basal and incorporated.
- When the green manure is applied, rock phosphate can be used as a cheap source of P fertilizer. If rock phosphate is applied, the succeeding rice crop need not be supplied with P. Application of rock phosphate + single super phosphate or DAP mixed in different proportions (75:25 or 50:50) is equally effective as SSP or DAP alone.

**Application of micronutrients**

**Soil Application**

- Soil application of 25 kg zinc sulphate/ha mixed with 50 kg dry sand or apply 25 kg of TNAU Wetland rice MN mixture/ha enriched in FYM at 1:10 ratio incubated for 30 days at friable moisture, just before transplanting.
- It is enough to apply 12.5 kg zinc sulphate /ha, if green manure (6.25 t/ha) or enriched FYM, is applied.
- For saline and sodic acid 37.5 kg $ZnSO_4$ can be applied.
- Apply 500 kg of gypsum/ha (as source of Ca and S nutrients) at last ploughing. Application of 50 kg $FeSO_4$ + 12.5 t FYM /ha, 40 kg S as gypsum can be followed, if the soils are deficient in respective elements.
- For Cauvery delta zone, application of 5 kg $CuSO_4$ can be recommended.

**Foliar nutrition**

- Foliar spray of 1% urea + 2% MAP + 1% KCl at Panicle Initiation (PI) and 10 days after first spray to inprove grain filling rate and yield in all varieties.
- If deficiency symptom appears in the standing crop (15 days after transplanting) foliar application of 0.5% zinc sulphate + 1.0% urea can be given at 7-10 days for short duration and 15 days interval for medium and copy duration crop until the Zn deficiency symptoms disappear.
- Biofortification strategies; For biofortification of Zn in rice, the efficient cultivars viz., CO51, CO47, ADT 47, ADT 37 may be grown with the basal soil application of 50 kg $ZnSO_4$ alongwith foliar spraying of 0.50% $ZnSO_4$ thrice at 50% flowering, milky and dough stages to enrich the grain Zn content.

**Nutrient deficiency / toxicity symptoms**

- **Nitrogen deficiency**: Plants become stunted and yellow in appearance first on lower leaves. In case of severe deficiency the leaves will turn brown and die. Deficiency symptoms first appear at the leaf-tip and progress along the midrib until the entire leaf is dead.
- **Potassium deficiency**: Bluish green leaves - when young, older leaves irregular.

Chlorotic and necrotic areas - grain formation is poor - weakening of the straw which results in lodging.

- **Magnesium deficiency:** Leaves are chlorotic with white tips.
- **Zinc deficiency:** Lower leaves have chlorotic particularly towards the base. Deficient plants give a brown rusty appearance.
- **Copper deficiency:** Leaves develop chlorotic streaks on either side of the midrib and appearance of dark brown necrotic lesions on leaf tips. Unfolding of the new leaves will also be seen.
- **Iron toxicity:** Brown spots on the lower leaves starting from tips and proceeding to the leaf base and turns into green or orange purple leaves and spreading to the next above leaves.

**Neem treated urea and coal-tar treated urea**

Blend the urea with crushed neem seed or neem cake 20% by weight. Powder neem cake to pass through 2mm sieve before mixing with urea. Keep it overnight before use (or) urea can be mixed with gypsum in 1:3 ratios, or urea can be mixed with gypsum and neem cake at 5:4:1 ratio to increase the nitrogen use efficiency. For treating 100 kg urea, take one kg coal-tar and 1.5 litres of kerosene. Melt coal-tar over a low flame and dissolve it in kerosene. Mix urea with the solution thoroughly in a plastic container, using a stick. Allow it to dry in shade on a polythene sheet. This can be stored for a month and applied basally.

**N management through LCC For sodic soil**

In the case of sodic soils, LCC critical value is 4.0 for varieties and 5.0 for the hybrids.

**Other special cultural practices (Contingent Plan)**

Application of Pink Pigmented Facultative Methylotroph (*Methylobacterium* sp.) as seed treatment (@ 200 g / 10 kg seeds), soil application (@ 2 kg / ha) and foliar spray (@ 500 ml / ha) at panicle initiation and flag leaf stages for alleviation of water stress effects in both SRI and transplanted system of rice cultivation.

### 1.2.4. Weed management

- Use of rotary weeder from 15 DAT at 10 days interval. It saves labour for weeding, aerates the soil and root zone, prolongs the root activity, and improves the grain filling though efficient translocation and ultimately the grain yield.
- Cultural practices like dual cropping of rice-azolla, and rice-green manure (described in wet seeded rice section 2.5 & 2.6 of this chapter) reduces the weed infestation to a greater extent.
- Summer ploughing and cultivation of irrigated dry crops during post-rainy periods reduces the weed infestation.

**Pre-emergence herbicides**

- Use Butachlor 1.25kg/ha or Anilophos 0.4kg/ha as pre-emergence application. Alternatively, pre-emergence application of herbicide mixture viz., Butachlor 0.6kg + 2,4 DEE 0.75kg/ha, or Anilophos + 2, 4 DEE 'ready-mix' at 0.4kg/ha followed by one hand weeding on 30 - 35 DAT will have a broad spectrum of weed control.

- Any herbicide has to be mixed with 50kg of dry sand on the day of application (3 - 4 DAT) and applied uniformly to the field with thin film water on the 3rd DAT. Water should not be drained for next 2 days from the field (or) fresh irrigation should not be given.
- Pre-emergence application of pretilachor at 1.0 kg $ha^{-1}$ on 3 DAT + weeding with Twin row rotary weeder at 40 DAT
- PE Pyrazosulfuron ethyl @ 20 g $ha^{-1}$ on 3 DAT + hand weeding (HW) on 45 DAT.
- PE butachlor 0.75 kg $ha^{-1}$ + bensulfuron methyl 50 g $ha^{-1}$ on 3 DAT + HW on 45 DAT
- PE Oxadiazon 87.5 g $ha^{-1}$ followed by Post emergence (POE) 2,4-D 1 kg $ha^{-1}$ along with hand weeding on 35 DAT.
- PE butachlor 0.75 kg per hectare + bensulfuron methyl 50 g $ha^{-1}$ on 3 DAT followed by mechanical weeding on 45 DAT is effective for broad spectrum weed control.
- Crop growth and yield were enhanced by butachlor 1.2 + 2,4-DEE 1.5 lit $ha^{-1}$ with 100% inorganic nitrogen.
- Conventional tillage of one dry ploughing and two passes of cage wheel puddling combined with pre-emergence application of butachlor at 1.25 kg $ha^{-1}$ under lowland situation.
- Stale bed preparation by pre-puddling minimum tillage with glyphosate combine with post- plant pre emergence butachlor 1.25 kg $ha^{-1}$ resulted in increased rice grain yield, net income and B: C ratio in rice-rice cropping.
- If pre-emergence herbicide application is not done, hand weeding has to be done on 15th DAT.
- 2,4-D sodium salt (Fernoxone 80% WP) 1.25 kg/ha dissolved in 625 litres with a high volume sprayer, three weeks after transplanting or when the weeds are in 3 - 4 leaf stage.
- Early post emergence application of Bispyripac sodium 40 g $ha^{-1}$ (2-3 leaf stage of weeds) + Hand weeding on 45 DAT
- Pre emergence application of Pretilachlor @ 750 g/ha at 3 DAT followed by post emergence application of Chlorimuron methyl + Metsulfuron methyl @ 4 g/ha on 25 DAT had higher weed contol efficiency and net return.
- Pre emergence application of Butachlor @ 1.0 kg ai/ha on 3 DAT + Finger type single row or double row rotary weeders weeding on 45 DAT. If pre emergence application is avoided, then finger type single row/double row rotary weeders weeding on 20 and 40 DAT.

### 1.2.5. Water management

- Puddling and leveling minimizes the water requirement
- Plough with tractor drawn cage wheel to reduce percolation losses and to save water requirement up to 20%.
- Maintain 2.5cm of water over the puddle and allow the green manure to decompose for a minimum of 7 days in the case of less fibrous plants like sunnhemp and 15 days for more fibrous green manure plants like Kolinchi (*Tephrosia purpurea*).
- At the time of transplanting, a shallow depth of 2cm of water is adequate since high depth of water will lead to deep planting resulting in reduction of tillering.

- Maintain 2 cm of water up to seven days of transplanting.
- After the establishment stage, cyclic submergence of water (as in table) is the best practice for rice crop. This cyclic 5cm submergence has to be continued throughout the crop period.

  Days after disappearance of ponded water at which irrigation is to be given

| Soil type | Summer | Winter |
|---|---|---|
| Loamy | 1 day | 3 days |
| Clay | Just before/immediately after disappearance | 1 - 2 days |

- Moisture stress due to inadequate water at rooting and tillering stage causes poor root growth leading to reduction in tillering, poor stand and low yield.
- Critical stages of water requirement in rice are a) panicle initiation, b) booting, c) heading and

  d) flowering. During these stages, the irrigation interval should not exceed the stipulated time so as to cause the depletion of moisture below the saturation level.
- During booting and maturity stages continuous inundation of 5cm and above leads to advancement in root decay and leaf senescence, delay in heading and reduction in the number of filled grains per panicle and poor harvest index.
- Provide adequate drainage facilities to drain excess water or strictly follow irrigation schedule of one day after disappearance of ponded water. Last irrigation may be 15 days ahead of harvest.

**Precautions for irrigation**

- The field plot size can be 25 to 50 cents depending on the source of irrigation.
- Field to field irrigation should be avoided. Field should be irrigated individually from a channel.
- Small bund may be formed parallel to the main bund of the field at a distance of 30 to 45 cm within the field to avoid leakages of water through main bund crevices.
- To minimize percolation loss, the depth of stagnated water should be 5 cm or less.
- In water logged condition, form open drains, about 60 cm in depth and 45 cm width across the field.
- Care should be taken not to allow development of cracks.
- In canal command area, conjunctive use of surface and ground water may be resorted to for judicious use of water.

**Alternate Wetting and Drying Irrigation (AWDI)**

- Safe Alternate Wetting and Drying Irrigation (AWDI) is to monitor the depth of ponded water on the field using 'Field Water Tube' (FWT) which is made of 40 cm long plastic pipe with a diameter of 15 cm so that water table is easily visible.
- Tube is perforated with 0.5 cm diameter holes in the bottom and the top 15 cm portion is non-perforated.

- Above the perforated portion, markings are made for 5 cm so that irrigation at 5 cm depth could be done.
- One Field Water Tube is required for adopting the AWDI in an area of 1 acre. The FWT is installed in the field using mallet and it is inserted upto the perforated portion buried inside the soil. The soil inside the tube is to be removed.
- FWT to be installed near the field levies so that the water level inside the FWT could be monitored easily.
- Safe AWDI of 10 cm depletion in light soils and 15 cm depletion in heavy soils was found to improve the water use efficiency in rice.

**Non-Puddled machine Transplanted Rice (NPTR)**

- Traditional transplanted rice cultivation requires 1200-1400 mm of water of which puddling consumes 250 mm of water.
- In NPTR, puddling is replaced with dry ploughing (using cultivator and rotavator) followed by laser leveling and wetting.
- Soil is allowed to settle for 12-24 hrs before transplanting very light irrigation is given again to maintain a uniform depth of 1 cm standing water.
- Machine transplanting is adopted in the wetted soil.
- Alternate Wetting and Drying Irrigation method is followed for water management.
- Though there was a yield reduction, considerable water saving under NPTR from 120 to 245 mm.

1.3. **Insect management:** See Crop Protection Chapter

1.4. **Disease management:** See Crop Protection Chapter

**1.5. Harvesting**

- Taking the average duration of the crop as an indication, drain the water from the field 7 to 10 days before the expected harvest date as draining hastens maturity and improves harvesting conditions.
- When 80% of the panicles turn straw colour, the crop is ready for harvest. Even at this stage, the leaves of some of the varieties may remain green.
- Confirm maturity by selecting the most mature tiller and dehusk a few grains. If the rice is clear and firm, it is in hard dough stage.
- When most of the grains at the base of the panicle in the selected tiller are in a hard dough stage, the crop is ready for harvest. At this stage harvest the crop, thresh and winnow the grains.
- Dry the grains to 12% moisture level for storage. Grain yield in rice is estimated only at 14% moisture for any comparison.
- Maturity may be hastened by 3-4 days by spraying 20% NaCl a week before harvest to escape monsoon rains.

**1.6. Seedling throwing method of stand establishment**

- 20 days old seedlings of short duration rice varieties
- Requirement of seedlings will be approximately 20% more than the line planting or equal to random planting.
- The seedlings are thrown into the puddled leveled field by labour without using force.
- Suitable for all seasons except *Thaladi* or heavy rain season.
- 50% labour shaving as compared to line planting and 35% to random planting.

- Up to 7-10 days of seedling throwing care should be taken to maintain thin film of water (similar to wet seeded rice).
- Other cultural operations are same as in transplanted rice
- Grain yield will be equal to line planted crop and 10-12% higher than random planted crop.

## 1.7. Transplanted hybrid rice

| | |
|---|---|
| Seed rate | 20 kg per hectare |
| Nursery | Basal application of DAP at 2 kg/cent of nursery area. Sparse sowing of seeds at one kg/cent of nursery area will give robust seedlings with 1-2 tillers per seedling at the time of planting. If the soil is heavy, apply 4 kg gypsum/cent of nursery area, 10 days before pulling of seedlings. |
| Age of seedling | 20 to 25 days |
| Spacing (cm) | 20 x 10 (50 hills/$m^2$ ) or 25 x 10 (40 hills/$m^2$ ) according to soil fertility |
| Seedlings/ hill | One (along with tillers if already produced) |
| Fertilizer | 175:60:60 kg N, $P_2O_5$ and $K_2O$/ha |

**Other package of practices:** same as in transplanted rice varieties.

## 1.8. INTEGRATED CROP MANAGEMENT (ICM) - RICE (SRI - System of Rice Intensification)

### 1.8.1.Season

- Dry season with assured irrigation is more suitable.
- Difficulty in crop establishment may be seen in areas with heavy downpour (NE Monsoon periods of Tamil Nadu

### 1.8.2.Varieties

- Hybrids and varieties with heavy tillering feature

### 1.8.3.Nursery

#### 1.8.3.1.Seed rate

- 5-7 kg/ha for single seedling per hill
- 12 -15 kg/ha for two seedlings per hill wherever difficulty in establishment of rice is seen

#### 1.8.3.2. Mat nursery preparation

- *<u>Preparation of nursery area</u>:* Prepare 100 $m^2$ nursery to plant 1 ha. Select a level area near the water source. Spread a plastic sheet or used polythene gunny bags on the shallow raised bed to prevent roots growing deep into soil.
- *<u>Preparation of soil mixture</u>:* Four (4) $m^3$ of soil mix is needed for each 100 $m^2$ of nursery. Mix 70% soil + 20% well-decomposed pressmud / bio-gas slurry / FYM + 10% rice hull. Incorporate 1.5 kg of powdered DAP or 2 kg 17-17-17 NPK fertilizer in the soil mixture.

- *Filling in soil mixture:* Place a wooden frame of 0.5 m long, 1 m wide and 4 cm deep divided into 4 equal segments on the plastic sheet or banana leaves. Fill the frame almost to the top with the soil mixture.
- *Seed Treatment with biofertilizers* : Five packets (1 kg/ha) of *Azospirillum* and five packets (1 kg/ha) of Phosphobacteria or five packets (1 kg/ha) of Azophos. Biofertilizers are mixed with water used for soaking and kept for 4 hrs. The bacterial suspension after draining may be sprinkled in the nursery before sowing the treated seeds
- *Pre-germinating the seeds 2 days before sowing:* Soak the seeds for 24 hr, drain and incubate the soaked seeds for 24 hr, sow when the seeds sprout and radicle (seed root) grows to 2-3 mm long.
- *Soil application of biofertilizers :* Application of *Azospirillum* @ 2 kg and Arbuscular mycorrhizal fungi @ 5 kg for 100 $m^2$ nursery area
- *Sowing:* Sow the pre-germinated seeds weighing 90 -100 g / $m^{-2}$ (100g dry seed may weigh 130g after sprouting) uniformly and cover them with dry soil to a thickness of 5mm. Sprinkle water immediately using rose can to soak the bed and remove the wooden frame and continue the process until the required area is completed.
- *Watering:* Water the nursery with rose can as and when needed (twice or thrice a day) to keep the soil moist. Protect the nursery from heavy rains for the first 5 DAS. At 6 DAS, maintain thin film of water all around the seedling mats. Drain the water 2 days before removing the seedling mats for transplanting.
- *Spraying fertilizer solution* (optional): If seedling growth is slow, sprinkle 0.5% urea + 0.5% zinc sulphate solution at 8-10 DAS.
- *Lifting seedling mats:* Seedlings reach sufficient height for planting at 15 days. Lift the seedling mats and transport them to main field.
- For elite seedling production under modified mat nursery : seed fortification with 1.0% KCl mixed with native soil and powdered DAP @ 2.0 kg per cent along with *Pseudomonas* 240 g/ cent followed by drenching with 0.5 % urea solution on 9 DAS

#### 1.8.4. Main field preparation

- Puddled lowland prepared as described in transplanted section
- Perfect leveling is a pre-requisite for the water management proposed hereunder

#### 1.8.5. Transplanting

- 1-2 seedlings of 14-15 days old
- Square planting of 25 x 25 cm (10 x 10 inch)
- Fill up the gaps between $7^{th}$ and $10^{th}$ DAT.
- Transplant within 30 minutes of pulling out of seedlings.
- There may be difficulty in crop establishment in areas with heavy downpour (North East Monsoon periods of Tamil Nadu)

#### 1.8.6. Irrigation management

- Irrigation to be done so as to moist the soil during early period upto 10 days
- Restoring irrigation to a maximum depth of 2.5 cm after development of hairline

cracks in the soil until panicle initiation (PI)

- Increasing irrigation depth to 5.0 cm after PI one day after disappearance of ponded water till completion of flowering stage.
- Placing of water pipe as safe alternate wetting and drying irrigation (AWDI) reduces the total number of irrigation given to rice crop (Perforated water pipe is placed 10 – 15 cm below the soil surface and the water lever moderation observed for time of irrigation)

#### 1.8.7. Weed management

- Using rotary weeder / Cono weeder / power operated two row weeder
- Moving the weeder with forward and backward motion to burry the weeds and as well as to aerate the soil at 7-10 days interval from 10-15 days after planting on either direction of the row and column.
- Manual weeding is also essential to remove the weeds closer to rice root zone.

#### 1.8.8. Nutrient management

- As per transplanted rice.
- Use of LCC has more advantage in N management.
- Green manure and farm yard manure application will enhance the growth and yield of rice in this system approach.
- Under sodic soils, during rotary weeding, apply Azophosmet @ 2.2 kg/ha and PPFM as foliar spray @ 500 ml/ha

#### 1.8.9. Other package of practices as recommended to transplanted rice

- STCR based fertilizer recommendation for transplanted rice (for some selected districts) is given in the **Appendix I.**

## 2. WET SEEDED PUDDLED LOWLAND RICE

**WET SEEDED RICE**

### 2.1 Area

- Direct wet seeding can be followed in all the areas wherein transplanting is in vogue.

### 2.2. Season

- As that of translated rice

### 2.3.Field preparation

- On receipt of showers during the months of May - July repeated ploughing should be carried out so as to conserve the moisture, destroy the weeds and break the clods.
- After inundation puddling is to be done as per transplanting. More care should be taken to level the field to zero level.
- Stagnation of water in patches during germination and early establishment of the crop leads to uneven crop stand.
- Land leveling has say over efficient weed and water management practices.
- Provision of shallow trenches (15 cm width) at an interval of 3m all along the field will facilitate the draining of excess water at the early growth stage.

### 2.4. Varieties

All the varieties recommended for transplanting can do well under direct wet seeded conditions also. However, the following varieties are more suited.

| Varieties | Duration (days) | Time of sowing |
|---|---|---|
| Ponmani | 160 to 165 | 1st to 30th August for *Samba* |
| CO 43, IR20, ADT 38 ADT 39, Ponni, Improved White Ponni | 125 to135 | 1st to 30th September for *Thaladi* |
| ADT 36, ADT 37 | 105 to 110 | 1st to 10th June for *Kuruvai*<br>1st to 10th October for late *Thaladi* |

### 2.5. Sowing

- Follow a seed rate of 60 kg / ha
- Pre-germinate the seeds as for wet nursery
- Seed treatments as adopted for transplanted rice
- Sow the seeds by **drum seeder** or broadcast uniformly with thin film of water.
- Dual cropping of rice-green manure is economic for nutrient budget and efficient for grain production. For this method use 'TNAU Rice-Green manure seeder'.

**TNAU Rice cum Green manure seeder**

- Manually drawn seeder developed at TNAU to sow pre-germinated paddy and green manure daincha crop (*Sesbania aculeata*) in alternate rows in puddled soil.
- On attaining a height of 40 cm after about one month of sowing the daincha crop was trampled by using long handled IRRI design cono weeder.
- Seeder sows four paddy rows and four daincha rows in a single pass.
- Using one (male) operator and two women labourers half of ha can be sown with the seeder in a day of 8 hours.
- Paddy was sown at 60 kg/ha seed rate and green manure crop at 20 kg/ha seed rate. The distance between the adjacent rows is 12.5 cm. When compared to sole wet seeded rice, weeds are better controlled in the wet seeded rice inter-cropped with green manure.
- Also intercropping of rice with green manure dhaincha and incorporation at 7.0 t/ha enhanced the growth and yield of rice and beneficial in terms of N addition (40 kg N /ha).
- There is greater possibility of intercropping green manures during early stage of rice crop with increased grain yield by one tones / ha.

### 2.6. After cultivation

- Thinning and gap filling should be done 14 - 21 days after sowing, taking advantage of the immediate rain.
- If dual cropped with green manure, incorporate the green manure when grown to 40 cm height or at 30 days after sowing, whichever is earlier, using Cono-weeder.
- Green manure incorporated fields may be operated again with rotary weeder a week later in order to aerate the soil and to exploit organic acids formed if any.

### 2.7. Manures and fertilizer application

- For direct wet seeded lowland rice, the recommendation is same at that of transplanted rice.
- Apply N and K as 25% each at 21 DAS, at active tillering, PI and heading stages.
- If N applied through LCC, use the critical value 4 for line sown drill seeded rice.
- Entire P as basal applied in the last plough or at the time of incorporation of green manure/ compost.
- Biofertilizers as recommended to transplanted rice may be followed wherever feasible and moisture available.
- Micro nutrient, foliar application and biofertlizers as recommended to transplanted rice.

### 2.8. Weed management

- In wet seeded rice, pre-emergence application of Pretilachlor 0.75 kg/ha on 8 DAS on 3-4 DAS followed by one hand weeding on 40 DAS in direct drum seeded rice
- In wet seeded rice, sowing with drum seeder and cono weeding (manual / power weeder) is done at 10, 20 and 30 DAS
- In wet seeded rice, hand weeding twice on 15 - 20 DAT and 45 DAT will control the weeds effectively (or) Pendimethalin 1.0 lit/ha at 8 DAT with optimum moisture condition and one hand weeding on 45 DAT.
- In rice -rice -fallow system intercropping of *Sesbania rostrata* control the weeds of rice field along with incorporation of *Sesbania rostrata* in to the field and one hand weeding on 35 DAS.
- Apply PE Pretilachlor 0.45 kg ha$^{-1}$ on 3 DAS + Roto cylindrical weeder + weeding on 45 DAS in wet seeded rice have good control of weeds like *Echinochloa crusgalli, Panicum repens, Eclipta alba* and *Monochoria vaginalis.*
- Pre-emergence application of Pendimethalin 1.0 kg/ha at 3 DAS followed by post emergence application of bispyribac sodium 25 g/ha at 25 DAS along with one hand weeding 45 DAS effectively reduced weed density in wet seeded rice.
- Pre emergence application of pyrazosulfuron ethyl at 20 g a.i /ha on 3 DAS followed by cono weeding on 25 DAS had higher weed control efficiency in drum seeded rice.
- Combination of drum seeded rice intercropped with green manure (dhaincha) along with pre-emergence herbicide application of Pretilachlor (30.7 EC) @ 0.45 kg ha$^{-1}$ + safener on 5 DAS is the best weed control method in drum seeded rice.

### 2.9. Water management

- During first one week irrigate the soil with thin film of water.
- Depth of irrigation may be increased to 2.5 cm progressively as per the crop age.
- Follow schedule as given in transplanted rice.

**2.10. Insect management:** See Crop Protection Chapter

**2.11. Disease management:** See Crop Protection Chapter

### Other package of practices

- As recommended in transplanted rice

# 3. DRY SEEDED RAINFED UN-PUDDLED LOWLAND RICE

**RAINFED RICE**

The crop establishment, growth and maturity depend up on the rainfall received. There will be standing water after crop establishment for a minimum period of few days to a maximum up to grain filling, depending up on the rainfall. This type of cultivation in Tamil Nadu is called as **'rainfed rice'**, with the assumption that the soil moisture will be under unsaturated (dry) condition during establishment or entire growth period, with reference to tropical climate.

**3.1. Area**

- Coastal districts of Tamil Nadu like Kanchipuram, Tiruvallur, Pudukottai, Ramanathapuram, Virudhunagar, Sivagangai and Kanyakumari.

**3.2. Season**

- June – July – (Coastal northern districts)
- September – October (Coastal southern districts)

**3.3. Field preparation**

- Dry plough to get fine tilth taking advantage of rains and soil moisture availability.
- Apply gypsum at 1 t/ha basally wherever soil crusting and soil hardening problem exist.
- Perfect land leveling for efficient weed and water management.
- Provide shallow trenches (15 cm width) at an interval of 3m all along the field to facilitate draining excess water at the early growth stage.

**3.4. Varieties**

- Short duration varieties as mentioned in season and varieties including local land races suitable for those tracts.

**3.5. Sowing**

- Seed rate: 75kg/ha dry seed for any recommended variety.
- Seed hardening with 1% KCl for 16 hours (seed and KCl solution 1:1) and shade dried to bring to storable moisture. This will enable the crop to withstand early moisture stress.
- On the day of sowing, treat the hardened seeds first with *Pseudomonas fluorescens* 10g/kg of seed and then with *Azophos* 1 kg or *Azospirillum and Phosphobacteria* @ 1 kg each per ha seed, whichever is available.
- Drill sow with 20 cm inter row spacing using seed drill.
- The seeds can also be sown behind the country plough
- Depth of sowing should be 3 - 5 cm and the top soil can be made compact with leveling board.
- Pre-monsoon sowing is advocated for uniform germination.

### 3.6. After cultivation

- 10 packets (2 kg/ha) each of *Azospirillum* inoculant and Phosphobacteria or 10 packets

  (2 kg/ha) of Azophos mixed with 25 kg of FYM may be broadcasted uniformly over the field just after the receipt soaking rain / moisture.
- Thinning and gap filling should be done 14 - 21days after sowing, taking advantage of the immediate rain
- Foliar spray of Cycocel 1000 ppm (1 ml of commercial product in one lit. of water) under water deficit situations to mitigate ill-effects.
- Foliar spray of Kaolin 3% or KCl 1% to overcome moisture stress at different physiological stages of rice.

### 3.7. Manures and fertilizer application

- Blanket recommendation : 50:25:25 kg $N:P_2O_5:K_2O$ /ha
- Apply a basal dose of 750 kg of FYM enriched with fertilizer phosphorus (P at 25 kg/ha)
- Apply N and K in two equal splits at 20 - 25 and 40 - 45 days after germination.
- If the moisture availability from the tillering phase is substantial, three splits (25 kg N and 12.5 kg K at 20-25, 40-45 and 60-65 DAG) can be adopted.
- N at PI may be enhanced to 40 kg, if the tiller production is high (may be when the estimated LAI is greater than 5.0) and moisture availability ensured by standing water for 10 days.
- Basal application of $FeSO_4$ at 50 kg/ha + 12.5 t FYM is desirable for iron deficient soil (or) apply TNAU Rainfed rice MN mixture @12.5 kg/ha as EFYM at 1:10 ratio incubated for 30 days at friable moisture.
- Need based foliar application of 0.5% $ZnSO_4$ and 1% $FeSO_4$ + 0.1% citric acid may be taken up at tillering and PI stages.
- Foliar spray of 1% urea + 2% MAP + 1% KCl at PI and 10 days after may be taken up for enhancing the rice yield if sufficient soil moisture is ensured
- Apply 25 kg $ZnSO_4$ if the soil is Zn deficient.

### 3.8. Weed management

- First weeding can be done between 15 and 21 days after germination.
- Second weeding may be done 30 - 45 days after first weeding.
- Apply pendimethalin 1.0 kg/ha on 5 days after sowing on the day of receipt of soaking rain followed by one hand weeding on 30 to 35 days after sowing.

**3.9. Insect management:** See Crop Protection Chapter

**3.10. Disease management:** See Crop Protection Chapter

### 3.11. Harvesting

Same as that for wet rice cultivation

## 4. DRY SEEDED RAINFED UN-PUDDLED LOWLAND RICE WITH SUPPLEMENTAL IRRIGATION

**Semi dry rice**

It is called as **semi-dry rice**. Crop establishment is as that of rainfed rice but the rain water collected in village tank (Kanmai) is supplemented to protect the crop during peak vegetative and reproductive phases. Interaction between applied nutrients and crop is positive here due to better moisture availability than rainfed rice and hence varieties may be improved ones and nutrient levels may be higher than the previous system.

### 4.1. Area

- Kanchipuram, Tiruvallur, Ramanathapuram,Sivaganga, Kanyakumari, Nagapattinam, Tiruvarur and Pudukottai.

### 4.2. Seasons

- July to August - Kanchipuram/Tiruvallur, Kanyakumari
- August - Nagapattinam/Tiruvarur, Pudukottai
- September to October - Ramanathapuram, Sivaganga

### 4.3. Field preparation

- Dry plough to get fine tilth taking advantage of rains and soil moisture availability.
- Apply gypsum at 1 t/ha basally wherever soil crusting and soil hardening problem exist.
- Perfect land leveling for efficient weed and water management.
- Provide shallow trenches (15 cm width) at an interval of 3m all along the field to facilitate draining excess water at the early growth stage.

### 4.4. Varieties

- Short duration varieties as mentioned in season and vanities including local land races suitable for those tracts.
- Since there is supplemental irrigation high yielding improved short duration varieties can yield more yield than the land races.

### 4.5. Sowing

- Seed rate: 75 kg/ha dry seed for any recommended variety.
- Seed hardening with 1% KCl for 16 hours (seed and KCl solution 1:1) and shade dried to bring to storable moisture. This will enable the crop to withstand early moisture stress.
- On the day of sowing, treat the hardened seeds first with *Pseudomonas fluorescens* 10g/kg of seed and then with *Azophos* 1 kg/ha or *Azospirillum and Phosphobacteria @ 1 kg/ha* each per ha seed, whichever is available.
- Drill sow with 20 cm inter row spacing using seed drill.
- The seeds can also be sown behind the country plough
- Depth of sowing should be 3 - 5 cm and the top soil can be made compact with leveling board.
- Pre-monsoon sowing is advocated for uniform germination.

- Sowing of seed by multi crop planter (Happy Seeder) under dry condition @ 40 kg/ha

**4.6. After cultivation**

- 10 packets (2kg/ha) each of *Azospirillum* inoculants and Phosphobacteria or 10 packets (2 kg/ha) of Azophos mixed with 25 kg of FYM may be broadcasted uniformly over the field just after the receipt soaking rain / moisture.
- Thinning and gap filling should be done 14-21days after sowing, taking advantage of the immediate rain
- Foliar spray of Cycocel 1000 ppm (1 ml of commercial product in one lit. of water) under water deficit situations to mitigate ill-effects.
- Foliar spray of Kaolin 3% or KCl 1% to overcome moisture stress at different physiological stages of rice. .

**4.7. Manures and fertilizer application**

- Blanket recommendation : 75:25:37.5 kg $N:P_2O_5:K_2O$ /ha
- Apply a basal dose of 750 kg of FYM enriched with fertilizer phosphorus (P at 25 kg/ha)
- Apply N & K in three splits at 20-25, 40-45 and 60-65 days after germination.
- Each split may follow 25kg N and 12.5 kg $K_2O$.
- If the moisture availability is substantial, the split at 40-45 DAS (panicle initiation) may be applied up to 40kg N and 12.5kg $K_2O$ to enhance the growth and the grain yield.
- Basal application of $ZnSO_4$ at 25kg/ha and $FeSO_4$ at 50 kg/ha + 12.5 t FYM is desirable wherever zinc and iron deficiency were noted (or) apply TNAU Rainfed rice MN mixture @12.5 kg/ha as EFYM at 1:10 ratio incubated for 30 days at friable moisture.
- Need based foliar application of 0.5% $ZnSO_4$ and 1% $FeSO_4$ + 0.1% citric acid at tillering and PI stages.
- Foliar spray of 1% urea + 2% MAP + 1% KCl at PI and 10 days after may be taken up for enhancing the rice yield if sufficient soil moisture is ensured

**4.8. Weed management**

- First weeding should be done between 15 and 21 days after germination.
- Second weeding may be done 30 - 45 days after first weeding.
- Apply Pendimethalin 1.0 kg/ha on 5 days after sowing followed by one hand weeding on 30 to 35 days after sowing.
- PE butachlor 1.0 kg $ha^{-1}$ followed by weeding using finger type single row and double row rotary weeders resulted in higher grain yield and net profit.
- Application of Pretilachlor@0.45 l/ha on 5 DAS and two machine weeding (Power weeder) on 30 and 45 DAS, if sowing is done by using Happy seeder.

**4.9. Water management**

- The crop to be irrigated from 30-35 days onwards, utilizing water impounded in the tanks.
- Irrigation to be given to a depth of 2.5 - 5.0 cm only. The schedule of irrigating

one day after disappearance of ponded water to be followed in order to save water and to bring additional area under rice cultivation.

**4.10. Insect management:** See Crop Protection Chapter
**4.11.Disease management:** See Crop Protection Chapter

**4.12.Harvest**

- It is same as that of transplanted rice.
- These areas are more suitable for combine-harvester

## 5. DRY SEEDED IRRIGATED UN-PUDDLED LOWLAND RICE

**Also be called 'semi-dry rice'**

It is a contingent plan to command areas, anticipating the release of water; rice crop can be established under rainfed condition up to a maximum of 45 days as that of previous two situations. Filed is converted to wet condition on receipt of canal water. Conversion depends up on receipt of canal water and nutrient management is decided according to the period of irrigation.

**5.1.Area**

- Tiruvarur and Nagapattinam districts

**5.2.Season**

- Samba / Thaladi seasons command areas.

**5.3. Field preparation**

- Dry plough to get fine tilth taking advantage of rains and soil moisture availability.
- Apply gypsum at 1 t/ha basally wherever soil crusting and soil hardening problem exist.
- Perfect land leveling for efficient weed and water management.
- Provide shallow trenches (15 cm width) at an interval of 3m all along the field to facilitate draining excess water at the early growth stage.

**5.4. Varieties**

- Medium duration varieties, if sown in August and short duration varieties beyond September, as mentioned in season and vanities.
- Since there is assured irrigation from canal, high yielding improved short or medium duration varieties can be cultivated depending up on the situation (month of sowing, nearness to canal, depth of standing water during NEM etc).

**5.5. Sowing**

- Seed rate: 75kg/ha dry seed for any recommended variety.
- Seed hardening with 1% KCl for 16 hours (seed and KCl solution 1:1) and shade dried to bring to storable moisture. This will enable the crop to withstand early

moisture stress.

- On the day of sowing, treat the hardened seeds first with *Pseudomonas fluorescens* 10g/kg of seed and then with *Azophos* 1 kg/ha or *Azospirillum and Phosphobacteria* @ 1 kg/ha each per ha seed, whichever is available.
- Drill sow with 20 cm inter row spacing using seed drill.
- The seeds can also be sown behind the country plough
- Depth of sowing should be 3 - 5 cm and the top soil can be made compact with leveling board.
- Pre-monsoon sowing is advocated for uniform germination.
- Pre-monsoon sowing with medium duration variety is an advantage for higher grain yield and as well to manage the heavy rainy season.

**5.6. After cultivation**

- 10 packets (2 kg/ha ) each of *Azospirillum* inoculant and Phosphobacteria or 10 packets (2 kg/ha) of Azophos mixed with 25 kg of FYM may be broadcasted uniformly over the field just after the receipt soaking rain / moisture.
- Thinning and gap filling should be done 14 - 21 days after sowing, taking advantage of the immediate rain.

**5.7. Manures and fertilizer application**

- Apply FYM/compost at 12.5 t/ha or 750 kg of FYM enriched with 50 kg $P_2O_5$ as basal dose in clay soils of Nagapattinam / Tiruvarur district.
- Blanket recommendation : 75:50:37.5 kg N:$P_2O_5$:$K_2O$ /ha
- N and K in three splits at around 20-25, 40-45 and 60-65 days for short duration varieties or four splits for medium duration varieties at around 20-25, 40-45, 60-65 and 80-85 days after germination is suitable.
- Each split may follow 25kg N and 12.5 kg $K_2O$.
- If the moisture availability is substantial and canal water received from tillering phases itself, the split at panicle initiation (40-45 DAS in short duration and 60-65 DAS in medium duration) may be applied up to 40kg N and 12.5kg $K_2O$ to enhance the growth and the grain yield.
- To induce tolerance under short and prolonged drought situation in Kuruvai season, apart from seed treatment, foliar spray with 1% KCl + CCC at 500ppm during vegetative stage is effective in mitigating the drought and in increasing the yield.
- Basal application of $ZnSO_4$ at 25 kg/ha and $FeSO_4$ at 50 kg/ha + 12.5t FYM is desirable wherever zinc and iron deficiency were noted (or) apply TNAU Rainfed rice MN mixture @12.5 kg/ha as EFYM at 1:10 ratio incubated for 30 days at friable moisture.
- Need based foliar application of 0.5% $ZnSO_4$ and 1% $FeSO_4$ + 0.1% citiric acid at tillering and PI stages
- Foliar spray of 1% urea + 2% MAP + 1% KCl at PI and 10 days later may be taken up for enhancing the rice yield if sufficient soil moisture is ensured

**5.8. Weed management**

- First weeding should be done between 15 and 21 days after germination.
- Second weeding may be done 30 - 45 days after first weeding.
- Apply pendimethalin 1.0 kg/ha on 5 days after sowing followed by one hand weeding on 30 to 35 days after sowing.
- Application of Pretilachlor@0.45 l/ha on 5 DAS and two machine weeding (Power weeder) on 30 and 45 DAS, if sowing is done by using Happy seeder.

**5.9. Other special cultural practices**

- Foliar spray of Cycocel 1000 ppm (1 ml of commercial product in one lit. of water) under water deficit situations to mitigate ill-effects.
- Foliar spray of Kaolin 3% or KCl 1% to overcome moisture stress at different physiological stages of rice.
- For delayed water release in LBP area, irrigating rice to 5cm depth three days after disappearance of pounded water and growing ADT 38 rice can be resorted to if the release of water is delayed up to September.
- First top dressing should be applied immediately after the receipt of sufficient rain or canal water.
- Hand weeding, thinning and gap filling should be done before N-fertilizer application.
- Subsequent top dressings in two or three splits should be done before heading.

**5.10. Water management**

- As that of irrigated rice when canal water is used for irrigation
- Possibility of subsequent conversion to deep water situation as seen in this tract, specfic variety should be chosen.

**5.11. Insect management:** See Crop Protection Chapter

5.12. **Disease management:** See Crop Protection Chapter

**5.13. Harvest**

5.13.1. As that of transplanted rice. This area is more suitable to combine harvester.

**5.14. DEEP WATER RICE**

5.14.1. Cultivation is like the methods described in this section except the harvest. Harvest may some times restricted only to panicle because of the standing water even after maturity.

**DRY SEEDED UPLAND RICE**

**Establishment**

5.14.2. As that of section 3 to 5.

**Area**

5.14.3. There are small batches in and around Dharmapuri district. Rainfall availability in these tract is better than the rainfed rice cultivated in other parts of Tamil Nadu. There is no bund to stagnate the water. Moisture availability is there but crop growth depends on the nutrient status.

**Other Cultural practices**

5.14.4. As recommended to semi-dry rice (sec. 4)

5.14.5. Nutrient may be split applied depending upon the growth.

5.14.6. LCC based N application is more suitable for this tract.

5.14.7. Use of PPFM-Pink Pigmented Facultative Microbes (seed treatment @ 0.2 kg / 5 kg seeds, soil application basal @ 2.0 kg/ha and foliar spray@ 500 ml/ha at PI & flag leaf stages)for mitigation of terminal drought is recommended.

**Intercropping**

5.14.8. Blackgram for every four rows of rice.

**Grain Yield**

5.14.9. Grain yield depends up on the moisture availability and nutrient status.

**AEROBIC RICE**

5.14.10. Suitable variety PMK (R) 3

5.14.11. Optimum plant population : 50 hills per $m^2$ (20 x 10 cm)

5.14.12. Green manure intercrop in aerobic rice : Daincha intercropping and incorporation at 25 DAS

5.14.13. Ridges and furrows

5.14.14. Weed management : Pre emergence application of pendimethalin at 0.75 kg/ha followed by two hand weeding or mechanical weeding on 25 and 45 DAS

5.14.15. PE pendimethalin 1.0 kg $ha^{-1}$ along with single tyne sweep weeding on 45 DAS which was comparable with PE along with hand weeding.

5.14.16. Fertilizer dose : 150 : 50 : 50 kg NPK/ha.

5.14.17. N in four splits : 20 % at 15 DAS, 30 % at tillering and PI and 20% at flowering or Nitrogen management at LCC value of 4

5.14.18. Basal application of $ZnSO_4$ at 25 kg/ha and $FeSO_4$ + 12.5t FYM at 50 kg/ha is desirable wherever zinc and iron deficiency were noted (or) apply TNAU Rainfed rice MN mixture @12.5 kg/ha as EFYM at 1:10 ratio incubated for 30 days at friable moisture.

5.14.19. Need based foliar application of 0.5% $ZnSO_4$ and 1% $FeSO_4$ + 0.1% citric acid may be taken up at tillering and PI stages

5.14.20. Irrigation : IW/CPE ratio of 1.0 with 3 cm depth of water – total water requirement of 650 mm.

5.14.21. **Surface drip fertigation:** Under aerobic rice conditions, schedule surface drip irrigation (with the lateral distance of 80 cm) at 125 % Open Pan Evaporation (PE) for clay soil / 150 % PE for sandy soil along with fertigation of 500 ml / ha of *Azophosmet* (composite biofertilizer) as seed treatment (@ 200 g / 10 kg seeds) and fertigation through drip system @ 500 ml / ha to be given during panicle initiation and flag leaf stages

5.14.22. **Sub-surface drip biogation:** Under aerobic rice conditions, schedule sub-surface drip fertigation (laterals concealed at 10 cm soil depth at a distance of 80 cm) scheduled at 125 % Open Pan Evaporation (PE) for clay soil / 150 % PE for sandy soil along with fertigation of *Azophosmet* as seed treatment @ 200 g 10 kg / seeds and fertigation @ 500 ml / ha and along with biogation of seaweed extract @ 500 ml / ha to be given during panicle initiation and flag leaf stages

**POST HARVEST TECHNOLOGY OF RICE PROCESSING OF RICE**

**Parboiling**

5.14.23. Parboiling is a hydrothermal treatment followed by drying before milling for the production of milled parboiled grain. Parboiling of paddy has been known in the orient for centuries. Nearly 50 per cent of the paddy produced in India at present is parboiled.

5.14.24. In general, the three major steps in parboiling, i.e. soaking, steaming and drying and have a great influence on the final characteristics and quality of parboiled rice.

5.14.25. Parboiling is the latest premilling treatment which improves the quality of rice. The traditional parboiling process in India is carried out in different ways.

- Paddy
- Cleaning
- Soaking in water (8 h)
- Draining
- Steaming (20 minutes)
- Aerating (3h) and heaping (3h)
- Tempering (1h)
- Sun drying (2-4 h)
- Dried paddy (14% moisture)

**Improved parboiling method of CFTRI, Mysore, India (Batch)**

- Paddy
- Cleaning
- Soaking in hot water for 3 h ($70^{0}$ C)
- Draining the water
- Steaming
- Shade drying (2-4 h)
- Dried paddy (15 % moisture)

**MILLING OF PADDY**

- Milling of dried paddy (raw and parboiled) Destoner (remove dust, dirt, chaff and stones)
- Sheller

 Husk Brown rice and unshelled paddy (aspirated through fan box)
 Huller (primary polishing)
 Bran Polished rice
 Cone polishing
 Bran Head rice
 Packaging

**PROCESSED PRODUCTS**

**Parched rice ***

It is prepared by throwing rice in sand heated to a high temperature in an iron or mud pan. On stirring, rice begins to crackle and swell. Then the content of the pan are removed and sieved to separate the parched rice from sand. Parboiled rice is used for making grayish to brilliant white colour parched rice and sold either salted or unsalted. It is eaten as such or mixed with butter milk or milk.

**Expanded cereals Expanded rice (Pori) ***

5.14.26. Expanded rice (murmura, pori, muri) is a traditional convenience food widely consumed in India either as such or with Jaggery, roasted Bengal gram and shredded vegetables and spices. The product is mostly produced in home or cottage sector by skilled artisans.

5.14.27. In the traditional process, the paddy is soaked in water preferably over night until saturation, drained and then either steamed or dry roasted in sand for parboiling. The parboiled paddy is milled, salted and again roasted in sand for expansion.

**Flow chart**

Paddy
↓
Soaking in water (30% m.c)
↓
Parboiled rice (14% m.c)
↓
Milling (15% m.c)
↓
Dry heat parboiled rice in pans (110$^{o}$C)
↓
Salting (Sodium chloride 10g/100ml water per kg of rice)
↓
Roasting in hot sand (250$^{o}$C)
↓
Expanded rice (0.5% m.c)

**Puffing / Popping * Puffed rice : (using rice)**

This popular ready-to-eat snack product is obtained by puffing milled parboiled rice. In the traditional process rice is gently heated on the furnace without sand to reduce the moisture content slightly. It is then mixed with salt solution and again roasted on furnace in small batches with sand on a strong fire for a few seconds to produce the expanded rice. Rice expands about 8 times retaining the grain shape and is highly porous and crisp.

**Parched paddy or puffed rice: (using paddy)**

Sun dried paddy is filled in mud jars and is moistened with hot water. After 2-3 min. the water is decanted and the jars are kept in an inverted position for 8-10 hours. Next the paddy is exposed to the sun for a short time and then parched in hot sand as in the preparation of parched rice. Puffed rice is prepared by throwing pretreated paddy into sand heated to a high temperature in an iron pan. During parching the grain swell and burst into a soft white product. The parched grains are sieved to remove sand and winnowed to separate the husk.

**Puffed rice from parboiled rice**

The rice is soaked in salt water to increase the moisture to about 20%. The moist rice is introduced into a hot vessel at about 250-275$^{o}$C for 30-40 seconds. The rice puffs suddenly.

**Popped rice**

This is yet another traditional value added product prepared from raw paddy. The paddy at a moisture content of 12-14% is directly roasted in iron pans using sand as a medium at a temperature of 150-200$^{o}$C. The production of popped rice is comparatively less and the product is mainly used in religious functions and ceremonies.

**Flaking ***

**Flaked rice** is another important value added product prepared from paddy. Traditionally, it is prepared from soaked paddy, after heat treatment and immediate flattening using a flaking machine (an edge runner)

Paddy
↓
Soaking (12-18 hours)
↓
Roasting (200 – 250$^{0}$C for 20-30 sec)
↓
Tempering (5 min)
↓
Flaking (using an edge runner) Flaking machine
↓
Flaked rice

**Flaked rice** is made from parboiled rice. Paddy is soaked in water for 2 -3 days to soften the kernel followed by boiling water for a few minutes and the water is drained off. The paddy is heated in a shallow earthen vessel or sand in iron pan till the husks break open. It is pounded by a wooden pestle which flattens the kernel and removes the husk. The husk is separated by winnowing. Flaked rice is thin and papery and of white colour.

**Quick cooking rice** is made by steeping polished rice in water to a moisture content of 35 per cent, cooking under pressure and drying. Alternatively the rice may be subjected to freezing, thawing and dehydration.

**Derived products**

Polished rice may be precooked and canned as rice pudding and also used to make dry breakfast cereals.

## RICE AND RICE PRODUCTS

Modernization of rice milling Industry also results in production of quality by-products viz., broken rice, husk and rice bran. Technology is now available for the production of value-added products from these by-products.

**Byproducts of Rice Broken rice**

The broken rice is widely used in the food preparations and in the industries for making flour and in the manufacture of baby foods. The starch extracted from broken rice finds wider application in the pharmaceutical, textile and other industries.

**Rice husk**

Rice husk that contains about 38% cellulose and 32% lignin and is one of the most abundant renewable agriculture based fuel materials. The production of rice husk is about 80 million tonnes per year, equivalent in energy to about 170 million barrels of oil. Paddy husk contains about 22 per cent ash of which 95 per cent is silica. Because of its high silica content, it is used as an abrasive. Large quantities of husk are used in India as fuel for boilers, kilns and household purposes.

**Rice bran**

Commercially rice bran is the most valuable by-product, which is characterized by its high fat (15 to 20%) and protein content. It also contains vitamins, minerals and many other useful chemicals. It is a potential source of edible oil. Because of its nutritional value, it is being used as feed for poultry and livestock. More stable defatted bran containing higher percentage of protein, vitamins and minerals is an excellent ingredient for both food and feed. The bran is the most nutritious byproduct of rice milling and is used almost exclusively as a feedstuff. It is generally contaminated with husk, which lowers its nutritive value. Rice bran contains about 12 per cent protein and 15 per cent fat.

**Rice bran oil**

Bran oil is obtained by the extraction of rice bran with solvents. Bran oil is also obtained in the solvent extraction milling of rice. The oil contains a high percentage of unsaturated fatty acids, yet it is quite stable because of the presence of natural antioxidants. When refined, bleached and deodorized, it is used for salad dressing and as cooking oil. Bran after solvent extraction has a higher percentage of protein that the original material. With its low fat content it keeps well.

**Importance**

Rice bran oil is the oil extracted from the germ and inner husk of rice. Rice bran oil is rich in vitamin E, γ-oryzanol (an antioxidant that may help prevent heart attacks) and phytosterols (compounds believed to help lower cholesterol absorption) which may provide associated health benefits. It has a mild taste and is popular in Asian cuisine because of its suitability for high- temperature cooking methods such as deep-frying and stir-frying. Rice bran oil is mostly monounsaturated - a tablespoon contains 7 grams of monounsaturated

fat, three of saturated fat and five of polyunsaturated fat.
Rice bran oil also contains components of vitamin E that may benefit health. The unique components, such as oryzanol or tocotrienol, have been drawing people's attention. Numerous studies show rice bran oil reduces the harmful cholesterol (LDL) without reducing good cholesterol (HDL). In those studies, Oryzanol is reported as the key element responsible for that function. Tocotrienol, on the other hand, is highlighted as the most precious and powerful vitamin E existing in nature and is said to have an anti-cancer effect, too. As a Vitamin-E source, rice bran oil is rich not only in alpha Tocopherol but also has the highest amount of Tocotrienol in liquid form vegetable oils.

**Uses**

Rice bran oil is ideal oil for margarine and shortening. The flavor gives the good palatability and the desired prime form crystal provides smooth plasticity and spreading qualities. When processed to retain high levels of tocols, rice bran oil may be used as a natural antioxidant source for topically coating a wide range of products such as crackers, nuts, and similar snacks to extend shelf life.

**Rice polishing**

Rice polishing is also rich in nutrients. They are not recovered in sizeable quantity in India. They are mostly used as animal feed.

**Uses of defatted bran and bran**

Defatted bran can be successfully used as an ingredient in the bakery products such as bread, cake, biscuits etc. After finer grinding, it can be incorporated into maida flour up to 20 per cent for the preparation of bakery products.

## Appendix – I

**1. Cereals**

**Rice (1)**

Soil : River alluvium (Noyyal series) — $FN = 4.39\,T - 0.52\,SN - 0.80\,ON$

Season: Kharif — $FP_2O_5 = 2.22\,T - 3.63\,SP - 0.98\,OP$

Target : 7 t $ha^{-1}$ — $FK_2O = 2.44\,T - 0.39\,SK - 0.72\,OK$

| Initial soil test values (kg $ha^{-1}$) | | | NPK (kg $ha^{-1}$) + GM @ 6.25 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| SN | SP | SK | FN | $FP_2O_5$ | $FK_2O$ | FN | $FP_2O_5$ | $FK_2O$ |
| 200 | 18 | 300 | 150 | 67 | 25* | 148 | 65 | 25* |
| 220 | 20 | 350 | 140 | 60 | 25* | 138 | 58 | 25* |
| 240 | 22 | 400 | 130 | 53 | 25* | 128 | 51 | 25* |
| 260 | 24 | 450 | 119 | 45 | 25* | 117 | 43 | 25* |
| 280 | 26 | 500 | 109 | 38 | 25* | 107 | 36 | 25* |

* Maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

**Rice (2)**

Soil : River alluvium (Noyyal series)
Season: Rabi
Target : 7 t ha$^{-1}$

FN = 4.63 T – 0.56 SN – 0.90 ON
$FP_2O_5$ = 1.98 T – 3.18 SP – 0.99 OP
$FK_2O$ = 2.57 T – 0.42 SK – 0.67 OK

| Initial soil test values (kg ha$^{-1}$) | | | NPK (kg ha$^{-1}$) + GM @ 6.25 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 18 | 300 | 159 | 58 | 25* | 157 | 56 | 25* |
| 220 | 20 | 350 | 148 | 52 | 25* | 146 | 50 | 25* |
| 240 | 22 | 400 | 137 | 46 | 25* | 135 | 44 | 25* |
| 260 | 24 | 450 | 126 | 39 | 25* | 124 | 37 | 25* |
| 280 | 26 | 500 | 114 | 33 | 25* | 112 | 31 | 25* |

*Maintenance dose

**Rice - SRI (3)**

Soil : River alluvium (Noyyal series)
Season: Kharif
Target : 8 t ha$^{-1}$

FN = 4.33 T – 0.53 SN – 0.68 ON
$FP_2O_5$ = 2.08 T – 3.18 SP – 0.70 OP
$FK_2O$ = 2.78 T – 0.30 SK – 0.63 OK

| Initial soil test values (kg ha$^{-1}$) | | | NPK (kg ha$^{-1}$) + GM @ 6.25 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 18 | 300 | 187 | 75** | 75** | 183 | 75** | 75** |
| 220 | 20 | 350 | 177 | 75** | 75** | 173 | 71 | 75** |
| 240 | 22 | 400 | 166 | 73 | 69 | 162 | 64 | 68 |
| 260 | 24 | 450 | 156 | 67 | 54 | 152 | 58 | 53 |
| 280 | 26 | 500 | 145 | 61 | 39 | 141 | 52 | 38 |

** Maximum dose

**Rice - SRI (4)**

Soil : River alluvium (Noyyal series)
Season: Rabi
Target : 8 t ha$^{-1}$

FN = 4.20 T – 0.45 SN – 0.68 ON
$FP_2O_5$ = 2.05 T – 2.65 SP – 0.66 OP
$FK_2O$ = 2.85 T – 0.29 SK – 0.59 OK

| Initial soil test values (kg ha$^{-1}$) | | | NPK (kg ha$^{-1}$) + GM @ 6.25 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 18 | 300 | 193 | 75** | 75** | 191 | 75** | 75** |
| 220 | 20 | 350 | 184 | 75** | 75** | 182 | 75** | 75** |
| 240 | 22 | 400 | 175 | 75** | 75** | 173 | 76 | 75** |
| 260 | 24 | 450 | 166 | 75** | 65 | 164 | 70 | 66 |
| 280 | 26 | 500 | 157 | 72 | 50 | 155 | 65 | 51 |

** Maximum dose

**Rice - SRI – White Ponni (5)**

Soil : River alluvium (Noyyal series)
Season: Rabi
Target : 6 t ha$^{-1}$

FN = 3.43 T – 0.34 SN – 0.64 ON
$FP_2O_5$ = 1.83 T – 3.24 SP – 0.61 OP
$FK_2O$ = 1.98 T – 0.18 SK – 0.37 OK

| Initial soil test values (kg ha$^{-1}$) | | | NPK (kg ha$^{-1}$) + GM @ 6.25 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 18 | 300 | 85 | 25* | 32 | 86 | 25* | 35 |
| 220 | 20 | 350 | 78 | 25* | 25* | 79 | 25* | 26 |
| 240 | 22 | 400 | 71 | 25* | 25* | 72 | 25* | 25* |
| 260 | 24 | 450 | 64 | 25* | 25* | 65 | 25* | 25* |
| 280 | 26 | 500 | 58 | 25* | 25* | 59 | 25* | 25* |

* Maintenance dose

**Rice - SRI (6)**

Soil : River alluvium (Ambasamudram series)
Season: Rabi
Target : 7 t ha$^{-1}$

FN = 3.54T– 0.30 SN – 0.94 ON
$FP_2O_5$ = 1.37T– 0.41 SP – 0.80 OP
$FK_2O$ = 2.61T – 0.64 SK –0.61 OK

| Initial soil test values (kg ha$^{-1}$) | | | NPK (kg ha$^{-1}$) + GM @ 6.25 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP$^{a}$** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 20 | 150 | 135 | 65 | 54 | 135 | 60 | 57 |
| 225 | 30 | 175 | 127 | 61 | 38 | 127 | 56 | 41 |
| 250 | 40 | 200 | 120 | 57 | 25* | 120 | 52 | 25* |
| 275 | 50 | 225 | 112 | 52 | 25* | 112 | 47 | 25* |
| 300 | 60 | 250 | 105 | 48 | 25* | 105 | 43 | 25* |

* Maintenance dose; SP$^{a}$- Bray P

**Rice - SRI (7)**

Soil : Red non calcareous (Vannapatti series)
Season : Rabi
Target : 7 t ha$^{-1}$

FN = 3.49 T - 0.36 SN - 0.74 ON
$FP_2O_5$ = 1.66 T - 2.76 SP - 0.69 OP
$FK_2O$ = 2.19 T - 0.66 SK - 0.52 OK

| Initial soil test values (kg ha$^{-1}$) | | | NPK (kg ha$^{-1}$) + GM @ 6.25 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 12 | 100 | 119 | 60** | 54** | 115 | 51** | 57** |
| 220 | 14 | 120 | 112 | 55** | 41** | 108 | 46 | 44** |
| 240 | 16 | 140 | 105 | 49** | 28** | 101 | 40 | 31** |
| 260 | 18 | 160 | 98 | 44 | 25 | 94 | 35 | 25* |
| 280 | 20 | 180 | 91 | 38 | 25 | 87 | 29 | 25* |

** Maintenance dose

**Rice (8)**

Soil : Red sandy loam (Irugur series) — FN = 5.19 T - 0.89 SN - 0.98 ON

Season : Kharif — $FP_2O_5$ = 2.27 T - 4.50 SP - 1.09 OP

Target : 7 t $ha^{-1}$ — $FK_2O$ = 3.11 T - 0.59 SK - 1.02 OK

| Initial soil test values (kg $ha^{-1}$) | | | NPK (kg $ha^{-1}$) + GM @ 6.25 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| SN | SP | SK | FN | $FP_2O_5$ | $FK_2O$ | FN | $FP_2O_5$ | $FK_2O$ |
| 160 | 12 | 160 | 168 | 60** | 60** | 166 | 60** | 60** |
| 180 | 14 | 180 | 150 | 60** | 60** | 148 | 60** | 60** |
| 200 | 16 | 200 | 132 | 60** | 60** | 130 | 57 | 60** |
| 220 | 18 | 220 | 115 | 55 | 55 | 113 | 48 | 58 |
| 240 | 20 | 240 | 97 | 46 | 43 | 95 | 39 | 46 |

** Maximum dose

**Rice (9)**

Soil : Red -Sandy loam (Irugur series) — FN = 4.88 T - 0.68 SN - 0.72 ON

Season : Rabi — $FP_2O_5$ = 2.06 T - 2.91 SP - 2.27 OP

Target : 7 t $ha^{-1}$ — $FK_2O$ = 2.89 T - 0.47 SK - 0.59 OK

| Initial soil test values (kg $ha^{-1}$) | | | NPK (kg $ha^{-1}$) + GM @ 6.25 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| SN | SP | SK | FN | $FP_2O_5$ | $FK_2O$ | FN | $FP_2O_5$ | $FK_2O$ |
| 180 | 12 | 200 | 166 | 75** | 75 | 164 | 75** | 75** |
| 200 | 14 | 220 | 153 | 75** | 66 | 151 | 73 | 69 |
| 220 | 16 | 240 | 139 | 75** | 57 | 137 | 68 | 60 |
| 240 | 18 | 260 | 125 | 69 | 47 | 123 | 62 | 50 |
| 260 | 20 | 280 | 112 | 63 | 38 | 110 | 56 | 41 |

** Maximum dose

**Rice (10)**

Soil : Black alluvium (Adanur series) — FN = 2.80 T - 0.29 SN - 0.89 ON

Season: Rabi — $FP_2O_5$ = 1.35 T - 1.28 SP - 1.78 OP

Target : 8 t $ha^{-1}$ — $FK_2O$ = 2.50 T - 0.42 SK - 1.14 OK

| Initial soil test values (kg $ha^{-1}$) | | | NPK (kg $ha^{-1}$) + GM @ 6.25 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| SN | SP | SK | FN | $FP_2O_5$ | $FK_2O$ | FN | $FP_2O_5$ | $FK_2O$ |
| 180 | 16 | 240 | 119 | 65 | 66 | 117 | 58 | 69 |
| 200 | 18 | 260 | 113 | 62 | 58 | 111 | 55 | 61 |
| 220 | 20 | 280 | 107 | 59 | 49 | 105 | 52 | 52 |
| 240 | 22 | 300 | 101 | 57 | 41 | 99 | 50 | 44 |
| 260 | 24 | 320 | 96 | 54 | 33 | 94 | 47 | 36 |

**Rice (11)**

Soil : Black alluvium (Kalathur series)

Season: Kharif (Kuruvai)

Target : 7t $ha^{-1}$

FN = 5.29 T - 0.75 SN - 0.89 ON

$FP_2O_5$ = 1.65 T - 1.76 SP - 0.78 OP

$FK_2O$ = 2.73 T - 0.37 SK- 0.82 OK

| Initial soil test values (kg $ha^{-1}$) | | | NPK (kg $ha^{-1}$) + GM @ 6.25 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 18 | 260 | 167 | 61 | 62 | 165 | 54 | 65 |
| 220 | 20 | 280 | 152 | 57 | 55 | 150 | 50 | 58 |
| 240 | 22 | 300 | 137 | 54 | 47 | 135 | 47 | 50 |
| 260 | 24 | 320 | 122 | 50 | 40 | 120 | 43 | 43 |
| 280 | 26 | 340 | 107 | 47 | 32 | 105 | 40 | 35 |

**Rice(12)**

Soil : Black alluvium (Kalathur series)

Season: Rabi

Target : 7 t $ha^{-1}$

FN = 5.34 T - 0.67 SN - 0.73 ON

$FP_2O_5$ = 1.90 T - 1.86 SP - 0.70 OP

$FK_2O$ = 2.81 T - 0.33 SK - 0.80 OK

| Initial soil test values (kg $ha^{-1}$) | | | NPK (kg $ha^{-1}$) + GM @ 6.25 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 18 | 260 | 187 | 75** | 75** | 185 | 70 | 75** |
| 220 | 20 | 280 | 173 | 73 | 71 | 171 | 66 | 74 |
| 240 | 22 | 300 | 160 | 69 | 65 | 158 | 62 | 68 |
| 260 | 24 | 320 | 147 | 65 | 58 | 145 | 58 | 61 |
| 280 | 26 | 340 | 133 | 62 | 52 | 131 | 55 | 55 |

** Maximum dose

**Rice (13)**

Soil : River alluvium (Manakkarai series)

Season: Kharif (Kuruvai)

Target : 7 t $ha^{-1}$

FN = 4.25 T - 0.60 SN - 0.79 ON

$FP_2O_5$ = 2.71 T - 4.39 SP - 0.89 OP

$FK_2O$ = 3.83 T - 0.60 SK - 0.82 OK

| Initial soil test values (kg $ha^{-1}$) | | | NPK (kg $ha^{-1}$) + GM @ 6.25 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 180 | 14 | 240 | 137 | 75** | 75** | 135 | 75** | 75** |
| 200 | 16 | 260 | 125 | 75** | 75** | 123 | 75** | 75** |
| 220 | 18 | 280 | 113 | 75** | 67 | 111 | 75** | 70 |
| 240 | 20 | 300 | 101 | 75** | 55 | 99 | 72 | 58 |
| 260 | 22 | 320 | 89 | 70 | 43 | 87 | 63 | 46 |

** Maximum dose

**Rice (14)**

Soil : River alluvium (Manakkarai series)
Season: Rabi (Pishanam)
Target : 7 t ha$^{-1}$

FN = 4.47 T - 0.58 SN - 0.79 ON
$FP_2O_5$ = 2.66 T - 3.68 SP - 0.89 OP
$FK_2O$ = 4.08 T - 0.65 SK - 0.82 OK

| Initial soil test values (kg ha$^{-1}$) | | | NPK (kg ha$^{-1}$) + GM @ 6.25 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 180 | 14 | 240 | 156 | 75** | 75** | 154 | 75** | 75** |
| 200 | 16 | 260 | 144 | 75** | 75** | 142 | 75** | 75** |
| 220 | 18 | 280 | 132 | 75** | 71 | 130 | 75** | 74 |
| 240 | 20 | 300 | 121 | 75** | 58 | 119 | 75** | 61 |
| 260 | 22 | 320 | 109 | 75** | 45 | 107 | 75** | 48 |

** Maximum dose

**12 Points for SRI**

Use of quality certified / hybrid seed Seed rate 2 kg per acre
40 m$^2$ nursery for one acre Raised bed nursery / Tray nursery
14 days old seedling (3-4 leaf stage) Levelling with lazer leveller
Marker for square planting
Square planting with 25 cm x 25 cm Single seedling per hill
Alternate wetting and drying method of irrigation
Cono weeding four times from 10 DAT at an interval of 10-15 days Use of leaf colour chart (LCC) for N management

## CROP PROTECTION

### A) Pest management

**Nursery**

Seed treatment with Imidacloprid 48FS @ 2.5 g/kg seed.

An area of 800 sq.m. (20 cents) nursery is required for planting one ha of main field. Forty litres of spray fluid is required for spraying the nursery area.

| Pests | Management strategies |
|---|---|
| **Thrips**<br>*Stenchaetothrips biformis* | • Sampling: Wet your palm with water and pass over the foliage in 12 places at random in the nursery and count the number of thrips.<br>• ETYL: If thrips population exceeds 60 numbers in 12 passes or if rolling of half of leaf area of first and 2nd leaves in 10% of seedlings is noticed.<br>• Spray any one of the following insecticides:<br>Monocrotophos 36% SL 40 ml |

| | |
|---|---|
| | Thiamethoxam 25% WG 4 g |
| **Green leafhopper**<br>*Nephotettix nigropictus*<br>*N. cincticeps*<br>*N. virescens* | • Sampling: Take 25 net sweepings in the nursery area. If the population exceeds 60 for 25 sweepings or 20/$m^2$ by actual counting,<br>• Maintain 2.5 cm of water in the nursery and broadcast carbofuran 3% CG 3.5 kg in 20 cents |
| **Caseworm**<br>*Parapoynx stagnalis* | • Mix 250 ml of kerosene with sand and apply to the standing water<br>• Dislodge the cases by passing a rope and drain water<br>• Collect the cases and destroy<br>• Spray any one of the following insecticides:<br>Monocrotophos 36% SL 40 ml<br>Quinalphos 25% EC 80 ml |
| **Army worm**<br>*Spodoptera mauritia* | • Drain water from the nursery<br>• Spray chlorpyriphos 20% EC 80 ml during evening hours. |

**ii) Main field**

- Remove/destroy stubbles after harvest
- Keep the fields free from weeds
- Trim field bunds
- Provide effective drainage
- Avoid use of excessive 'N' fertilizers.
- Avoid close planting, especially in BPH and leaffolder prone areas/seasons
- Leave 30 cm space at every 2.5 m
- Use irrigation water judiciously
- Use light traps (1/ha) to monitor pest incidence
- Use pheromone traps (12/ha) to monitor stem borer and leaffolder incidence
- Remove and destroy egg masses of stem borer
- In BPH prone areas/seasons, avoid use of resurgence causing chemicals like synthetic pyrethroids and quinalphos
- Use suggested insecticides at recommended doses based on ETL
- Avoid repeated use of same insecticide
- Dose recommended are per ha, unless otherwise specified

**Economic threshold level (ETL) for important pests**

| Pest | ETL |
|---|---|
| Stem borer | 2 egg masses/$m^2$ or 10% dead hearts or 2% white ear |
| Leaffolder | 10% leaf damage at vegetative phase and 5% of flag leaf damage at flowering |

| | |
|---|---|
| Gall midge | 10% silver shoots |
| Whorl maggot | 25% damaged leaves |
| Thrips | 60 numbers in 12 passes or rolling of the first and second leaves in 10% of seedlings. |
| Brown planthopper | 1 hopper/ tiller in the absence of predatory spider and 2 hoppers / tiller when spider is present at 1/hill. |
| Green leafhopper | 60/25 net sweeps or 5/hill at vegetative stage or 10/hill at flowering or 2/hill in tungro endemic area |
| Earhead bug | 5 bugs/100 earheads at flowering and 16 bugs/100 ear heads from milky stage to grain maturity |

| Pests | Management strategies |
|---|---|
| **Stem borer**<br>*Scirpophaga incertulas* | • Release of the egg parasitoid, *Trichogramma japonicum* thrice (at weekly interval from 37 DAT) @ 1,00,000/ha each release (when moth activity is noticed)<br>• *Bacillus thuringiensis* var. *kurstaki* @ 1.50 kg/ha<br>• Spray any one of the following insecticides: (per ha)<br>Acephate 75 % SP 670-1000 g<br>Acephate 95 % SG 590 g<br>Azadirachtin 0.03% 1000 ml<br>Carbofuran 3% CG 25 kg<br>Carbosulfan 6% G 16.7 kg<br>Carbosulfan 25% EC 800-1000 ml<br>Cartap hydrochloride 50 % SP 1000 g<br>Chlorantraniliprole 18.5% SC 150 ml<br>Chlorantraniliprole 0.4% G 10 kg<br>Chlorpyriphos 20% EC 1250 ml<br>Fipronil 5% SC 1000-1500 g<br>Fipronil 80%WG 50- 62.5 kg<br>Flubendiamide 20% WG 125 g<br>Flubendiamide 39.35% M/M SC 50 g<br>Thiacloprid 21.7% SC 500 g<br>Thiamethoxam 25% WG 100 g |

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| **Leaffolder**<br>*Cnaphalocrocis medinalis* | • Release *Trichogramma chilonis* thrice (at weekly interval from 30 DAT) @ 1,00,000/ha each (when moth activity is noticed)<br>• Spray *Bacillus thuringiensis* var. *kurstaki* 1.50 kg/ha<br>• Apply *Beauveria bassiana* 1.15 WP 2.5 kg/ha<br>• Spray any one of the following insecticides per ha:<br>Acephate 75 % SP 666-1000 ml<br>Acephate 95 % SG 590 g<br>Azadirachtin 0.03% 1000 ml<br>Chlorpyriphos 20% EC 1250 ml<br>Carbosulfan 6% G 16.7 kg<br>Cartaphydrochloride 50 % SP 1000 g<br>Chlorantraniliprole 18.5% SC 150 g<br>Chlorantraniliprole 0.4% G 10 kg<br>Fipronil 80%WG 50-62.5 g<br>Flubendiamide 20% WG 125-250 g<br>Flubendiamide 39.35% M/M SC 50 g<br>Indoxacarb 15.8% EC 200 g<br>Thiamethoxam 25% WG 100 g |
| **Gall midge**<br>*Orseolia oryzae* | • Distribute *Platygaster oryzae* parasitised galls at 1 per 10 $m^2$ on 10 days after transplanting (DAT), when natural parasitisation is noticed in abundance.<br>• Spray any one of the following insecticides per ha:<br>Carbosulfan 25% EC 800-1000 ml<br>Chlorpyriphos 20% EC 1250 ml<br>Fipronil 5% SC 1000-1500 g<br>Fipronil 0.3% G 16.67 - 25 kg<br>Quinalphos 5% G 5 kg<br>Thiamethoxam 25% WG 100 g |
| **Whorl maggot**<br>*Hydrellia sasakii* | • Spray any one of the following insecticides per ha:<br>Cartap hydrochloride 4% G 18.75 – 25 kg<br>Chlorpyriphos 20% EC 1250 ml<br>Fipronil 5% SC 1000-1500 g<br>Fipronil 0.3% GR 16.67- 25 kg |
| **Case worm**<br>*Parapoynx stagnalis* | Spray phenthoate 50% EC 1000 ml |
| **Hispa/ spiny beetle**<br>*Dicladispa armigera* | • Spray any one of the following insecticides per ha:<br>Carbofuran 3% CG 25 kg<br>Chlorpyriphos 20% EC 1250 ml<br>Malathion 5% DP 25 kg |

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| | Malathion 50%EC 1150 ml |
| **Grasshopper** | Dust chlorpyriphos 1.5% DP 25 kg/ha |
| **Thrips**<br>*Stenchaetothrips biformis* | • Spray any one of the following insecticides per ha:<br>Azadirachtin 0.15% W/W 1.5 – 2.5 kg<br>Thiamethoxam 25% WG 100 g |
| **Brown planthopper**<br>*Nilaparvata lugens* | • Avoid excessive use of nitrogen<br>• Control irrigation by intermittent draining<br>• Set up light traps during night or yellow pan traps during day time<br>• Drain water before use of insecticides<br>• Direct spray towards the base of the plants.<br>• Spray any one of the following insecticides per ha:<br>Acephate 75 % SP 666-1000 g<br>Acephate 95 % SG 590 g<br>Acetamiprid 20% SP 50-100 g<br>Azadirachtin 0.03% 1000 ml<br>Neem oil 3% 15 lit<br>Buprofezin 25% SC 800 ml<br>Carbosulfan 25% EC 800-1000 ml<br>Clothianidin 50% WG 20-24 g<br>Chlorantraniliprole 18.5% SC 150 g<br>Chlorantraniliprole 0.4% G 10 kg<br>Chlorpyriphos 1.5% DP 25 kg<br>Chlorpyriphos 20% EC 1250 ml<br>Dinotefuran 20% SG 150-200g<br>Fenobucarb 50% EC 500-1500 ml<br>Fipronil 5% SC 1000-1500 ml<br>Fipronil 0.3% GR 16.67-25 kg<br>Imidacloprid 70% WG 30-35 kg<br>Imidacloprid 17.8 SL 100-125 ml<br>Pymetrozine 50% WG 300g |
| **White backed planthopper**<br>*Sogatella furcifera* | • Spray any one of the following insecticides per ha:<br>Phosphamidon 40% SL 1000 ml<br>Azadirachtin 0.03% 1000 ml<br>Buprofezin 25% SC 800 ml<br>Carbosulfan 25% EC 800-1000 ml<br>Chlorantraniliprole 18.5% SC 150 g<br>Chlorantraniliprole 0.4% G 10 kg |

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| | Fipronil 5% SC 1000-1500 ml<br>Fipronil 0.3% GR 16.67-25 kg<br>Imidacloprid 70% WG 30-35 kg<br>Imidacloprid 17.8% SL 100-125 ml |
| **Green leafhopper**<br>*Nephotettix nigropictus*<br>*N. cincticeps*<br>*N. virescens* | • Spray any one of the following insecticides twice, 15 and 30 days after transplanting per ha:<br>Phosphamidon 40% SL 1000 ml<br>Carbofuran 3% CG 25 kg<br>Buprofezin 25% SC 800 g<br>Carbosulfan 25% EC 800-1000 ml<br>Fipronil 5% SC 1000-1500 g<br>Fipronil 0.3% G 16.67-25 kg<br>Imidacloprid 17.8% SL 100 -125 ml<br>Thiamethoxam 25% WG 100 g<br>• The vegetation on the bunds should also be sprayed with the insecticides<br>• Set up light traps to attract and control the leafhoppers as well as to monitor the vector population.<br>• Destroy/ kill the leafhoppers attracted to light trap |
| **Mealybug**<br>*Brevennia rehi* | • Spray methyl demeton 25% EC 1000 ml/ha |
| **Blue leafhopper/ white leafhopper** | • Spray methyl demeton 25% EC 500-1000 ml/ha |
| **Black bug**<br>*Scotinophara lurida* | • Spray neem seed kernel extract 5% (25 kg kernel/ha) |
| **Earhead bug**<br>*Leptocorisa acuta and L. oratorius* | • Dust/ spray any one of the following, the first during flowering and second a week later (per ha):<br>Quinalphos 1.5% D 25 kg<br>Malathion 50% EC 500 ml<br>Neem seed kernel extract 5% (25 kg kernel/ha)<br>Notchi or *Ipomoea* or *Prosopis* leaf extract 10%<br>KKM 10% D 25 kg |
| **Termite**<br>*Anacanthotermus viarum* | • Apply chopped paddy straw treated with chlorpyriphos 1.5% DP 25 kg/ha |
| **Mite**<br>*Oligonychus oryzae* | Spray any one of the following insecticides per ha:<br>• Dicofol 18.5% EC 1250 ml<br>Azadirachtin 0.03% 1000 ml |

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| **Rat**<br>*Rattus rattus rufuscens, Rattus meltada* | • Poison bait at 1 part zinc phosphide with 49 parts popped corn/rice/dry fish or warfarin 0.5% 1 part with 19 parts of popped corn/rice/dry fish or bromodialone 0.25 w/w (1:49) at 0.005%. Mix one part of bromodialone + 49 parts of bait and keep inside the field.<br>• Mechanical collection and destruction<br>• Narrow bund maintenance (45 x 30 cms)<br>• Setting up of owl perches<br>• Setting up of Thanjavur bow trap @ 100/ha |

**IPM module**

- Seed treatment with Imidacloprid 48%FS @ 2.5 g/kg
- *Pseudomonas fluorescens* – Seed treatment (10 g/kg), seedling dip (2.5 kg/ha), main field application (2.5 kg/ha)
- Pest and disease management in nursery (preferably neem seed kernel extract 5% or Neem oil 2%)
- Integrated Nutrient Management
- Use of neem cake coated urea (5 : 1)
- Incorporation of green manures / biofertilizers
- 'N' management by Leaf Colour Chart (LCC)
- 'K' application – basal (50%) + one top dressing (50%)
- Adoption of cultural practices
- Variety selection
- Spacing based on season, variety and location (endemic / hot spot)
- Rogueing space (1' for every 8')
- Water management – alternate wetting and drying and submergence of recommended level during critical periods only
- Release of biocontrol agents (*Trichogramma japonicum* for stem borer and *Trichogramma chilonis* for leaffolder*)*, when the moth activity is noticed
- Set up bird (owl) perches at 40 to 50 /ha
- Application of botanicals especially Neem seed kernel extract 5% and Neem oil 2%
- ETL based insecticide / fungicide application (No synthetic pyrethroids)
- Integrated rodent management
  Narrow bund maintenance (45 x 30 cms)
  Zinc phosphide baiting (49: 1)
  Trapping with Thanjavur bow trap (100 nos./ha)
  Baiting with bromodialone

**Resurgence**

Repeated application of the following insecticides can cause resurgence of insect pests Avoid spraying of synthetic pyrethroids and the following insecticides

- BPH, *Nilaparvata lugens :* acephate, carbofuran, chlorpyriphos, deltamethrin, ethopenprox, fenthion, fenvalerate, methomyl, methylparathion, monocrotophos, permethrin, perthane, phosalone, quinalphos, thiometon, vamidothion
- GLH, *Nephotettix virescens :* deltamethrin, phorate
- WBPH, *Sogatella furcifera :* cypermethrin, deltamethrin, fenvalerate
- Leaf folder, *Cnaphalocrocis medinalis :* Carbofuran

## B. Disease Management

### I. Disease management in nursery

| | |
|---|---|
| **Dry seed treatment** | • Treat the seeds with thiram or captan or carboxin or carbendazim @ 2 g/kg of seeds<br>• Treat the seeds at least 24 hours prior to soaking for sprouting<br>• The treated seeds can be stored for 30 days without any loss in viability |
| **Wet seed treatment** | • Treat the seeds with carbendazim or tricyclazole @ 2 g/l/kg of seeds<br>• Soak the seeds in the solution for 2 hours<br>• Drain the solution, sprout the seeds and sow in the nursery bed<br>• This wet seed treatment gives protection to the seedlings up to 40 days from seedling diseases such as blast and this method is better than dry seed treatment or<br>• Treat the seeds with talc based formulation of *Pseudomonas fluorescens* @ 10g/kg of seed and soak in 1lit of water overnight<br>• Decant the excess water and allow to sprout the seeds for 24 h and then sow<br><br>**CIB Recommendation**<br>• Treat the seeds with carbendazim 25% + mancozeb 50% WS @ 3-3.5 g/kg of seeds |
| **Seedling dip with *Pseudomonas fluorescens*** | • Stagnate water to a depth of 2.5cm over an area of $25m^2$ in the main field<br>• Sprinkle 2.5 kg of the talc based formulation of *P. fluorescens* and mix with stagnated water<br>• The seedlings pulled out from the nursery are to be soaked for 30 min. in the stagnated water and then transplanted |
| ❖ Biocontrol agents are compatible with biofertilizers<br>❖ Biofertilizers and biocontrol agents can be mixed together for seed soaking<br>❖ Fungicides and biocontrol agents are incompatible | |

**II. Disease management in main field**

| Name of the Disease | Recommendations |
|---|---|
| **Blast :** ***Pyricularia grisea*** **(*Magnaporthe grisea)*** | **1. Cultural methods**<br>• Remove collateral weed hosts from bunds and channels<br>• Use only disease free seedlings<br>• Avoid excess nitrogen<br>• Apply N in three split doses (50% as basal, 25% at tillering phase and 25% at panicle initiation stage)<br>• Use resistant varieties like CO 47, CO 52 and TNAU rice hybrid CO 4 and moderately resistant varieties like CO 50 and CO 51 in endemic areas<br><br>**2. Chemical method**<br>• Spray carbendazim 50WP @ 500 g/ha or tricyclozole 75 WP @ 500 g/ha or metominostrobin 20 SC @ 500 ml/ha or Azoxystrobin 25 SC @ 500 ml/ha after observing initial infection of the disease<br><br>**CIB Recommendation**<br>• Spray isoprothiolane 40 % EC @ 750 ml/ha or kasugamycin 3% S.L @ 1000 -1500 ml/ha or kasugamycin 5% + copper oxychloride 45% WP @ 700gm/ha or picoxystrobin 22.52% SC @ 600 ml/ha or tebuconazole 25% WG @ 750 gm/ha or mancozeb 75 % WP @ 1.5 - 2.0 kg/ha or aureofungin 46.15% SP @ 1% after observing initial infection of the disease and repeat after 15 days, if required.<br><br>**3. Biological control**<br>• Treat the seeds with *Pseudomonas fluorescens* TNAU liquid formulation @ 10 ml/kg of seeds<br>• Seedling root dipping with *P. fluorescens* TNAU liquid formulation @ 500 ml for one hectare seedlings<br>• Soil application with *P. fluorescens* TNAU liquid formulation @ 500 ml/ha<br>• Foliar spray with *P. fluorescens* TNAU liquid formulation @ 5 ml/l |
| **Brown spot:** *Drechslera oryzae* (*Cochliobolus miyabeanus*) | • Spray metominostrobin @ 500 ml/ha after observing initial infection of the disease<br><br>**CIB Recommendation**<br>• Spray propineb 70% WP @ 1500 – 2000 gm/ha or propineb 54.2% + tricyclazole15 % WP @ 1250 gm/ha or carbendazim 5% GR @ 12.5 kg/ha<br>**r combined infection of blast and brown spot**<br>• Spray propineb 54.2% + tricyclazole 15 % WP @ 1250 gm/ha after |

<table>
<tr><td></td><td>observing initial infection of the disease.<br>For combined infection of blast, sheath blight and brown spot<br>• Spray azoxystrobin 16.7 % + tricyclazole 33.3% SC @ 500 ml/ha after observing initial infection of the disease</td></tr>
<tr><td>Sheath rot:<br>Sarocladium oryzae</td><td>Botanicals<br>• Spray neem oil 3% or Ipomoea leaf powder extract @ 25 kg/ha or Prosopis leaf powder extract @ 25 kg/ha. First spray at boot leaf stage and second at 15 days later<br>Chemical method<br>• Spray carbendazim @ 500 g/ha or metominostrobin @ 500 ml/ha or hexaconazole 75% WG @ 100 mg/ lit. First spray at the time of disease appearance and second spray at 15 days later<br>Biological control<br>• Treat the seeds with Pseudomonas fluorescens TNAU liquid formulation @ 10 ml/kg of seeds<br>• Seedling root dipping with P. fluorescens TNAU liquid formulation @ 500 ml for one hectare seedlings<br>• Soil application with P. fluorescens TNAU liquid formulation @ 500ml/ha<br>• Foliar spray with P. fluorescens TNAU liquid formulation @ 5ml/l</td></tr>
<tr><td>Sheath blight:<br>Rhizoctonia solani (Thanatephorus cucumeris)</td><td>Cultural method<br>• Apply neem cake @ 150 kg/ha to soil<br>Using botanical<br>• Foliar spray with neem oil 3% @ 15 l/ha starting from disease appearance<br>Chemical method<br>• Spray carbendazim 50 WP @ 500 g/ha or azoxystrobin @ 500 ml/ha or hexaconazole 75% WG @ 100 mg/l. First spray at the time of disease appearance and second spray at 15 days later.<br>CIB Recommendation<br>• Spray azoxystrobin 11% + tebuconazole 18.3% w/w SC @ 750 ml/ha or azoxystrobin 7.1% + propiconazole 11.9 % W/W SE @ 500 ml/ha or flusilazole 40% EC @ 300 ml/ha or iprodione 50 % W.P @ 2.25 kg/ha or pencycuron 22.9 % SC @ 600-750 ml/ha or propiconazole 25% E.C @ 500 ml/ha or thifluzamide 24 % SC @ 375 ml/ha or carbendazim 25 % + flusilazole 12.5% SE @ 800-960 ml/ha after observing initial infection of the disease<br>For combined infection of blast and sheath blight<br>• Spray hexaconazole 4% + carbendazim 16% SC @ 750 gm/ha or hexaconazole 5% EC @ 1000 ml/ha or iprodione 25% + carbendazim 25% WP@ 500 gm/ha or carpropamid 27.8% SC @ 100 ml/ha or iprobenphos 48 % EC @ 200 ml/ha or kresoxim-methyl 44.3% SC @ 500 gm/ha or tebuconazole 25.9% E.C. @ 750 ml/ha or tricyclazole 45% + hexaconazole 10% WG @ 500 gm/ha or carbendazim 1.92% + mancozeb 10.08% GR @ 12.5 kg/ha after observing initial infection of</td></tr>
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| | |
|---|---|
| | the disease. Repeat the applications as per severity of diseases. Broadcast the granules under standing water condition<br>**Biological control**<br>• Treat the seeds with *Pseudomonas fluorescens* TNAU liquid formulation @ 10 ml/kg of seeds<br>• Seedling root dipping with *P. fluorescens* TNAU liquid formulation @ 500 ml for one hectare seedlings<br>• Soil application with *P. fluorescens* TNAU liquid formulation @ 500 ml/ha<br>• Foliar spray with *P. fluorescens* TNAU liquid formulation @ 5 ml/l |
| **Rice grain discoloration:** *Helminthosporium oryzae, Alternaria tenuis, Fusarium Moniliforme, Sarocladium oryzae* | • Spray carbendazim + thiram + mancozeb (1:1:1) @ 0.2% at 50% flowering stage<br><br>**CIB Recommendation**<br>• Spray tebuconazole 50% + trifloxystrobin 25% WG @ 200 gm/ha at 50% flowering stage<br>**For combined infection of sheath blight, leaf blast and neck blast and grain discolouration**<br>• Spray tebuconazole 50% + trifloxystrobin 25% @ 200 gm/ha For combined infection of blast, brown spot and grain discolouration, spray tricyclazole 18% + mancozeb 62% WP @ 1000 – 1250 g/ha |
| **Bacterial leaf blight:** *Xanthomonas oryzae* pv. *oryzae* and **Bacterial leaf streak:** *Xanthomonas oryzae* pv. *oryzicola* | • Spray 20% fresh cow dung extract twice (starting from initial appearance of the disease and another at fortnightly interval) or spray twice copper hydroxide 77 WP @1.25 kg/ha 30 and 45 days after planting or spray streptomycin sulphate + tetracycline combination @ 300 g + copper oxychloride @ 1.25 kg/ha. If necessary repeat 15 days later<br>• Application of bleaching powder @ 5 kg/ha in the irrigation water is recommended at the kresek stage<br>• Spray neem oil 60 EC @ 3% or NSKE @ 5% for the control of sheath rot, sheath blight, grain discolouration and bacterial blight |
| **False smut:** *Ustiloginoidea virens* | • Two sprays with propiconazole 25 EC @ 500 ml/ha or copper hydroxide 77 WP @ 1.25 kg/ha at boot leaf and 50% flowering stages<br>**CIB Recommendation**<br>Two sprays with copper hydroxide 77 WP @ 2.0 kg/ha at boot leaf and 50% flowering stages |
| **Rice tungro disease:** *Rice tungro Bacilliform virus* and *Rice tungro Spherical virus* (Vectors: *Nephotettix* | **Physical methods**<br>• Set up light traps to attract and control the leaf hopper vectors as well as to monitor the population.<br>• In the early morning, the population of leafhopper alighting near the light trap should be killed by spraying / dusting the insecticides. This should be practiced every day<br>**Chemical method**<br>• Spray phosphamidon 40% SL 1000 ml/ha or carbofuran 3% CG 25 kg/ha or buprofezin 25% SC 800 g/ha or carbosulfan 25% EC 800- |

| | |
|---|---|
| *virescens*<br>*N. nigropictus*<br>*N. parvus*<br>*N. malayanus*<br>*Recilia dorsalis*) | 1000 ml/ha or fipronil 5% SC 1000-1500 g/ha or fipronil 0.3% G 16.67-25 kg/ha or imidacloprid 17.8% SL 100 -125 ml/ha or thiamethoxam 25% WG 100 g/ha twice at 15 and 30 days after transplanting<br>• The vegetation on the bunds should also be sprayed with the insecticides |
| **Rice Orange leaf:**<br>***Candidatus Phytoplasma***<br>(Vector: *Nephotettix virescens,*<br>*N. nigropictus*) | **Cultural method**<br>• Plough the stubbles as soon as the crop is harvested to prevent the survival of orange leaf pathogen during offseason<br>**Chemical method**<br>• Spray phosphamidon 40% SL 1000 ml/ha or carbofuran 3% CG 25 kg/ha or buprofezin 25% SC 800 g/ha or carbosulfan 25% EC 800-1000 ml/ha or fipronil 5% SC 1000-1500 g/ha or fipronil 0.3% G 16.67-25 kg/ha or imidacloprid 17.8% SL 100 -125 ml/ha or thiamethoxam 25% WG 100 g/ha twice at 15 and 30 days after transplanting<br>• The vegetation on the bunds should also be sprayed with the insecticides |

***C) Nematode management***

❖ Application of carbofuran 3G @ 1 kg a.i./ha both in nursery and in main field at 45days after planting reduces of rice root-knot nematode, *Meloidogyne graminicola*.

## RICE - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety, if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production, a distance of 3 m all around the field from the same and other varieties of the crop.

**Pre-sowing seed management**

- In dormant cultivars, break the dormancy by soaking the seeds in equal volume of 0.1 N conc. $HNO_3$ or 0.5 % $KNO_3$ for 12 - 16 h.
- Upgrade the seeds adapting specific gravity grading with salt solution prepared by dissolving 1.5 kg of common salt in 10 lit of water. Remove the floaters and sinkers should be used for sowing after repeated washing with water.
- Harden the seeds for rainfed or direct sowing by soaking in equal volume of 1% KCl solution for 16 h and dry back the seeds to original moisture content.
- Soak the seed in 4% *Pseudomonas fluorescens* for 12 h at the ratio of 1 : 1 and dry back the seeds to original seed moisture content under shade.
- Soak the seeds in equal volume of 80 µM concentration of sodium nitroprusside for 16 hrs to raise the nursery in saline / sodic soils.

**Method of planting**

- SRI method can be adapted.

**Recommendation for planting under saline soil condition**

- Incorporation of green manure like daincha in soil.
- Shallow planting at 3 - 4 seedlings / hill.
- Basal application of gypsum @ 500 kg / ha.
- Foliar spray with 0.5 % $FeSO_4$ and $ZnSO_4$ at tillering stage.

**Recommendation for Zinc deficient soils**

- Apply $ZnSO_4$ @ 25 kg / ha.

**Fertilizer recommendation for different duration varieties**

- Short duration : NPK @ 120:40:40 kg / ha
- Medium duration : NPK @ 150:50:60 kg / ha
- Long duration : NPK @ 150:50:80 kg / ha

**Roguing space**

- Leave a roguing space of 30 cm for every 150 cm.

**Foliar application**

- Foliar spray of 2 % DAP at boot leaf stage and at 5 - 10% flowering.

**Harvesting**

- When 90 % of the panicle are in golden yellow colour with the moisture content of 20% for short and medium duration varieties and 17% moisture for long duration varieties.

**Threshing**

- Thresh either manually or using mechanical threshers at a seed moisture content of 16 - 17%.

**Drying**

- Dry the seeds to 12 - 13 % moisture content for short term storage and 8-9 % moisture for long term storage.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed.
- Treat the seeds with halogen mixture @ 3 g / kg ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1) as eco-friendly treatment.
- Seeds of poor storable paddy varieties (ADT 38, ADT 46) at 10 per cent moisture content are to be treated with halopolymer @ 4 g / kg + Bavistin @ 2 g / kg + Imidacloprid @ 1 ml / kg and stored in super grain bag for extending the storability.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8-9 months) with a seed moisture content of 12 - 13 %.
- Store the seeds in polylined gunny bag for medium term storage (12- 15 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

## RICE - HYBRID SEED PRODUCTION TECHNIQUES

**Land requirement**

- Select fertile land with good drainage and irrigation facilities.
- Previous crop should not be different varieties / hybrids of paddy

**Isolation**

- Space isolation : 100 m
- Time isolation : 25 days (later)
- Barrier isolation : Either a distance of 30 m with vegetative barrier or plastic sheet with 2 m height.

**Staggered sowing**

- Male parent should be sown in three to four staggered sowings based on the duration of parental lines for continuous availability of pollen till the completion of flowering in the female parent.

**Main field management**

**Spacing**

- Between 'A' lines 10 cm; between 'R' lines 30 cm; between A and 'R' line 20 cm : within rows 15 cm.

**Planting design**

- Two paired row @ 2 - 3 seedlings / hill.

**Fertilizer application**

- Apply NPK @ 150 : 60 : 60 kg / ha.
- Apply N and K in 3 split doses during the basal, active tillering and panicle initiation stages.

**Foliar Application**

- Foliar spray of 2 % DAP at boot leaf stage and another at 5 - 10 % flowering stage.

**Special operations**

**Foliar spray of $GA_3$ @ 75 g/ha for Panicle exertion**

- First foliar spray of 40 g of $GA_3$ at 5-10 % panicle emergence stage followed by 35 g of $GA_3$ at 24 h after first spray.

**Note:** $GA_3$ should be dissolved in 70 % ethyl alcohol.

**Supplementary pollination**

- Rope pulling or shaking the pollen parent (R line) with the help of two bamboo sticks at 30 - 40% of spikelets opening stage is followed as supplementary pollination technique. This process is repeated for 3 to 4 times during the day time (10 am to 1 pm) at an interval of 30 min and continued for 7 to 10 days during flowering period.

**Harvesting**

- Harvest the male parent (R line) first and remove completely from the field.
- Then harvest the seed parent (A line).

**Grading**

- For getting better seed quality, size grade the seeds using 1.3 mm x 19 mm oblong sieve.
- Size graded seeds may be upgraded by density grading using specific gravity separator. Heavy and medium fractions with 90 - 92% recovery are selected for seed purpose.

**Drying**

- Sundry the seeds to reduce the moisture content to 12 - 13 %.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg.
- Treat the seeds with halogen mixture @ 3 g / kg ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 as eco-friendly treatment.

# 2. MILLETS

## (i) SORGHUM (*Sorghum bicolor*)

### CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 7 - 8 | 27 - 35 | 400 - 600 | up to 2300 |

Tropical crop. It can tolerate drought conditions as well as water logging condition. Short day plant

### CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Sl. No. | Agro ecological zones | Districts | Season | Varieties/ Hybrids |
|---|---|---|---|---|
| 1 | North Eastern Zone | Vellore, Thiruvannamalai, Cuddalore, Villupuram, Thiruvallur and Kancheepuram | Jan-Feb (Thaipattam)<br>April - May (Chithiraipattam)<br>June-July (Adipattam)<br>Sep-Oct (Puratassipattam) | CO 30 |
| 2 | North Western Zone | Salem, Namakkal, Dharmapuri and Krishnagiri | | |
| 3 | Western Zone | Coimbatore, Erode, Karur, Tiruppur, Theni and Dindigul | | |
| 4 | Cauvery Delta Zone | Trichy, Thanjavur, Thiruvarur, Nagapattinam, Pudukkottai Perambalur and Ariyalur | Jan-Feb (Thaipattam)<br>April - May (Chithiraipattam)<br>June-July (Adipattam) | |
| 5 | Southern Zone | Madurai, Sivagangai, Virudhunagar, Ramanathapuram Tirunelveli and Thoothukudi | Jan-Feb (Thaipattam)<br>April - May (Chithiraipattam)<br>Sep-Oct (Puratassipattam) | CO 30 and K 12 |

### II. PARTICULARS OF SORGHUM VARIETIES

| PARTICULARS | K 12 | CO 30 |
|---|---|---|
| Year of Release | 2015 | 2010 |
| Year of Notification | SO.1379(E)/ 27.03.2018 | SO.1708(E)/26.07.2012 |
| Parentage | Derivative of SPV 772 × S 35-29 | Derivative of APK 1 x TNS 291 |
| Duration (Days) | 95-100 | 95-105 |
| Area (Districts) | Southern districts of Tamil Nadu | All districts |
| Season (Pattam) | | |
| Rainfed | Puratasi | Adi,Puratasi |
| Irrigated | Chithirai | Thai, Chithirai |

| | | |
|---|---|---|
| Grain yield (kg/ha) | | |
| Rainfed | 3123 | 2400 |
| Irrigated | - | 3360 |
| Fodder yield (kg/ha) | | |
| Rainfed | 11900 | 7000 |
| Irrigated | - | 9200 |
| Stalk | Juicy | Juicy |
| Plant height (cm) | 225-240 | 220-240 |
| Sheath Colour | Reddish purple | Tan Green |
| Midrib | White | Dull white |
| Earhead shape | Elongated | Cylindrical |
| Compactness | Semi Compact | Semi Compact |
| Grain Colour | Creamy white | White |
| Special features | Tolerant to drought, photo insensitive, moderately resistant to shoot fly and stem borer, resistant to downy mildew. Suitable for rainfed situation | High dry Matter digestibility, tolerance to shoot fly, grain mould and downy mildew |

## CROP MANAGEMENT

### I. SELECTION OF SEEDS

Good quality seeds are to be collected from disease and pest-free fields.

**Quantity of seed required**

Irrigated Transplanted - 7.5 kg/ha; Direct sown - 10 kg/ha Rainfed Direct sown - 15 kg/ha Sorghum under irrigated condition is raised both as a direct sown and transplanted crop. Transplanted crop has the following advantages:

a. Main field duration is reduced by 10 days.
b. Shoot fly, which attacks direct sown crops during the first 3 weeks and which is difficult to control, can be effectively and economically controlled in the nursery itself.
c. Seedlings which show chlorotic and downy mildew symptoms can be eliminated, thereby incidence of downy mildew in the main field can be minimised.
d. Optimum population can be maintained as only healthy seedlings are used for transplanting.
e. Seed rate can also be reduced by 2.5 kg/ha.

### II. NURSERY PRACTICES

### 1. NURSERY PREPARATION

For raising seedlings to plant one hectare, select 7.5 cents (300 $m^2$ ) near a water source where water will not stagnate.

### 2. APPLICATION OF FYM TO THE NURSERY

i. Apply 750 kg of FYM or compost for 7.5 cents nursery and apply another 500 kg of compost or FYM for covering the seeds after sowing.
ii. Spread the manure evenly on the unploughed soil and incorporate by ploughing or apply just before last ploughing.

3. **LAYING THE NURSERY**

i. Provide three separate units of size 2 m x 1.5 m with 30 cm space in between the plots and all around the unit for irrigation.
ii. Excavate the soil from the inter-space and all around to a depth of 15 cm to form channels and spread the soil removed on the bed and level.

4. **PRE-TREATMENT OF SEEDS**

i. Treat the seeds 24 hours prior to sowing with Carbendazim or Captan or Thiram at 2g/kg of seed.
ii. Carrier based formulation: Treat one hectare of seeds with 1 kg each of biofertilizers *viz., Azsopirillum,* Phosphobacteria (or) Azophos, Silicate solubilizing bacteria (SSB) / Potash bacteria (KRB) and 25 g of powder formulation of AM fungi using binder (polymer), shade dry for 30 minutes before sowing.
iii. Liquid formulation: Treat one hectare of seeds with 125 ml of each biofertilizers *viz., Azsopirillum,* Phosphobacteria (or) Azophos and Silicate solubilizing bacteria (SSB) shade dry for 30 minutes before sowing

5. **SOWING AND COVERING THE SEEDS**

1. Make shallow rills, not deeper than 1 cm on the bed by passing the fingers vertically over it.
2. Broadcast 7.5 kg of treated seeds evenly on the beds.
3. Cover by leveling the rills by passing the hand lightly over the soil.

6. **WATER MANAGEMENT**

i. Provide one inlet to each nursery unit.
ii. Allow water to enter through the inlet and cover all the channels till the raised beds are covered with water and then cut off.
iii. Adjust the frequency of irrigation according to the soil types as follows:

| Number of irrigations | Red soil | Heavy soil |
|---|---|---|
| First irrigation | Immediately after sowing | Immediately after sowing |
| Second irrigation | 3$^{rd}$ day after sowing | 4$^{th}$ day after sowing |
| Third irrigation | 7$^{th}$ day after sowing | 9$^{th}$ day after sowing |
| Fourth irrigation | 12$^{th}$ day after sowing | 16$^{th}$ day after sowing |

NOTE: Do not keep the seedlings in the nursery for more than 18 days. If older seedlings are used, establishment and yield are adversely affected. Do not allow cracks to develop in the nursery by properly adjusting the quantity of irrigation water.

**MAIN FIELD PREPARATION FOR IRRIGATED CROP**

1. **PLOUGHING**

Plough the field with an iron plough once (or) twice. Sorghum does not require fine tilth since it adversely affects germination and yield in the case of direct sown crop. To overcome the subsoil hard pan in Alfisols (deep red soils) chiselling the field at 0.5 m intervals to a depth of 40 cm on both the directions of the field followed by disc ploughing once and cultivator ploughing twice help to increase the yield of sorghum and the succeeding crops.

Application of FYM and 100% of recommended N can also be followed. In soils with sub-soil hard pan, chiselling should be done every year at the start of the cropping sequence to create a favourable physical environment.

**2. APPLICATION OF FYM**

Spread 12.5 t/ha FYM or any compost along with 2 kg each *Azospirillum,* Phosphobacteria or 2 kg of Azophos on the unploughed field and incorporate the manure in the soil. Apply well decomposed poultry manure @ 5 t/ha to improve the grain yield as well as physical properties of soils.

**3. FORMATION OF RIDGES AND FURROWS**

i. Form ridges and furrows of 6 m length and 45 cm apart
ii. Form irrigation channels across the furrows
iii. Alternatively form beds of sixe 10 $m^2$and 20 $m^2$depending on the availability of water.

**4. APPLICATION OF FERTILIZERS Transplanted crop**

If soil test recommendations are not available, adopt a blanket recommendation of 90 N, 45 $P_2O_5$ 45 $K_2O$ kg/ha. Apply N @ 50:25:25 % at 0, 15 and 30 DAS and full dose of $P_2O_5$ and $K_2O$ basally before planting. Apply 30 kg S basally for sulphur deficient soils. Soil test crop response based integrated plant nutrition system (STCR-IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets (ready reckoners are furnished).

**Sorghum - Hybrid (1)**

Soil : Red sandy loam (Irugur series)
Target : 4.0 - 5.0 t $ha^{-1}$

FN = 4.86T - 0.53 SN - 0.98 ON
$FP_2O_5$ = 1.63T - 0.87 SP - 0.90 OP
$FK_2O$ = 4.56T - 0.59SK - 0.76 OK

| **Initial soil test values (kg $ha^{-1}$)** | | | **Yield target – 4 t $ha^{-1}$** | | | **Yield target – 5 t $ha^{-1}$** | | |
|---|---|---|---|---|---|---|---|---|
| | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 160 | 58 | 23 | 48 | 106 | 39 | 68** |
| 180 | 14 | 180 | 47 | 23* | 36 | 96 | 37 | 68** |
| 200 | 16 | 200 | 36 | 23* | 24 | 85 | 36 | 68** |
| 220 | 18 | 220 | 26 | 23* | 23* | 74 | 34 | 58 |
| 240 | 20 | 240 | 45* | 23* | 23* | 64 | 32 | 46 |

* Maintenance dose; ** Maximum dose

**Sorghum -Varieties (2)**

| | | |
|---|---|---|
| Soil : | Mixed black calcareous (Perianaickenpalayam series) | FN = 6.06T-0.81SN-0.53 ON |
| Target : | 4.0- 5.0 t $ha^{-1}$ | $FP_2O_5$ = 2.06T-3.14 SP-0.72 OP |
| | | $FK_2O$ = 5.03T-0.47SK-0.66 OK |

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 4 t $ha^{-1}$ | | | Yield target – 5 t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
| SN | SP | SK | FN | $FP_2O_5$ | $FK_2O$ | FN | $FP_2O_5$ | $FK_2O$ |
| 180 | 12 | 300 | 45* | 23* | 23* | 105 | 33 | 71 |
| 200 | 14 | 340 | 45* | 23* | 23* | 89 | 27 | 52 |
| 220 | 16 | 380 | 45* | 23* | 23* | 73 | 23* | 33 |
| 240 | 18 | 420 | 45* | 23* | 23* | 57 | 23* | 23* |
| 260 | 20 | 460 | 45* | 23* | 23* | 45* | 23* | 23* |

* Maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure inkg $ha^{-1}$.

i. In the case of ridge planted crop, open a furrow 5 cm deep on the side of the ridge at two thirds the distance from the top of the ridge and place the fertilizer mixture along the furrow and cover with soil upto 2 cm.
ii. Soil application of Azospirillum at 10 packets (2 kg/ha) and 10 packets (2000g/ha) of phosphobacteria or 20 packets of Azophos (4000g/ha) after mixing with 25 kg of FYM + 25 kg of soil may be carried out before sowing/planting.

**Direct sown crop**

i. Apply NPK fertilizers as per soil test recommendations as far as possible. If soil test recommendations are not available, adopt a blanket recommendation of 90 N, 45 $P_2$ $O_5$, 45 2 5 $K_2O$ kg/ha.
ii. Apply N @ 50:25:25 % at 0, 15 and 30 DAS and full dose of $P_{25}O_5$ and $K_2$ O basally before sowing and if basal application is not possible the same could be top dressed within 24 hours.
iii. In the case of bed planted crop, mark lines to a depth of 5 cm and 45 cm apart. Place the fertilizer mixture at the depth of 5 cm along the lines. Cover the lines upto 2 cm from the top before sowing.
iv. In the case of sorghum raised as a mixed crop with a pulse crop (Blackgram, Greengram or Cowpea) open furrows 30 cm apart to a depth of 5 cm.
v. Apply fertilizer mixture in two lines in which sorghum is to be raised and cover upto 2 cm.
vi. Skip the third row in which the pulse crop is to be raised and place fertilizer mixture in the next two rows and cover upto 2 cm with soil.

vii. Application of bio-fertilizers: When Azospirillum is used apply only 75% of recommended N for irrigated sorghum.

**5. APPLICATION OF MICRONUTRIENTS Transplanted Crop**

i. Mix 12.5 kg/ha of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu with enough sand to make a total quantity of 50 kg and apply the mixture over the furrows and on top one third of the ridges (or) TNAU MN mixture @ 12.5 kg $ha^{-1}$ for irrigated; 7.5 kg for rainfed crop as enriched FYM. Prepare enriched FYM @ 1:10 ratio of MN Mixture & FYM at friable moisture and incubate for one month in shade.

ii. If micronutrient mixture is not available, mix 25 kg of zinc sulphate with sand to make a total quantity of 50 kg and apply on the furrows and on the top one third of the ridges.

**Direct Sown Crop**

i. Mix 12.5 kg of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu with enough sand to make a total quantity of 50 kg.

ii. Spread the mixture evenly on the beds.

iii. Basal application of 25 kg $ZnSO_4/ha^{-1}$ (or) 12.5 kg kg Zn $SO_4$ + 12.5 t/ha FYM for deficient soils.

iv. Basal application of $FeSO_4$ @ 50 kg/ha along with 12.5 t/ha FYM for iron deficient soils.

v. Foliar spraying of 0.5% $ZnSO_4$, 1.0% $FeSO_4$+0.1% citric acid thrice on 30, 40 and 50 DAS if deciciency observed in plants.

**III. MANAGEMENT OF MAIN FIELD** Spacing: 45 x 15 cm Population: $15/m^2$

**1. TRANSPLANTED CROP**

i. Pull out the seedlings when they are 15 to 18 days old.

ii. Prepare slurry with 5 packets of Azospirillum (1000g/ha) and 5 packets (1000g/ha) of Phosphobacteria or 10 packets of Azophos (2000 g/ha) in 40 lit. of water and dip the root portion of the seedlings in the solution for 15-30 minutes and transplant.

iii. Let in water through the furrows

iv. Plant one seedling per hill

v. Plant the seedlings at a depth of 3 to 5 cm.

vi. Plant the seedlings on the side of the ridge, half the distance from the top of the ridge and the bottom.

**2. DIRECT SOWN CROP**

i. In the case of pure crop of sorghum, maintain the seed rate at 10kg/ha.

ii. In the case of inter crop of sorghum with pulse crop, maintain the seed rate of sorghum at 10 kg/ha and pulse crop at 10 kg/ha.

iii. In the case of pure crop of sorghum, sow the seeds with a spacing of 15 cm between seeds in the rows which are 45 cm apart.

iv. Maintain one plant per hill.

v. If shootfly attack is there, remove the side shots and retain one healthy shoot.

vi. Sow the seeds over the lines where fertilizers are placed.

vii. Sow the seeds at a depth of 2 cm and cover with soil.

viii. In the case of sorghum intercropped with pulses sow one paired row of sorghum alternated with a single row of pulses. The spacing between the row of sorghum and pulse crop is 30 cm.

Forage cowpea CO 1 can be intercropped in sorghum at two rows of fodder cowpea in between paired rows of sorghum.

**3. WEED MANAGEMENT**

i. Apply PE Atrazine @ 0.25 kg/ha on 3-5 DAS followed by 2,4-D @ 1 kg/ha on 20-25 DAS on the soil surface, using Backpack/Knapsack/Rocker sprayer fitted with a flat fan nozzle using 500 litres of water/ha (or) if herbicides are not used, hand weeding twice on 10-15 DAS and 30-35 DAS.
ii. Apply PE Atrazine@0.25 kg/ha on 3-5 DAS followed by one hand weeding on 30-35 DAS.
iii. In line sown crop, apply PE Atrazine @ 0.25 kg/ha on 3-5 DAS followed by Twin Wheel hoe weeder weeding on 30-35 DAS.
iv. In transplanted crop, apply PE Atrazine @ 0.25 kg/ha on 3-5 DAT followed by 2,4-D @ 1 kg/ha on 20-25 DAT.
v. If pulse crop is to be raised as an intercrop in sorghum do not use Atrazine, spray PE Pendimethalin @ 0.75 kg/ha on 3-5 DAS

**4. THINNING OF THE SEEDLINGS AND GAP FILLING Direct sown crop**

Thin the seedlings and gap fill with the seedlings thinned out. Maintain a spacing of 15 cm between plants after the first hand weeding. Thin the pulse crop to a spacing of 10 cm between plants for all pulse crop except cowpea, for which spacing is maintained at 20 cm between plants.

**5. DEFICIENCY SYMPTOMS**

Zinc: Deficiency symptoms first appear in the newly formed leaves at 20 to 30 days age. Older leaves have yellow streaks or chlorotic striping between veins.

Iron:Interveinal chlorosis will be observed. If the deficiency continues the entire leaf including the veins may exhibit chlorotic symptoms. Newly formed leaves exhibit chlorotic symptoms. The entire crop may exhibit bleached appearance, dry and may die.

**Direct sown crop**

i. Foliar spraying of 1% $FeSO_4$+0.1% citric acid thrice if deficieny symptom appeared.
ii. Recommendation given in transplanted crop may be followed.

NOTE:

a. Spray only if micronutrient mixture is not applied.
b. Apply in case of iron deficiency.
c. If soil is calcareous

## IV. WATER MANAGEMENT

**Regulate irrigation according to the following growth phase of the crop.**

| | Transplanted crop | Direct sown crop |
|---|---|---|
| Growth phase | 1 to 40 days | 1 to 33 days |
| Flowering phase | 41 to 70 days | 34 to 65 days |
| Maturity phase | 71 to 95 days | 66 to 95 days |

| Stages | No. of Irrigation | Days of Transplanting / Sowing of Crop: Transplanted | Direct Sown |
|---|---|---|---|
| **Light Soils** | | | |
| i. Irrigate for germination | 1 | 1st day | 1st day |
| or establishment | 2 | 4th day | 4th day |
| Regulate irrigation | 1 | 15th day | 15th day |
| during vegetative phase | 2 | 28th day | 28th day |
| iii. Flowering phase (copious irrigation) | 1 | 40th day | 40th day |
| | 2 | 52nd day | 52nd day |
| | 3 | .. | 64th day |
| iv. Maturity phase (Control irrigation) | 1 | 65th day | 76th day |
| | 2 | .. | 88th day |
| v. Stop irrigation thereafter | .. | .. | |
| Heavy soils | | | |
| i. Irrigate for germination | 1 | 1st day | 1st day |
| or establishment | 2 | 4th day | 4th day |
| ii. Regulate irrigation | 1 | 17th day | 17th day |
| during vegetative phase | 2 | 30th day | 30th day |
| iii. Flowering phase (give | 1 | 40th day | 45th day |
| copious irrigation) | 2 | 52nd day | 60th day |
| | 3 | .. | 75th day |
| iv. Maturity phase (Control irrigation) | 1 | 72nd day | 90th day |
| v. Stop irrigation thereafter | | | |

**NOTE :** Adjust irrigation schedule according to the weather conditions and depending upon the receipt of rains. Contingent Plans to be done before 75% of soil moisture is lost from available water. Foliar Spray of 3% Kaolin (30 g in one litre of water) during period of stress will mitigate the ill effects.

## V. HARVESTING AND PROCESSING

i. Consider the average duration of the crop and observe the crop. When the crop matures the leaves turn yellow and present a dried up appearance.
ii. The grains are hard and firm.
iii. At this stage, harvest the crop by cutting the earheads separately.
iv. Cut the stalk after a week, allow it to dry and then stack.
v. In the case of tall varieties, cut the stem at 10 to 15 cm above ground level and afterwards separate the earheads and stack the stalk.
vi. Dry the earheads.
vii. Thresh using a mechanical thresher or by drawing a stone roller over the earheads or by using cattle and dry the produce and store.

# RATOON SORGHUM CROP

## 1. RATOONING TECHNIQUE

i. Harvest the main crop leaving 15 cm stubbles.
ii. Remove the first formed two sprouts from the main crop and allow only the later formed two sprouts to grow. Allow two tillers per hill.

## 2. HOEING AND WEEDING

i. Remove the weeds immediately after harvest of the main crop.
ii. Hoe and weed twice on $15^{th}$ and $30^{th}$ day after cutting.

## 3. APPLICATION OF FERTILIZERS

i. Apply 100 kg N/ha in two split doses.
ii. Apply the first dose on $15^{th}$ day after cutting and the second on $45^{th}$ day after cutting.
iii. Apply 50 kg $P_2 O_5$ /ha along with the application of N on $45^{th}$ day.

## 4. WATER MANAGEMENT

i. Irrigate immediately after cutting the main crop.
ii. Irrigation should not be delayed for more than 24 hours after cutting.
iii. Irrigate on $3^{rd}$ or $4^{th}$ day after cutting.
iv. Subsequently irrigate once in 7 - 10 days.
v. Stop irrigation on 70 - 80 days after ratooning.

## 5. HARVEST

Harvest the crop when the grains turn yellow.

NOTE: The duration of the ratoon crop is about 15 days less than the main crop.

# RAINFED SORGHUM

## 1. RAINFALL

Average and well distributed rainfall of 250-300 mm is optimum for rainfed sorghum.

## 2. DISTRIBUTION

Madurai, Dindigul, Theni, Ramanathapuram, Tirunelveli, Thoothukudi, Virudhunagar, Sivagangai, Tiruchirapalli, Erode, Salem, Namakkal, Coimbatore and Dharmapuri Districts.

## 3. SEASON

The crop can be grown in South West and North East monsoon seasons provided the rainfall is evenly distributed.

## 4. FIELD PREPARATION

i Field has to be prepared well in advance taking advantage of early showers. FYM application should be done @ 12.5 t / ha and well incorporated at the time of ploughing.

ii. Chiseling for soils with hard pan
Chisel the soils having hard pan formation at shallow depths with chisel plough at 0.5 m interval, first in one direction and then in the direction perpendicular to the previous one once in three years. Apply 12.5 t FYM or composted Coir pith/ha besides chiseling to get an additional yield of about 30% over control.

iii. To conserve the soil moisture sow the seeds in flat beds and form furrows between crop rows during inter cultivation or during third week after sowing.

## 5. SEED RATE

15 kg/ha

## 6. SEED TREATMENT Direct sown crop

Seed hardening ensures high germination. The seeds are pre-soaked in 2% potassium dihydrogen phosphate solution for 6 hours in equal volume and then dried back to its original moisture content in shade and are used for sowing. (or)

i) Harden the seeds with 1% aquous fresh leaf extract of *Prosopis juliflora* and pungam, (*Pongamia pinnata*) mixed in 1:1 for 16 hrs at 1:0.6 ratio (Seed and solution) followed by drying and subsequently pelleting the seeds with Pungam leaf powder @300 g/kg with gruel.

ii) Halogenise the seeds containing CaOCl, $CaCO_3$ and arappu leaf powder @ 5:4:1 ratio or iodine based (containing 2 mg of Iodine in 3 g of $CaCO_3$) formulation @ 3g/kg packed in polylined cloth bag to maintain seed viability for more than 10 month.

iii) Treat the seeds with three packets of azospirillum (600 g) and 3 packets of phosphobacteria or 6 packets of Azophos (1200 g/ha). In the main field, apply 10 packets of azospirillum 2000g/ha and 10 packets (2000g/ha) of phosphobacteria or 20 packets of Azophos (4000 g/ha) with phosphobacteria 2 kg with 25 kg FYM + 25 kg soil.

iv) The seed is pelletised with 15 g of Chloropyriphos in 150 ml of gum and shade dried.

## 7. SOWING

Sow the seeds well before the onset of monsoon at 5 cm depth (by seed drill or by country plough).

### Pre-monsoon sowing

Sow the hardened seeds at 5 cm depth with seed cum fertilizer drill to ensure uniform depth of sowing and fertilizer application before the onset of monsoon as detailed below:

| | District | Optimum period |
|---|---|---|
| 1. | Coimbatore | 37-38th week (II to III week of Sep.) |
| 2. | Erode | 38th week (III week of Sep.) |
| 3. | Sivaganga | 40th week (I week of Oct.) |
| 4. | Ramanathapuram | 40th week (I week of Oct.) |
| 5. | Thoothukudi | 39-40th week (Last week of Sep. to I week of Oct) |
| 6. | Vellore, Tiruvannamalai | 37th-38th week (Sep. II week to Sep. III week) |

i. Sow the sorghum seeds over the line where the fertilizers are placed.
ii. Sow the seeds at a depth of 5 cm and cover with the soil.
iii. Sow the seeds with the spacings of 15 cm in the paired rows spaced 60 cm apart.
iv. Sow the pulse seeds to fall 10 cm apart in the furrows between the paired rows of sorghum.

## 8. SPACING

45 x 15 cm or 45 x 10 cm.

## 9. FERTILIZER

Apply 12.5 t/ha of Composted Coir pith + NPK at 40:20:0; Apply enriched FYM @ 750 kg/ha. The recommended dose of 40 kg N and 20 kg $P_2O_5$ /ha for rainfed sorghum can be halved if FYM @ 5 t/ha is applied.

## 10. WEED MANAGEMENT

Keep sorghum field free of weeds from second week after germination till $5^{th}$ week. If sufficient moisture is available spray Atrazine 0.25 kg/ha as pre-emergence application within 3 days after the receipt of the soaking rainfall for sole sorghum and for sorghum based intercropping system with pulses, use Pendimethalin at 0.75 kg/ha.

Under rainfed sorghum intercropped with cowpea as a pre-plant incorporation of isoproturan @ 0.5 kg $ha^{-1}$ gave good control of weed with applied after $1^{st}$ and $2^{nd}$ spell of rainfall pendimethalin 1.0 kg $ha^{-1}$ will be safer for both the crops.

## 11. CROPPING SYSTEM

- The most profitable and remunerative sorghum based cropping system adopted is sorghum with cowpea, redgram, lab-lab, blackgram.
- In rainfed Vertisol, adopt paired row planting in sorghum and sow one row of blackgram/ cowpea in between paired rows of sorghum to have 100% population of sorghum plus 33% population of blackgram/cowpea.
- Intercropping of sunflower CO 1, with the main crop of sorghum CO 26 in 4:2 ratio is recommended under rainfed conditions during North-East monsoon for black soils of CBE.
- Intercropping of soybean with sorghum in the ratio 4:2 is recommended for kharif seasons.
- For sorghum - blackgram intercropping system as well as sole cropping, application of 20 kg N and 20 kg P O /ha through enriched FYM and treating the seeds with Azospirillum is 25 recommended for Aruppukottai region.
- For sorghum (CO 25) + Fodder cowpea (CO 1) intercropping system, application of 20 kg N and 20 kg P O /ha with enriched FYM is recommended for Coimbatore region 25
- The intercropping system, fodder sorghum (K 7) + Fodder cowpea (CO 5) at 3:2 ratio is found profitable for rainfed Vertisols of Aruppukottai.
- Tamarind and Neem trees upto 3-4 years from date of planting form an ideal tree component for agroforestry in black cotton soils of Kovilpatti. Sorghum and blackgram gave higher yield even at 50 per cent of the recommended level of fertilizer application.

## CROP PROTECTION

### A. Pest management

- Protect nursery by applying any one of the following insecticides (in 6 litres of water) on 7th and 14th day of sowing
  - Methyl demeton 25EC 12 ml
  - Dimethoate 30EC 12 ml
- Plough soon after harvest, remove and destroy the stubbles.
- Treat seeds with chlorpyriphos 20EC or phosalone 35 EC (4 ml/kg) or imidacloprid 48FS or imidacloprid 70WS or thiamethoxam 30FS (10 g/kg) before sowing.
- Avoid repeated application of insecticides which may induce resurgence
- The sowing of sorghum should be completed in as short a time as possible to avoid continuous flowering which favours grain midge and earhead bug multiplication in an area.
- Set up light traps till mid night to monitor, attract and kill adults of stem borer, grain midge and earhead caterpillars.

**Economic threshold level (ETL) for important pests**

| Insect pest | ETL |
|---|---|
| Shoot fly | 1 egg/plant in 10% of plants in the first two weeks of sowing or 10 % dead hearts |
| Mite | 5 mites/$cm^2$ of leaf area |

| | |
|---|---|
| Stem borer | 10 % damage |
| Grain midge | 5 / earhead |
| Earhead caterpillar | 2 / earhead |
| Earhead bug | 10 / earhead |
| **Shoot fly** *Atherigona soccata* | • Take up early sowing of sorghum immediately after the receipt of South West or North East monsoon to minimise shoot fly incidence<br>• In case of direct seeding, use increased seed rate up to 12.5 kg/ha and remove shoot fly damaged seedlings at the time of thinning<br>• In case of trasnsplanting, transplant only healthy seedlings<br>• Spray dimethoate 30EC 12 ml for an area of 120 $m^2$ nursery<br>• Set up fish meal trap @ 12/ha till the crop is 30 days old<br>• Plough soon after harvest, remove and destroy the stubbles<br>**Apply any one of the following/ha**<br>• Carbofuran 3CG 33.3 kg (at the time of sowing)<br>• Dimethoate 30EC 500 ml<br>• Neem seed kernel extract 5%<br>• Quinalphos 25EC 1500 ml |
| **Mite,** *Oligonychus indicus* | Spray quinalphos 25EC 1500 ml/ha<br>Direct the spray fluid towards the under surface of the leaves |
| **Aphids** *Rhopalosiphum maidis Melanaphis sacchari* | Spray dimethoate 30EC 500 ml/ha |
| **Stem borer,** *Chilo partellus, Sesamia inferens* | • Sowing lab lab / cowpea as an intercrop to minimize stem borer damage (Sorghum: Lab lab /cowpea 4:1)<br>• Apply carbofuran 3CG 17 kg/ha (with sand) to make up a total quantity of 50 kg/ha and apply in leaf whorls |
| **Grain midge,** *Contarinia sorgicola* | • **Apply any one of the following/ha on 3rd and 18th day after panicle emergence**<br>• Dimethoate 30EC 1650ml<br>• Malathion 50EC 1600 ml<br>• Malathion 5D 25 kg<br>• Neem seed kernel extract 5%<br>• Phosalone 35EC 1150 ml<br>• Phosalone 4D 25 kg |
| **Earhead bug,** *Calocoris angustatus* | **Apply any one of the following/ha on 3rd and 18th day after panicle emergence**<br>• Malathion 50EC 1000 ml<br>• Malathion 5D 25 kg<br>• Neem seed kernel extract 5%<br>• Quinalphos 1.5DP 25 kg |
| **Earhead caterpillar,** *Helicoverpa armigera* | • Set up sex pheromone traps at 12 nos./ha to attract males of *Helicoverpa armigera* from flowering to grain hardening<br>• Apply NPV at 1.5 X$10^{12}$ POB along with crude sugar 2.5 kg + cotton seed kernel powder 250 g on the earheads twice at 10 days interval (preferably during early morning or evening)<br>**Apply any one of the following/ha on 3rd and 18th day after panicle emergenc** |

| | |
|---|---|
| | • Malathion 5D 25 kg<br>• Phosalone 4D 25 kg |
| **Rice weevil,** *Sitophilus oryzae* | • Treat seeds with chlorpyriphos 20EC 4 ml/kg |

**Disease Management**

**Nursery practices**

**Seed treatment**: Treat the seeds 24h prior to sowing with carbendazim or captan or thiram @ 2 g/kg of seeds or metalaxyl @ 6 g/ kg of seeds.

| Name of the Disease | Recommendations |
|---|---|
| **Rust:** *Puccinia purpurea* | • Spray mancozeb @ 1 kg/ha. Repeat fungicidal application after 10 days |
| **Ergot or Sugary disease:** *Sphacelia sorghi* | • Adjust the sowing period to prevent flowering during rainy and winter seasons<br>• Spray mancozeb @ 1000 g/ha or propiconazole @ 500 ml/ha at 5 - 10% flowering and at 50% flowering stages. Repeat the spray after a week, if necessary |
| **Head Mould:** Fungal complex *Fusarium, Curvularia, Alternaria, Aspergillus* and *Phoma*sp. | • Spray mancozeb or captan @ 1000 g + aureofungin sol 100 g/ha in case of intermittent rainfall during earhead emergence and repeat, if necessary a week later |
| **Downy Mildew:** *Peronosclerospora sorghi* | • Rogue out infected plants up to 45 days of sowing<br>• Spray metalaxyl + mancozeb @ 500 g or mancozeb @ 1000 g/ha after symptom development<br>**CIB recommendation**<br>• Seed treatment with metalaxyl-M 31.8% ES @ 2 ml/kg of seed or slurry seed treatment with metalaxyl35%WS @ 2 g/ kg seed |
| **Charcoal Rot:** *Macrophomina phaseolina* | • Treat the seeds with *Pseudomonas fluorescens* @10 g/kg or *Trichoderma viride* @ 4 g/kg of seed |
| **Grain smut :** *Sphacelotheca sorghi* | **CIB recommendation**<br>• Treat the seeds with sulphur 80% WP @ 3-4 g/kg seed |

## SORGHUM - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety, if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 100 m all around the field from the same and other varieties of the crop.
- The distance may be extended to 400 m for the presence of Johnson grass.

**Season**

- June - July and October - November.

**Pre-sowing seed treatment**

- Soak the seeds in $KH_2PO_4$ 2 % for 16 h at of 1:0.6 ratio and dry back the seeds to original seed moisture content (8 - 9 %) under shade. This can be adopted both for the garden and dry land ecosystem.
- Soak the seed in 4% *Pseudomonas fluorescens* for 12 h at 1 : 1 ratio and dry back the seeds to original seed moisture content under shade.

**Fertilizer requirement**

- As basal application NPK @ 100 : 50 : 50 kg / ha.

**Spacing**

- 45 x 10 cm.

**Pre-harvest sanitation spray**

- Spray 2 % carbendazim at ten days before harvest against black mould.

**Harvesting**

- Seeds attain physiological maturity 40 - 45 days after 50 % flowering.
- Harvest the earheads as once over harvest, when the seeds have attained the characteristic yellow colour.

**Threshing**

- Thresh the earheads either manually or mechanically at a moisture content of 15 - 18 %.

**Seed grading**

- Size grade the seeds either with 9 / 64" or depending upon the variety.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg.
- Treat the seeds with halogen mixture @ 3 g / kg ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8-9 months) with a seed moisture content of 10 - 12 %.
- Store the seeds in polylined gunny bag for medium term storage (12- 15 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

## SORGHUM - HYBRID SEED PRODUCTION

**Land requirement**

- Fertile land with good drainage and irrigation facility.

- Field should not have volunteer plants. Hence, the previous crop should not be the same or different variety / hybrid of sorghum.

**Isolation**

- For certified / quality seed production leave a distance of 200 m all around the field from same and other varieties of sorghum.

**Season**

- For increased seed set and effective synchronization, sow the crop during October - November.

**Planting ratio**

- Sow the female and male parents in the ratio of 4:2 for foundation seed production and 5:2 for certified seed production

**Border rows**

- Sow the male parent in four rows around the field for the availability of adequate pollen.

**Fertilizer requirement**

- NPK @ 100: 50: 50 kg / ha.
- Apply NPK @ 50:50:50 kg / ha as basal; 25 kg of nitrogen after first weeding and during boot leaf stage as top dressing.

**Foliar Application**

- Foliar spray of 0.5% $FeSO_4$ at primordial initiation stage and there after two sprays at ten days interval to enhance the seed set.

**Synchronization techniques (Adopt any one of the following)**

- Apply 1 % urea at flower initiation to the delayed parent.
- Withhold one irrigation to the advanced parent.
- Staggering the sowing of male and female parents depending upon the hybrid and location.
- Foliar spray of cycocel (CCC) @ 300 ppm to delay the flower formation
- Foliar spray of growth retardant, MH @ 500 ppm at 45 DAS to the advanced parent.

**Harvesting**

- Harvest the male parent (R line) first and remove from field.
- Harvest the hybrid crop when 90 % of seeds in the earhead have attained the characteristic yellow colour.

**Other management practices**

The techniques recommended for varieties can be adapted.

# (i) CUMBU (*Pennisetum glaucum* (L) R. Br. )

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 8 - 10 | 27 - 35 | 250 - 350 | up to 1800 |

Tropical warm weather crop. Grow in a wide range of ecological conditions and can still yield well even under unfavourable conditions of drought stress and high temperatures. Best suited temperature for crop growth is between 27 - 30°C. Short day plant.

## CROP IMPROVEMENT
## I SEASON AND VARIETIES

| Sl.No. | Agro ecological zones | Districts | Season | Varieties/ Hybrids |
|---|---|---|---|---|
| 1 | North Eastern Zone | Vellore, Thiruvannamalai, Cuddalore, Villupuram, Thiruvallur, Kancheepuram | Jan-Feb (Thaipattam) April - May (Chithiraipattam) June-July (Adipattam) Sep-Oct Puratassipattam) | CO 10 and Hybrid CO 9 |
| 2 | North Western Zone | Salem, Namakkal, Dharmapuri, Krishnagiri | | |
| 3 | Western Zone | Coimbatore, Erode, Karur, Tiruppur, Theni and Dindigul | | |
| 4 | Cauvery Delta Zone | Trichy, Thanjavur, Thiruvarur, Nagapattinam, Pudukkottai Perambalur and Ariyalur | Jan-Feb (Thaipattam) April - May (Chithiraipattam) June-July (Adipattam) | |
| 5 | Southern Zone | Madurai, Sivagangai, Virudhunagar, Ramanathapuram Tirunelveli and Thoothukudi | Jan-Feb (Thaipattam) April - May (Chithiraipattam) Sep-Oct (Puratassipattam) | |

### II. PARTICULARS OF CUMBU HYBRID AND COMPOSITE

| PARTICULARS | Hybrid CO 9 | CO 10 |
|---|---|---|
| Year of Release | 2011 | 2016 |
| Year of Notification | SO.1708(E)/26.07.2012 | SO. 2238 (E) /29.06.2016 |
| Parentage | ICMA 93111A x PT 6029-30 | Composite of five elite inbred lines |
| Season-irrigated/ rainfed | Both | Both |
| Duration (Days) | 75-80 | 85-90 |
| Grain yield (kg/ha) | | |
| Rainfed | 2707 | 2923 |
| Irrigated | 3728 | 3526 |
| Plant height (cm) | 160-180 | 160-180 |
| Tillers (No.) | 4-6 | 4-6 |

| | | |
|---|---|---|
| Pigmentation | - | - |
| Hairiness | Absent | Absent |
| Days to 50% bloom | 45-50 | 47-50 |
| Shape of earhead | Candle to Cylindrical | Spindle |
| Bristles | Absent | Absent |
| Length of earhead (cm) | 25-35 | 25-30 |
| Earhead girth diameter (cm) | 3.1-3.6 | 3.1-3.6 |
| Grain Colour | Grey yellow | Grey brown |
| 1000 grains weight (gm) | 13-14 | 12-13 |
| Special features | Short duration, High Fe content (8mg/100g) Resistant to downy Mildew | High protein Content (12.07%) and Resistant to downy mildew |

## CROP MANAGEMENT

### II NURSERY

**1. PREPARATION OF LAND**

i. For raising seedlings to plant one ha select 7.5 cents near a water source. Water should not stagnate.

ii. Plough the land and bring it to the fine tilth.

**2. APPLICATION OF FYM**

Apply 750 kg of FYM or compost and incorporate by ploughing. Cover the seeds with 500 kg of FYM.

**3. FORMING RAISED BED**

i. In each cent mark 6 plots of the size 3 m x 1.5 m with 30 cm channel in between the plots and all around.

ii. Form the channel to a depth of 15 cm.

iii. Spread the earth excavated from the channel on the beds and level.

NOTE: The Unit of 6 plots in one cent will form one unit for irrigation.

**4. REMOVAL OF ERGOT AFFECTED SEEDS AND SCLEROTIA TO PREVENT PRIMARY INFECTION**

i. Dissolve one kg of common salt in 10 litres of water.

ii. Drop the seeds into the salt solution

iii. Remove the ergot and sclerotia affected seeds which will float.

iv. Wash seeds in fresh water 2 or 3 times to remove the salt on the seeds.

v. Dry the seeds in shade.

vi. Treat the seeds with three packets (600g) of the Azospirillum inoculant and 3 packets (600g) of phosphobacteria or 6 packets (1200g) of azophos.

**5. TREATMENT OF THE NURSERY BED WITH INSECTICIDES**

Apply phorate 10 G 180 g or Carbofuran 3 G 600 g mixed with 2 kg of moist sand, spread on the beds and work into the top 2 cm of soil to protect the seedlings from shootfly infestation.

6. **SOWING AND COVERING THE SEEDS**

i. Open small rills not deeper than 1 cm on the bed by passing the fingers over it.

ii. Sow 3.75 kg of seeds in 7.5 cents (0.5 kg / cent) and use increased seed rate upto 12.5 kg per ha in shootfly endemic area and transplant only healthy seedlings.

iii. Cover the seeds by smoothening out the rills with hand. Sprinkle 500 kg of FYM or compost evenly and cover the seeds completely with hands.

NOTE: Do not sow the seeds deep as germination will be affected.

7. **IRRIGATION TO THE SEED BED**

i. Provide one inlet to each unit so as to allow water in the channels.

ii. Allow water to enter the channel and turn off the water when the raised bed is completely wet.

iii. Irrigate as per the following schedule.

| | Light Soil | Heavy Soil |
|---|---|---|
| 1st | immediately after sowing | Immediately after sowing |
| 2nd | on 3rd day after sowing | On 3rd day after sowing |
| 3rd | on 7th day after sowing | On 9th day after sowing |
| 4th | on 12th day after sowing | On 16th day after sowing |
| 5th | on 17th day after sowing | |

8. **PROTECTION OF SEEDLINGS IN THE NURSERY FROM PEST ATTACK**

If seed bed is not treated before sowing, protect the nursery by applying any one of the insecticides given below on the 7th and 14th day of sowing by mixing in 6 litres of water. Endosulfan 35 EC 12ml ; Methyl demeton 25 EC 12 ml, Dimethoat 30 EC 12 ml.

Note:

1. The seedlings should not be kept in nursery for more than 18 days. Otherwise the establishment and yield will be affected adversely.
2. Ensure that cracks should not develop in the nursery. This can be avoided by properly adjusting the quantity of irrigation water.

## I. PREPARATION OF MAIN FIELD

1. **FIELD PREPARATION**

i. Plough with an iron plough twice and with country plough twice. Bring the soil into fine tilth.

ii. CHISELING FOR SOILS WITH HARD PAN: Chisel the soils having hard pan formation at shallow depths with chisel plough at 0.5m interval, first in one direction then in the direction perpendicular to the previous one, once in three years.

## 2. APPLICATION OF FYM OR COMPOST

Spread 12.5 t/ha of FYM or compost or composted coir pith uniformly on unploughed soil. Incorporate the manure by working the country plough and apply Azospirillum to the soil @ 10 packets per ha (2000 g) and 10 packets (2000g) of phosphobacteria (or) 20 packets (4000g) of azophos with 25kg of soil and 25 kg of FYM.

## 3. FORMING RIDGES AND FURROWS/BEDS

i. Form ridges and furrows (using 3 ridges) 6 m long and 45 cm apart. If pulses is intercropped, form ridges and furrows 6 m long and 30 cm apart.
ii. If ridge planting is not followed, form beds of the size 10 $m^2$ or 30 $m^2$ depending upon water availability.
iii. Form irrigation channels.
iv. To conserve soil moisture under rainfed condition, sow the seeds in flat and form furrows between crop rows during intercultivation on third week after sowing

## 4. APPLICATION OF FERTILIZERS

Apply NPK fertilizers as per soil test recommendations as far as possible. If soil test recommendation is not available follow the blanket recommendation of 70:35:35 kg N, $P_2O_5$, $K_2O$/ha for all varieties. For hybrids, apply 80 kg N, 40 kg $P_2O_5$ and 40 kg $K_2O$ per ha. Apply the recommended N in three splits as 25:50:25 per cent at 0.15 and 30 DAS and full dose of phosphorus and potassium basally. Combined application of azospirillum and phosphobacteria or azophos along with 75 per cent of the recommended level of N and P is recommended for rainfed conditions. Apply 30 kg S basally for S deficient soils.

**Method of application:** For transplanted crop, open a furrow more than 5 cm deep on the side of the ridge (1/3 distance from the bottom), place the fertilizer and cover. For the direct sown crop, mark the lines more than 5 cm deep 45 cm apart in the beds. Place the fertilizer below 5 cm depth and cover upto 2 cm from the top before sowing. In the case of intercropping with pulses, mark lines more than 5 cm deep 30 cm apart in the beds. Apply fertilizer only in the rows in which cumbu is to be sown and cover upto 2 cm. When azospirillum inoculant is used for seeds, seedlings use only 50 kg N/ha for variety, 60 kg N/ha for hybrid, as soil application in other words, reduce 25% N of soil test recommendations.

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yieldtargets. (ready reckoners are furnished )

**Pearl millet- Hybrid**

| | | |
|---|---|---|
| Soil : | Mixed black calcareous (Perianaickenpalayam series) | FN = 6.04 T - 0.49 SN - 0.80 ON<br>$FP_2O_5$ = 2.78 T - 1.65 SP - 0.97 OP |
| Target : | 3.0 – 4.0 t $ha^{-1}$ | $FK_2O$ = 3.29 T - 0.17 SK - 0.58 OK |

| Initial soil test value (kg $ha^{-1}$) | | | Yield target – 3 t $ha^{-1}$ | | | Yield target – 4 t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 180 | 15 | 300 | 40* | 25 | 20* | 98 | 52 | 53 |
| 200 | 20 | 325 | 40* | 20* | 20* | 89 | 44 | 48 |
| 220 | 25 | 350 | 40* | 20* | 20* | 79 | 36 | 44 |
| 240 | 30 | 375 | 40* | 20* | 20* | 69 | 28 | 40 |
| 260 | 35 | 400 | 40* | 20* | 20* | 59 | 19 | 36 |

* Maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

**5. APPLICATION OF MICRONUTRIENT MIXTURE**

Apply 12.5 kg/ha of micronutrient mixture formulated by the Department of Agriculture. Mix the mixture with enough sand to make 50 kg and apply on the surface just before planting/after sowing and cover the seeds. Broadcast the mixture on the surface of seed line (or) Apply TNAU MN mixture @ 12.5t/ha for irrigated and 7.5 kg/ha for rainfed crops as enriched FYM (prepare enriched FYM at 1:10 ratio of MN mixture and FYM at friable moisture and incubate for one month in shade). If micronutrient mixture is not available apply 25 kg of zinc sulphate per ha. Mix the chemical with enough sand to make 50 kg and apply as above. For Mn deficiency apply 12.5 kg $MnSO_4 ha^{-1}$ basally or foliar spraying of 0.2% $MnSO_4$ thrice can be followed.

## II. MANAGEMENT OF MAIN FIELD

**1. TRANSPLANTING SEEDLINGS OR SOWING PRE-TREATED SEEDS Transplanted Crop**

i. Pull out the seedlings when they are 15 to 18 days old.
ii. Adopt the spacing 45 x 15 cm for all the varieties / hybrids.
iii. Plant seedlings on the side of ridge, half way from the bottom. Depth of planting should be 3 to 5 cm.
iv. Root dipping with bio-fertilizers: Prepare the slurry with 5 packets (1000 g)/ha of Azospirillum inoculant and 5 packets (1000g/ha) of phosphobacteria or 10 packets of azophos (2000g/ha) in 40 lit. of water and dip the roots of the seedlings 15 - 30 minutes before planting.

**Direct sown crop**

Soaking of cumbu seeds either in 2% Potassium chloride (KCl) or 3% Sodium Chloride (NaCl) for 16 hours followed by 5 hours shade drying improves germination and stand.

i. Adopt the spacing of 45 x 15 cm for all varieties / hybrids. If pulse is intercropped, adopt a spacing of 30 x 15 cm for cumbu and 30 x 10 cm for pulses. One pair row of cumbu is alternated with a single row of pulse crop.
ii. In the furrows in which fertilizers have been applied, place 5 kg of seed, allowing them to fall 4 - 5 cm apart (Use higher seed rate of 5 kg to offset mortality). The optimum population should be 1,45,000 per ha. Use increased seed rate upto 12.5 kg per hectare in shoot fly endemic area and remove the shootfly damaged seedlings at the time of thinning.
iii. Where pulse seeds are to be sown, drop pulse seeds to fall 5 cm apart and cover.

**2. WEED MANAGEMENT Transplanted crop**

Spray PE Atrazine 0.25 kg/ha on 3 DAT followed by one hand weeding on 30 - 35 DAT. If herbicide is not used hand weeding twice on 15 DAT and 30 - 35 DAT.

**Direct Sown crop**

i. Apply the PE Atrazine 0.25 kg/ha on 3 DAS as spray on the soil surface using Back-pack/Knapsack/Rocker sprayer fitted with flat type nozzle using 500 litres of water/ha.
ii. Apply herbicide when there is sufficient moisture in the soil.
iii. Hand weeding 30 - 35 DAT if pre-emergence herbicide is applied.
iv. If pre-emergence herbicide is not applied hand weeding twice on 15 and 30 DAT.

**3. THINNING AND GAP FILLING**

In direct sown crop after 1st weeding at the time of irrigation, gap fill and thin the crop to a spacing of 15 cm between plants; cowpea crop to 20 cm between plants and other pulses crops to 10 cm between plants.

**4. TOP DRESSING OF FERTILIZERS**

i. Top dress the nitrogen at 15 and 30 days after transplanting or direct sowing.
ii. In transplanted crop, open a furrow 5 cm deep with a stick or hoe at the bottom of the furrow, place the fertilizer and cover.
iii. In the case of direct sown crop apply the fertilizer in band. If intercropped with pulses apply the fertilizer to cumbu crop only.
iv. After the application of fertilizer, irrigate the crop.

## III. WATER MANAGEMENT

| STAGES | Days after transplantation/sowing: Transplanted Crop | Direct Sown Crop |
|---|---|---|
| **Light Soils** | | |
| i. Germination | 1st day after transplanting | 1st day after sowing |
| | 4th day | 4th day |
| ii. Vegetative phase | 15th Day | 17th day |
| | 28th day | 30th day |
| iii. Flowering phase | 40th day | 42nd day |
| | 52nd day | 55th day |
| | 65th day | 68th day |
| iv. Maturity phase | 77th day | 79th day |
| Total | 8 irrigations | 8 irrigations |
| **Heavy Soils** | | |
| i. Germination | 1st day after planting | 1st day after sowing |
| | 4th day | 5th day |
| ii. Vegetative phase | 15th day | 15th day |
| | 28th day | 30th day |
| iii. Flowering phase | 42nd day | 45th day |
| | 54th day | 57th day |
| iv. Maturity Phase | 66th day | 70th day |
| Total | 7 irrigations | 7 irrigations |

NOTE: This is only a guideline and the irrigation schedule is to be adjusted depending upon the prevailing weather conditions.

## IV. HARVESTING THE CROP

**1. SYMPTOMS OF MATURITY**

i. Leaves will turn yellow and present a dried appearance.
ii. Grains will be hardened.

**2. HARVESTING**

i. Cut the earheads separately.
ii. Cut the straw after a week, allowing it to dry and stack it in the field till it can be transported.

**3. THRESHING, CLEANING, DRYING AND STORING**

i. Dry the earheads
ii. Thresh in a mechanical thresher or
iii. Spread it and drag a stone roller over it or

iv. Cattle thresh.
v. Dry the seeds below 10 per cent and mix 100 kg of grains with 1kg of activated kaolin to reduce the rice weevil and rice moth incidence.
vi. Spray Malathion 50EC 10 ml/ lit @ 3 lit of spray fluid/100 $m^2$ over the bags during storage godowns,
vii. For grain purpose the grain should be dried well below 10% moisture and stored in gunny bags.

**CROP PROTECTION**

**Protection of seedlings in the nursery from pest attack**

If seed bed is not treated before sowing, protect the nursery by applying any one of the insecticides given below on the 7th and 14th day of sowing by mixing in 6 litres of water; Methyl demeton 25 EC 12 ml, Dimethoate 30 EC 12 ml.

Note:

1. The seedlings should not be kept in nursery for more than 18 days. Otherwise the establishment and yield will be affected adversely.
2. Ensure that cracks should not develop in the nursery. This can be avoided by properly adjusting the quantity of irrigation water.

**A. PEST MANAGEMENT**

**Pest management strategies**

| Pest | Management strategies |
|---|---|
| **Shoot fly**<br>*Atherigona approximata* | ▪ Use seeds pelleted with insecticides (see sorghum)<br>▪ Seed treatment with imidacloprid 70 WS 10 g/kg of seeds<br>▪ Plough soon after harvest, remove and destroy the stubbles.<br>▪ Set up the TNAU low cost fish meal trap 12/ha till the crop is 30 days old.<br>▪ **Spray any one of the following :** Methyl demeton 25 EC 500 ml/ha Dimethoate 30 EC 500 ml/ha Neem seed kernel extract 5% |
| **Ear midge**<br>*Geromyia pennisetti* | ▪ **Apply any one of the following at 50 % flowering :**<br>Carbaryl 10 D 25 kg/ha<br>Malathion 5 D 25 kg/ha<br>Carbaryl 50 WP 750 g/ha or dimethoate 30 EC 600 ml/ha (500 l of spray fluid/ ha). |

**B. Disease Management**

**Seed treatment:**

- **For removal of ergot / sclerotia to prevent primary infection:**
  Dissolve 1 kg of common salt in 10 litres of water and add the seeds into the salt solution. Remove the floating ergot and sclerotia affected seeds. Wash the seeds in fresh water for 2 to 3 times to remove the salt, shade dry the seeds and treat the seeds with thiram @ 2 g /kg of seed.
- Treat the seeds with metalaxyl @ 6 g/kg for the management of downy mildew in endemic areas

| Name of the Disease | Recommendations |
|---|---|
| **Sugary or Ergot disease:** *Claviceps fusiformis* | • Spray carbendazim @ 500 g or mancozeb @1000 g /ha during 5 - 10% flowering and repeat at 50% flowering stage |
| **Rust:** *Puccinia substriata* | • Sow during December – May to reduce the level of incidence<br>• Spray wettable sulphur@ 2500 g / ha or mancozeb @ 1000 g/ha during initiation of disease symptom and repeat after 10 days, if necessary |
| **Downy Mildew:** *Sclerospora graminicola* | • Grow downy mildew resistant varieties CO (Cu) 9 and TNAU-Cumbu Hybrid-CO 9 and CO 10<br>• Transplant the seedlings to reduce the disease incidence<br>• Remove the infected seedlings in both transplanted and direct sown crop up to 45days<br>• Spray metalaxyl + mancozeb @ 500 g or mancozeb @ 1000 g/ha |

**Integrated management strategies for major pest and diseases of pearl millet**

Treat the seeds with metalaxyl @ 6 g/kg of seed + imidacloprid @ 5 g/kg of seeds + remove the downy mildew infected plants up to 45 days of sowing + spray mancozeb @ 1000 g/ha + spray NSKE 5% at 50% flowering to manage downy mildew, rust and shoot fly.

## CUMBU (PEARL MILLET) - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety, if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 200 m all around the field from the same and other varieties of pearl millet.

**Season**

- October - December and June - September.

**Pre-sowing seed treatment**

- Soak the seeds in 2 % KCl for 16 h at 1:1 ratio and dry back the seeds to original seed moisture content (8 - 9 %) under shade. This can be adapted both for the garden and dry land ecosystem.

**Fertilizer requirement**

- Apply NPK @ 100 : 50 : 50 kg / ha.
- Apply NPK @ 50 :50:50 kg / ha as basal and 50 kg N on 30 days after sowing as top dressing.

**Spacing**

- 45 x 20 cm.

**Foliar spray**

- Spray 1 % DAP at peak tillering stage to increase seed filling.

**Harvesting**

- Seeds attain physiological maturity at 27 - 30 days after 50 % flowering.
- Harvest the earheads when the seed attained the characteristic pale green colour, as once over harvest at 20 - 25 % moisture content.
- Harvest the crop two times when the tillers number is more.
- Earheads from late-formed tillers (after 7 earheads from first formed tillers) should not be selected for seed purpose.

**Threshing**

- Thresh the earheads either manually or mechanically at moisture content of 15 - 20%.

**Drying**

- Dry the seeds either under sun or using mechanical hot air driers to reduce the moisture content to 10%.

**Seed grading**

- Grade the seeds with 4 / 64” (or) 5 / 64” round perforated metal sieve for grading.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed (or)
- Treat the seeds with halogen mixture @ 3 g / kg ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1) as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 10 - 12 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

## CUMBU (PEARL MILLET) - HYBRID SEED PRODUCTION

**Land requirement**

- Select fertile land with good drainage and irrigation facilities.
- Field should not have volunteer plants. Hence, the previous crop should not be the same or different variety / hybrid of pearl millet.

**Isolation**

- All around the field, leave 200 m distance from same and other varieties / hybrids of pearl millet.

**Season**

- October - November and June - July.

**Spacing**

- 45 x 20 cm.

**Planting ratio**

- Sow the female and male lines in the ratio of 8 : 2 to 12 : 2 depending upon the hybrids.

**Fertilizer requirement**

- Apply NPK @ 120:60:60 kg / ha as basal application.

**Foliar spray**

- Spray 2 % DAP at peak tillering stage for enhanced seed set.

**Synchronization techniques**

- Stagger the sowing of male and female parents depending upon the hybrid and location.

**Harvesting**

- Harvest the male parent (R line) first and remove from the field.
- Harvest the hybrid crop when 90 % seeds on the ear head have attained the characteristic pale green colour.

## (ii) **RAGI (***Eleusinecoracana*)

### CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 8 - 10 | 25 - 35 | 500 - 1000 | up to 2100 |

Tropical and sub tropical. It is a heat loving plant and requires minimum of 8 - 10°C for germination, 26 - 29°C for the growth. Does not tolerate heavy rainfall and requires a dry spell during grain ripening. Short day plant.

### CROP IMPROVEMENT

### SEASONS AND VARIETIES

<table>
<tr><th>Sl. No.</th><th>Agro ecological zones</th><th>Districts</th><th>Season</th><th>Varieties</th></tr>
<tr><td>1</td><td>North Eastern Zone</td><td>Vellore, Thiruvannamalai, Cuddalore, Villupuram, Thiruvallur and Kancheepuram</td><td>Dec-Jan (Marghazipattam)<br>April-May (Chithiraipattam)<br>June-July (Adipattam)</td><td>CO (Ra) 14<br>CO 15</td></tr>
<tr><td>2</td><td>North Western Zone</td><td>Salem, Namakkal, Dharmapuri and Krishnagiri</td><td>Dec-Jan (Marghazipattam)<br>April-May (Chithiraipattam)<br>June-July (Adipattam)</td><td>CO (Ra) 14<br>CO 15<br>Paiyur 2</td></tr>
<tr><td>3</td><td>Western Zone</td><td>Coimbatore, Erode, Karur, Tiruppur and Dindigul</td><td>Dec-Jan (Marghazipattam)<br>April-May (Chithiraipattam)<br>June-July (Adipattam)</td><td rowspan="2">CO (Ra) 14<br>CO 15</td></tr>
<tr><td>4</td><td>Cauvery Delta Zone</td><td>Trichy, Thanjavur, Thiruvarur, Nagapattinam, Pudukkottai, Perambalur and Ariyalur</td><td>Dec-Jan (Marghazipattam)<br>April-May (Chithiraipattam)<br>June-July (Adipattam)</td></tr>
<tr><td>5</td><td>Southern Zone</td><td>Madurai and Theni</td><td>Dec-Jan (Marghazipattam)<br>April-May (Chithiraipattam)<br>Sep-Oct (Puratassipattam)</td><td rowspan="3">CO (Ra) 14<br>CO 15</td></tr>
<tr><td></td><td></td><td>Sivagangai, Virudhunagar, Ramanathapuram, Tirunelveli and Thoothukudi</td><td>Sep-Oct (Puratassipattam)</td></tr>
<tr><td>6</td><td>Hilly and High Altitude Zone</td><td>Ooty</td><td>Dec-Jan (Marghazipattam)<br>June-July (Adipattam)<br>Sep-Oct (Puratassipattam)</td></tr>
</table>

### I. PARTICULARS OF RAGI VARIETIES

| PARTICULARS | Paiyur 2 | CO (Ra) 14 | CO 15 |
|---|---|---|---|
| Year of Release | 2008 | 2013 | 2015 |
| Year of Notification | SO.2187(E)/27.08.2009 | SO.1177(E)/25.08.2005 | SO.2805(E)/25.08.2017 |
| Parentage | VL 145 x Selection 10 | Malawi 1305 x CO 13 | CO 11 x PR 202 |
| Duration (days) | 115 | 105-110 | 120 – 125 |

| | | | |
|---|---|---|---|
| Rainfed/ Irrigated | Rainfed | Both | Both |
| Grain yield (kg/ha) | | | |
| Irrigated | -- | 2892 | 3461 |
| Rainfed | 2527 | 2794 | 2950 |
| Straw yield (kg/ha) | | | |
| Irrigated | -- | 8113 | 6698 |
| Rainfed | 4200 | 8503 | 5030 |
| Stem | Erect | Erect | Erect |
| Height (cm) | 90 | 115-120 | 95-100 |
| Tillers | 3-4 | 8-9 | 5-7 |
| Days to 50% flowering | 81 | 72 | 84-88 |
| Ear size and shape | Incurved | Top curved | Large, Compact fingers top curved |
| Fingers | 7-8 | 9-12 | 8-11 |
| Ear length (cm) | 7.0 | 10-12 | 9-12 |
| Grain colour | Brown | Brown | Copper brown |
| 1000 grain wt (g) | 2.9 | 3.1 | 3.2 |

## CROP MANAGEMENT

## I. PREPARATION OF NURSERY (IRRIGATED TRANSPLANTED CROP)

### 1. PREPARATION OF LAND

i. For raising seedlings to plant one ha of main field, select 12.5 cents (500 $m^2$ ) of nursery area near a water source, where water does not stagnate.

ii. Mix 37.5 kg of super phosphate with 500 kg of FYM or compost and spread the mixture evenly on the nursery area.

iii. Plough two or three times with a mould board plough or five times with a country plough.

### 2. FORMING RAISED BED

i. Mark units of 6 plots each of size 3 m x 1.5 m. Provide 30 cm space between plots for irrigation.

ii. Excavate the soil from the interspace and all around to a depth of 15 cm to form channels and spread the soil removed from the channels on the bed and level.

### 3. PRE-TREATMENT OF THE SEEDS WITH FUNGICIDES

i. Seed treatment with Azospirillum may be done @ 3 packets/ha (600 g/ha) and 3 packets (600 g/ha) of Phosphobacteria or 6 packets of Azophos (1200 g/ha).

ii. Mix the seeds in a polythene bag to ensure a uniform coating of seeds with Thiram 4 g/ kg or Captan 4 g/kg or Carbendazim 2 g/kg of seeds.

### 4. SOWING AND COVERING THE SEEDS

i. Make shallow rills not deeper than one cm on the beds by passing the fingers vertically over them.

ii. Broadcast 5 kg of treated hand seeds evenly on the beds.
iii. Cover the seeds by the hand lightly over the soil.
iv. Sprinkle 500 kg of powdered FYM over the beds evenly to cover the seeds which are exposed and compact the surface lightly.

NOTE: Do not sow the seeds deep as germination will be adversely affected.

**5. WATER MANAGEMENT**

i. Provide one inlet to each nursery unit.
ii. Allow water to enter so as to cover all the channels around the bed. Allow the water in the channel to raise till the raised beds are fully wet and then cut off water.
iii. Adjust the frequency of irrigation according to the soil type.

| No. of irrigations | RED SOILS | HEAVY SOILS |
|---|---|---|
| 1st | Immediately after sowing | Immediately after sowing |
| 2nd | 3rd day after sowing | 4th day after sowing |
| 3rd | 7th day after sowing | 9th day after sowing |
| 4th | 12th day after sowing | 16th day after sowing |
| 5th | 17th day after sowing | |

NOTE:

1. One irrigation is given on the 3rd day in the case of red soil to soften the hard crust formed on the soil surface and also to facilitate seedlings to emerge out.
2. Do not allow cracks to develop in the nursery bed by properly adjusting the quantity of irrigation water.

**6. PULLING OUT THE SEEDLINGS FOR PLANTING**

Pull out seedlings on the 17th to 20th day of sowing for planting.

## II. PREPARATION OF MAIN FIELD

**1. PLOUGHING THE FIELD**

Plough twice with mould board plough or thrice with wooden plough till a good tilth is obtained.

**2. APPLICATION OF FYM OR COMPOST**

Spread 12.5 t/ha of FYM or compost or composted coir pith evenly on the unploughed field and then plough and incorporate in the soil. NOTE: Do not spread and leave the manure uncovered in the field as nutrients will be lost.

## 3. APPLICATION OF FERTILIZERS

In soils having high intensive cropping system viz., Ragi-Maize-Cowpea, having high soil available K (310 kg/ha) potassium need not be applied.

- If soil test recommendation is not available, adopt a blanket recommendation of 60 kg N, 30 kg $P_2O_5$ and 30 kg $K_2O$ per ha.
- Apply half the dose of N and full dose of $P_2O_5$ basally before sowing and the remaining 50% in two equal splits at 25-30 and 40-45 days after sowing is recommended.
- Broadcast the fertilizer mixture over the field before the last ploughing and incorporate into the soil by working a country plough.

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished )

**Ragi (1)**

Soil : Mixed black calcareous (Perianaickenpalayam series)

Target : 3.5 - 4.0 t $ha^{-1}$

FN = 4.35T-0.37 SN-0.98 ON

$FP_2O_5$ = 1.18T-1.03 SP-0.80 OP

$FK_2O$ = 2.68T-0.14SK-0.40 OK

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 3.5 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 4.0t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 180 | 12 | 300 | 34 | 15* | 15* | 55 | 15* | 25 |
| 200 | 14 | 340 | 30* | 15* | 15* | 48 | 15* | 20 |
| 220 | 16 | 380 | 30* | 15* | 15* | 41 | 15* | 15* |
| 240 | 18 | 420 | 30* | 15* | 15* | 33 | 15* | 15* |
| 260 | 20 | 460 | 30* | 15* | 15* | 30* | 15* | 15* |

* Maintenance dose

**Ragi (2)**

Soil : Red sandy loam (Somayanur series)

Target : 3.5 – 4.0t $ha^{-1}$

FN =4.94T-0.55 SN

$FP_2O_5$=1.36T-0.96 SP

$FK_2O$=4.20T-0.46 SK

| Initial soil test value (kg $ha^{-1}$) | | | Yield target – 3.5 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 4.0 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 160 | 33 | 15* | 33 | 58 | 15* | 54 |
| 180 | 14 | 180 | 30* | 15* | 24 | 47 | 15* | 45 |
| 200 | 16 | 200 | 30* | 15* | 15* | 36 | 15* | 36 |
| 220 | 18 | 220 | 30* | 15* | 15* | 30* | 15* | 27 |
| 240 | 20 | 240 | 30* | 15* | 15* | 30* | 15* | 18 |

* Maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

Apply 10 packets/ha (2000 g) of Azospirillum and 10 packets (2000 g/ha) of Phosphorous solubilizing bacteria or 20 packets of Azophos (4000 g/ha) after mixing with 25 kg of soil and 25 kg FYM before transplanting. Apply TNAU MN mixture @12.5 kg/ha for irrigated and 7.5 kg/ha for rainfed crops as enriched FYM (prepare enriched FYM at 1:10 ratio of MN mixture and FYM at friable moisture and incubate for one month in shade.

**4. FORMING BEDS AND CHANNELS**

i. Form beds of size 10 $m^2$ to 20 $m^2$ according to topography of the field.
ii. Provide suitable irrigation channels.

**5. APPLICATION OF MICRONUTRIENTS**

Mix 12.5 kg of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu with enough sand to make a total quantity of 50 kg/ha (or) Apply the mixture evenly on the beds. (or) For alleviating Zn deficiency in plants, spray 0.5% $ZnSO_4$ on 30, 40 and 50 days after sowing. For specific micronutrient deficiencies, apply 25 kg $ZnSO_4$, 10 kg $CuSO_4$ and 50 kg $FeSO_4$ + 12.5 t FYM /ha can be followed.

## III. MANAGEMENT OF MAIN FIELD

**1. TRANSPLANTING THE SEEDLINGS**

i. Let water into the bed, level the bed, if it is not levelled.
ii. Plant 2 seedlings per hill.
iii. Plant the seedlings at a depth of 3 cm.
iv. Plant 18 to 20 days old seedlings.
v. Adopt a spacing of 30x10 cm for planting.
vi. Adopt 22.5 x 10 cm spacing for direct sowing.
vii. Root dipping with Azospirillum: Prepare slurry with 5 packets (1000 g/ha) of Azospirillum and 5 packets (1000g/ha) of Phosphobacteria or 10 packets of Azophos (2000 g/ha) in 40 litres of water and dip the root portion of the seedlings in the solution for 15-30 minutes and transplant.

**2. WEED MANAGEMENT**

i. Apply PE Oxyfluorfen @ 0.05 kg /ha on 3 DAS using Backpack Knapsack/Rocker sprayer fitted with flat fan type of nozzle with 500 litre of water/ha followed by one hand weeding on 20 DAS.
ii. Apply the herbicides when there is sufficient moisture in the soil or irrigate immediately after application of herbicide.
iii. If pre-emergence herbicide is not applied, hand weed twice on 10th and 20th DAT.
iv. For rainfed direct seeded crop, apply post emergence herbicide; 2,4-DEE or 2,4-D Na salt at
0.5 kg/ha on 10 DAS depending on the moisture availability.

**3. HOEING AND HAND WEEDING**

i. Hoe and hand weed on the 15th day of planting in light soils and 17th day of planting in heavy soils and subsequently on 30th and 32nd days, respectively.

ii. Allow the weeds to dry for 2 or 3 days after hand weeding before giving irrigation. NOTE: Do not adopt hoeing and hand weeding if herbicide is applied.

## IV. WATER MANAGEMENT

**Regulate irrigation according to the following growth phases of the crop**

| Stages/ Phase | No. of irrigations | Crop duration days | | |
|---|---|---|---|---|
| | | 80 | 100 | 120 |
| Vegetative phase (Nursery) | As per soil type | 1 to 16 | 1 to 18 | 1 to 20 |
| Vegetative phase (main field) | | 1 to18 | 1 to 20 | 1 to 22 |
| Flowering phase | | 19 to 40 | 21 to 55 | 23 to 69 |
| Maturity phase | | Beyond 40 days | Beyond 55 days | Beyond 69 days |
| **Heavy soils** | | | | |
| Establishment | 1 | 1st day | 1st day | 1st day |
| (1-7 days) | 2 | 5th day | 5th day | 5th day |
| Vegetative phase | 1 | 18th day | 20th day | 20th day |
| (8-20 days) | 2 | 31st day | 33rd day | 30th day |
| Flowering phase | 1 | 41st day | 42nd day | 37th day |
| (21-55 days) | 2 | 51st day | 52nd day | 44th day |
| | 3 | -- | -- | 63rd day |
| Maturity phase | 1 | 61st day | 62nd day | 78th day |
| (56-120 days) | 2 | -- | -- | 93rd day |
| Stop irrigation thereafter | | | | |
| **Light soils** | | | | |
| Establishment | 1 | 1st day | 1st day | 1st day |
| (1 – 7 days) | 2 | 5th day | 5th day | 5th day |
| Vegetative phase | 1 | 15th day | 16th day | 16th day |
| (8 - 20 days) | 2 | 26th day | 28th day | 28th day |
| Flowering phase | 1 | 36th day | 36th day | 36th day |
| (21 - 55 days) | 2 | 45th day | 45th day | 45th day |
| | 3 | -- | 54th day | 54th day |
| Maturity phase | 1 | 58th day | 69th day | 78th day |
| (56 - 120 days) | 2 | 70th day | 85th day | 93rd day |

**NOTE:** The irrigation schedule is given only as a general guideline. Regulate irrigation depending upon the prevailing weather conditions and receipt of rain.

## V. HARVESTING

**1. DECIDE WHEN TO HARVEST**

i. Ragi crop does not mature uniformly and hence the harvest is to be taken up in two stages.

ii. When the earhead on the main shoot and 50% of the earheads on the crop turn brown, the crop is ready for the first harvest.

**2. HARVEST OF THE CROP First harvest**

i. Cut all earheads which have turned brown.
ii. Dry, thresh and clean the grains by winnowing.

**Second Harvest**

i. Seven days after the first harvest, cut all the earheads including the green ones.
ii. Cure the grains to obtain maturity by heaping the harvested earheads in shade for one day without drying, so that the humidity and temperature increase and the grains get cured.
iii. Dry, thresh and clean the grains by winnowing and store the grains in gunnies.

**Threshing**

Green earheads if harvested will contaminate the seeds with immature seeds and interfere cleaning, drying and grading. Dry earheads until seed moisture content reaches 15% and separate manually by threshing with bamboo stick or machine thresher.

**Precleaning and drying**

Threshed seeds should be precleaned before sundrying, seeds must be dried to 12% moisture content before grading.

**Protection from storage pests**

1. Grain purpose: Dry the seeds adequately to reduce the moisture level to 10%.
2. Seed purpose: Admix one kg of Activated kaolin or Malathion 5% D for every 100 kg of seed. Pack in gunny or polythene lined gunny bags for storage.

**Special problems**

i. Root Aphids: Mix Dimethoate 3 ml in one litre of water and drench the rhizosphere of the infested and surrounding plants with the insecticidal solution.
ii. Rainfed ragi: Azospirillum mixed with FYM and applied to field saves the cost of nitrogen by 50% with a comparable yield obtained with 40 kg N/ha.
iii. Management of aged seedlings of ragi under rainfed conditions: When planting **ragi** seedlings beyond 21 days, increase the number of seedlings to 3/hill and increase N level by 25% to minimise yield loss.
iv. Apply VAM culture (*Glomus fasciculatum*) at 100 g/$m^2$ in the nursery and also treat with Azospirillum and Phosphobacterium as seed treatment, seedling dip and field application to reduce the reniform nematode population in ragi.

**RAGI : RAINFED**

**Rainfall**

Average and well distributed rainfall of 450-500 mm is optimum for rainfed ragi

**Season**

Finger millet is grown in different seasons in different parts of the country. As a rainfed crop, it
is normally sown in June- July in Tamil Nadu. It also grown in winter season (rabi) by planting in September – October in Tamil Nadu and as a summer irrigated crop by planting January – February.

**Tillage**

Fall ploughing is advantageous for moisture conservation. In the month of April or May, one deep ploughing with mould board plough followed by ploughing with wooden plough twice is necessary. Before sowing secondary tillage with cultivator and multiple tooth hoe to prepare smooth seed bed is necessary.

**Seed rate and planting**

A plant population of 4 – 5 lakhs per ha is optimum for getting higher yields and higher or lower population than the optimum will reduce the yield. Line sowing is ideal and seed drills giving spacing of 22.5 – 30 cm between rows should be used. Finger millet seeds are very small (400 seeds/g) and the recommended seed rate is 10 kg/ha. Therefore, even when seed drill is used thinning within the row leaving a spacing of 7.5 – 10 cm between plants, must be followed.

Sowing by seed-cum-fertilizer drill is advantageous for line sowing besides efficient utilization of applied nutrients.

Maintenance of optimum plant population is an important prerequisite for getting higher yield under rainfed conditions. Poor germination, often, is the result of inadequate moisture after sowing in low rainfall areas. Under these conditions, the adoption of a simple technique like seed hardening will not only improve germination and subsequent plant stand but also impart early seedling vigour and tolerance to drought.

The procedure of seed hardening technique is as follows.

1. Sole seeds in water for 6 hours. Use one litre water for every kg seed for soaking.
2. Drain the water and keep the seeds in wet cloth bag tightly tied for two days.
3. At this stage, the seeds will show initial signs of germination.
4. Remove seeds from the wet cloth bag and dry them in shade on a dry cloth for 2 days.
5. Use the above hardened seeds for sowing.

**Manuring and fertilization**

Finger millet responds well to fertilizer application especially to N and P. The recommended doses of fertilizers vary from state to state for rainfed crop. Recommended dose of 40:20:20 kg/ha N:P:K was applied. With judicious application of farmyard manure inorganic fertilizer efficiency is enhanced. Entire $P_2O_5$ and $K_2O$ are to be applied at sowing, whereas nitrogen is to be applied in two or three split doses depending upon moisture availability. In areas of good rainfall and moisture availability, 50% of recommended nitrogen is to be applied at sowing and the remaining 50% in two equal splits at 25-30 and 40-45 days after sowing. In areas of uncertain rainfall, 50% at sowing and the remaining 50% around 35 days after sowing is recommended.

**Bio-fertilizers**

Treating seeds with *Azospirillum brasilense* (N fixing bacterium) and *Aspergillus awamori* (P solubilizing fungs) @ 25 g/kg seed is beneficial. In case seeds are to be treated with seed dressing chemicals, treat the seeds first with seed dressing chemicals and then with bio-fertilizers at the time of sowing.

**Procedures for inoculating seeds with biofertilizers**

1. Bio-fertilizer culture specific to the crop is to be used @ 25 g per kg of seed.
2. Sticker solution is necessary for effective seed inoculation. This can be prepared by dissolving 25 g jaggery or sugar in 250 ml water and boiling for 5 minutes. The solution thus prepared is cooled.
3. Smear the seeds well using the required quantity of sticker solution. Then add culture to the seeds and mix thoroughly so as to get a fine coating of culture on the seed.
4. The culture-coated seeds is to be dried well in shade to avoid clumping of seeds.
5. Use the inoculated seeds for sowing.

**Weed control**

i. In line sown crop 2-3 inter-cultivations are necessary. In assured rainfall and irrigated areas spraying 2,4-D sodium salt @ 0.75 kg.a.i./ha as post-emergent spray on 20-25 days after sowing effectively controls weeds.
ii. Apply, Isoproturon @ 0.5 a.i/ha as pre-emergence on 3 DAS is also effective in control of weeds. In broadcast crop two effective hand weedings will minimize weeds as inter cultivations is not possible.
iii. For direct sown rainfed ragi post-emergence application of 2, 4 D Na salt (or) EE formulation at 0.5 kg $ha^{-1}$ applied on 10 days after sowing and at 0.75 kg $ha^{-1}$ applied on 15 days after sowing will give effective weed control as well as higher grain yield.

**Cropping systems Crop rotation**

Rotation with legumes like greengram / blackgram / field bean / soybean / horse gram or ground nut in southern state will minimize inorganic fertilizer application and also sustain higher yields.

**Intercropping**

Finger millet based inter cropping system with pigeon pea at 4:1 ratio is recommended for rainfed situation to obtain high grain yield

**CROP PROTECTION**

**A. Pest Management**

| | |
|---|---|
| **Aphids** *Schizaphis graminum, Rhopalosiphum maidis* | Spray dimethoate 30EC 20 ml per 5 cent nursery |
| **Stem borer** *Sesamia inferens* | Apply carbofuran 3CG 50 kg/ha in leaf whorls |
| **Root aphid** *Tetraneura nigriabdominalis* | Drench dimethoate 30EC 1:1 (with water) in the rhizosphere of infested and surrounding plants |
| **Ear head bug** *Calocoris angustatus* | **Apply any one of the following/ha on 3rd and 18th day after panicle emergence**<br>• Malathion 5D 25 kg<br>• Neem seed kernel extract 5%<br>• Malathion 50EC 500 ml/ha (twice at 10% heading and 9 days after) |

**B. DISEASE MANAGEMENT**

**Nursery:**

Treat the seeds with thiram or captan @ 4 g or carbendazim @ 2 g/kg or *Pseudomonas fluorescens* @ 10 g/kg of seed.

**Main field:**

| Name of the Disease | Recommendations |
|---|---|
| **Blast:** *Pyricularia grisea* | • Spray carbendazim @ 500 g or iprobenphos(IBP) @ 500 ml/ha immediately after symptom development and repeat at flowering stage and 15 days later to manage neck and finger blast<br>• Spray aureofungin sol 100 ppm (100 mg/l) at 50% ear head emergence followed by spray with mancozeb 1000 g/ha or *Pseudomonas fluorescens* @ 0.2% ten days later<br>• Two sprays of tricyclazole 75% WP @ 500 g/ha at maximum tillering and heading stages |
| **Virus diseases**<br>**Mosaic and Mottle streak** | • Rogue out the virus infected plants<br>• Spray methyl demeton 25EC @ 500 ml/ha on noticing symptoms and repeat twice at 20 days interval, if necessary |

## RAGI (FINGER MILLET) - VARIETAL SEED PRODUCTION

**Land Requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 3 m all around the field from the same and other varieties of the finger millet.

**Pre-sowing seed treatment**

- Soak the seeds in 0.5 % $CaCl_2$ for 6 h at 1:1 ratio and dry back the seeds to original seed moisture content (8 - 9 %) under shade. This can be adapted both for the garden and dry land ecosystem.
- Treat the graded seed with carbendazim @ 2 g / kg of seed.

**Nursery sowing**

- In raised bed, sow the seeds not deeper than 1 cm and sprinkle with 200 kg of powdered FYM. Lightly level and compact the surface of nursery.

**Harvesting**

- Harvest the crop in 2 harvests.
- First harvest should be taken up when 50 % of seeds in the ear-heads have attained the characteristic brown colour.
- Second harvest should be taken up a week to ten days after first havest, when all the remaining earheads turned brown (spikelets are non-shattering).

**Threshing**

- Dry the earheads until the seed moisture content is reduced to 15 % and seeds are separated manually by threshing with pliable bamboo stick or machine thresher.
- Pre-clean the threshed seeds before sun drying.
- Dry the seeds to 12 % moisture content before grading.

**Seed grading**

- Grade the seeds either with BSS 10 x 10 or BSS 12 x 12 depending upon the variety.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 10 to 12 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 to 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

# (i) MAIZE (*Zea mays* L.)

**CLIMATE REQUIREMENT**

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 - 44 | 6 - 7 | 21 - 32 | 500 - 750 | up to 3000 |

Tropical and sub tropical. Minimum temperature for germination is 6 - 7°C, suitable temperature for germination and growth is 21 - 23 and 30 - 32°C, respectively. Day neutral plant.

## CROP IMPROVEMENT
## SEASON AND VARIETIES

| Sl. No. | Agro ecological zones | Districts | Season | Hybrids |
|---|---|---|---|---|
| 1 | North Eastern Zone | Vellore, Thiruvannamalai, Cuddalore, Villupuram, Thiruvallur, Kancheepuram | Jan-Feb (Thaipattam)<br>April - May Chithiraipattam)<br>June-July (Adipattam)<br>Sep-Oct (Puratassipattam) | Hybrid CO 6 and COH(M) 8 |
| 2 | North Western Zone | Salem, Namakkal, Dharmapuri, Krishnagiri | | |
| 3 | Western Zone | Coimbatore, Erode, Karur, Tiruppur, Theni and Dindigul | | |
| 4 | Cauvery Delta Zone | Trichy, Thanjavur, Thiruvarur, Nagapattinam, Pudukkottai<br>Perambalur and Ariyalur | Jan-Feb (Thaipattam)<br>April - May Chithiraipattam)<br>June-July (Adipattam) | |
| 5 | Southern Zone | Madurai and Virudhunagar | Jan-Feb (Thaipattam)<br>June-July (Adipattam)<br>Sep-Oct(Puratassipattam) | |
| | | Sivagangai, Ramanathapuram, Tirunelveli and Thoothukudi | Sep-Oct(Puratassipattam) | |
| 6 | High rainfall zone | Kanyakumari | Jan-Feb (Thaipattam)<br>June-July (Adipattam)<br>Sep-Oct(Puratassipattam) | |
| 7 | Hilly and High Altitude Zone | Ooty | Jan-Feb (Thaipattam)<br>June-July (Adipattam)<br>Sep-Oct(Puratassipattam) | |

**II. PARTICULARS OF MAIZE HYBRIDS**

| PARTICULARS | CO 6 | COH(M) 8 |
|---|---|---|
| Year of Release | 2012 | 2014 |
| Year of Notification | SO.1708(E)/26.07.2012 | SO.1919(E)/30.07.2014 |
| Parentage | UMI 1200 x UMI 1230 | UMI 1201 x UMI1230 |
| Duration (days) | 110 | 85 – 95 |
| Area of adaption | All maize growing areas | All maize growing areas |
| Rainfed/Irrigated | Both | Both |
| **Grain yield (kg/ha)** | | |
| Irrigated | | 7600 |
| Rainfed | 5500 | 5500 |
| Special features | High shelling (81%) with high test weight (40 g /100 seeds). Multiple disease resistance to sorghum downy mildew, *Maydis* leaf blight, *Turcicum* leaf blight, Post flowering stock rot and Banded leaf and sheath blight. Moderately resistant to stem borer. | Medium maturity hybrid, grains are bold, orange yellow in colour and semi dent type. Single cross normal corn. Multiple disease resistance *viz*. MLB, TLB, RDM, DM and moderately resistant to PFSR and *polysora* rust under artificial Conditions. Moderately resistant to stem borer *(chilo partellus*) and resistant to cyst nematode *(Heterodera zeae).* |
| Stem Colour | Green | Green |
| Leaf: Anthocyanin Colouration of sheath | Present | Present |
| Ear: Anthocyanin Colouration of silk | Present | Present |
| Cob size | Big | Big |
| Ear: Husk Coverage | Fully covered | Fully covered |
| Colour of top of Grains | Orange Yellow | Orange yellow |
| Type of kernels | Semi dent | Semi dent |

## CROP MANAGEMENT

## i. IRRIGATED MAIZE

### 1. APPLICATION OF FYM OR COMPOST

Spread 12.5 t/ha of FYM or compost or composted coir pith evenly on the unploughed field along with 10 packets of Azospirillum (2000 g/ha) and incorporate in the soil.

### 2. FIELD PREPARATION

Plough the field with disc plough once followed by cultivator ploughing twice, after spreading FYM or compost till a fine tilth is obtained.

### 3. FORMING RIDGES AND FURROWS OR BEDS

Form ridges and furrows providing sufficient irrigation channels. The ridges should be 6 m long and 60 cm apart.

If ridges and furrows are not made, form beds of size 10 $m^2$ or 20 $m^2$ depending on the availability of water.

Use a bund former or ridge plough to economise cost of production.

## 4. APPLICATION OF FERTILIZERS

i. Soil test crop response based integrated plant nutrition system (STCR- IPNS) I If soil test recommendation is not available adopt a blanket recommendation of 135:62.5:50 Kg/NPK $ha^{-1}$ for varieties and 250:75:75 kg NPK $ha^{-1}$ for hybrid maize
ii. Apply quarter of the dose of N; full dose of $P_2O_5$ and $K_2O$ basally before sowing.
iii. In the case of ridge planted crop, open a furrow 6 cm deep on the side of the ridge, at two thirds the distance from the top of the ridge.
iv. Apply the fertilizer mixture along the furrows evenly and cover to a depth of 4 cm with soil.
v. If bed system of planting is followed, open furrows 6 cm deep at a distance of 60 cm apart.
vi. Place the fertilizer mixture along the furrows evenly and cover to a depth of 4 cm with soil.

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished )

**Maize - Hybrid (1)**

Soil : Red sandy loam (Palaviduthi series)

Target : 9 – 10 t $ha^{-1}$

F N = 3.96 T – 0.62 SN – 0.69 ON

$FP_2O_5$= 1.56 T – 1.93 SP – 0.60 OP

$FK_2O$ = 1.66 T – 0.27 SK – 0.49 OK

| **Initial soil test values (kg $ha^{-1}$)** | | | **Yield target – 9 t $ha^{-1}$** | | | **Yield target – 10 t $ha^{-1}$** | | |
|---|---|---|---|---|---|---|---|---|
| | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 14 | 200 | 177 | 83 | 65 | 217 | 99 | 82 |
| 220 | 16 | 220 | 165 | 80 | 60 | 205 | 95 | 77 |
| 240 | 18 | 240 | 153 | 76 | 55 | 192 | 91 | 71 |
| 260 | 20 | 260 | 140 | 72 | 49 | 180 | 87 | 66 |
| 280 | 22 | 280 | 128 | 68 | 44 | 167 | 84 | 60 |

**Maize - Hybrid (2)**

Soil : Mixed black calcareous (Perianaickenpalayam series)

Target : 9 – 10 t $ha^{-1}$

F N = 4.01 T – 0.76 SN – 0.83 ON

$FP_2O_5$= 1.57 T – 2.71 SP – 0.61 OP

$FK_2O$ = 2.09 T – 0.26 SK – 0.65 OK

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 9 t $ha^{-1}$ | | | Yield target – 10 t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 14 | 300 | 154 | 73 | 80 | 194 | 89 | 101 |
| 220 | 16 | 350 | 139 | 68 | 67 | 179 | 84 | 88 |
| 240 | 18 | 400 | 125* | 63 | 54 | 164 | 78 | 75 |
| 260 | 20 | 450 | 125* | 57 | 41 | 148 | 73 | 62 |
| 280 | 22 | 500 | 125* | 52 | 38* | 133 | 67 | 49 |

* Maintenance dose

**Maize- Hybrid (3)**

Soil : Black calcareous (Pilamedu series)

Target : 10 – 11t $ha^{-1}$

F N = 3.78 T – 0.78 SN – 0.89 ON

$FP_2O_5$= 1.47 T – 2.02 SP – 0.91 OP

$FK_2O$ = 1.79 T – 0.14 SK – 0.62 OK

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 10 t $ha^{-1}$ | | | Yield target – 11 t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 180 | 12 | 400 | 178 | 91 | 91 | 215 | 105 | 109 |
| 200 | 14 | 450 | 162 | 87 | 84 | 200 | 101 | 102 |
| 220 | 16 | 500 | 146 | 83 | 77 | 184 | 97 | 95 |
| 240 | 18 | 550 | 131 | 79 | 70 | 169 | 93 | 88 |
| 260 | 20 | 600 | 125* | 75 | 63 | 153 | 89 | 81 |

*****maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

When Azospirillum is used as seed and soil application, apply 100 kg of N/ha (25% reduction on the total N recommended by soil test).

**Defieciency symptoms**

| | | |
|---|---|---|
| Nitrogen deficiency | : | Leaves become yellow, older leaves show drying at the tips which progress along mid veins, stalks become slender. |
| Phosphorus deficiency | : | Leaves are purplish green during early growth. Growth spindly, slow maturity, irregular ear formation. |
| Potassium deficiency | : | Leaves show yellow or yellowish green streaks, become corrugated. Tips and marginal scorch. Tips end in ears are poorly filled. Stalks have short internode. Plants become weak and may fall down. |
| Magnesium deficiency | : | Older leaves are the first to become chlorotic at margins and between veins. Streaked appearance of leaves. Necrotic or chlorotic spots seen in leaves. |
| Zinc deficiency | : | Older leaves have yellow streaks or chlorotic striping between veins. In several cases, unfolding of young leaves, which may be white or yellow. |
| Iron deficiency | : | Interveinal chlorosis. The entire crop may exhibit bleached appearance. |

**5. APPLICATION OF MICRONUTRIENT**

i. 12.5 kg of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu, mixed with sand to make a total quantity of 50 kg/ha is to be applied. (or)

ii. Apply TNAU MN mixture @ 30 kg/ha as enriched FYM (Prepare enriched FYM at 1:10 ratio MN mixture and FYM; mix at friable moisture and incubate for one month in shade.

iii. Apply zinc sulphate @ 37.5 kg $ha^{-1}$ for hybrid maize and 25 kg $ha^{-1}$ for varieties can be followed in Zn deficient soils.

iv. Apply 50 kg $FeSO_4$ + 12.5 t FYM $ha^{-1}$ along with 40 kg S as elemental sulphur for calcareous soils. Apply the mixture over the furrows and two thirds in the top of ridges, if ridge planting is followed. If bed system of sowing is followed, apply the micronutrient mixture over the beds.

v. Apply 40 kg S, 10 kg borax and 50 kg $FeSO_4$ + 12.5 t FYM for specific respective nutrient deficiency in soils.

vi. For zinc and iron deficiencies in plants foliar spraying 0.5% $ZnSO_4$, 1% $FeSO_4$ + 0.1% citric acid thrice on 30, 40 and 50 days after sowing can be followed.

**6. SEED RATE**

Select good quality seeds and adopt the seed rate of 20 kg/ha for CO 1 and TNAU Maize Hybrid CO 6 and 25 kg /ha for COBC 1.

**7. SPACING**

Adopt a spacing of 25 cm between plants in the rows which are 60 cm apart.

Population : For varieties and hybrids 6 – 7 plants / sq. m. and
For baby corn, 8 – 9 plants / sq. m.

## 8. SEED TREATMENT

**Step 1:** Use pelleted seeds with insecticides (treat one kg of seeds with Chlorpyriphos 20EC or Monocrotophos 36 WSC or Phosalone 35 EC @ 4 ml + 0.5 gram gum in 20 ml of water) for the control of stem borer or seed treatment with imidacloprid 70 WS 10 g/kg of seeds.

**Step 2:** Seed treatment with Metalaxyl or Thiram @ 2 g/kg of seed for the control of downy mildew and crazy top

**Step 3**: Seeds treated with fungicides may be treated with three packets (600 g/ha) of Azospirillum before sowing.

## 9. SOWING

i. Dibble the seeds at a depth of 4 cm along the furrow in which fertilizers are placed and cover with soil.
ii. Put one seed per hole if the germination is assured otherwise put two seeds per hole

## 10. WEED MANAGEMENT

i. Apply Atrazine @ 0.50 – 0.75 kg/ha as pre-emergence on 3-5 DAS using Backpack/ Knapsack/ Rocker sprayer fitted with a flat fan nozzle using 500 litres of water/ha followed by one hand weeding on 30-35 DAS. (or)
ii. Apply Atrazine @ 0.50 kg/ha as pre-emergence on 3-5 DAS followed by 2,4-D @ 1 kg/ha on 20-25 DAS, using Backpack/Knapsack/Rocker sprayer fitted with a flat fan nozzle using 500 litres of water/ha.
iii. In line sown crop, apply PE Atrazine @ 0.50 kg/ha on 3-5 DAS followed by Twin Wheel hoe weeder weeding on 30-35 DAS.
iv. Apply herbicide when there is sufficient moisture in the soil.
v. Do not disturb the soil after herbicide application.
vi. If pulse crop is to be raised as intercrop, do not use Atrazine. Spray Pendimethalin @0.75 kg/ha as pre emergence on 3-5 DAS.

## 11. THINNING AND GAP FILLING

i. If two seeds were sown, leave only one healthy and vigorous seedling per hole and remove the other on the 12-15 days after sowing.
ii. Where seedlings have not germinated, dibble presoaked seeds at the rate of 2 seeds per hole and immediately irrigate.

## 12. HOEING, HAND-WEEDING AND EARTHING UP

i. Hoe and hand-weed on the 30th day of sowing.
ii. Earth up and form new ridges so that the plants come directly on the top of the ridges. This will provide additional anchorage to the plants.

## 13. TOP DRESSING WITH NITROGEN

i. Place half of the dose of N on the 25$^{th}$ day of sowing along the furrows evenly and cover it with soil.
ii. Place the remaining quarter of N on the 45$^{th}$ day of sowing

## 14. WATER MANAGEMENT

Maize crop is sensitive to both moisture stress and excessive moisture, hence regulate irrigation according to the requirement. Ensure optimum moisture availability during the most critical phase (45 to 65 days after sowing); otherwise yield will be reduced by a considerable extent.

Regulate irrigation according to the following growth phase of the crop.

| | |
|---|---|
| Germination & establishment phase | 1 to 14 days |
| Vegetative phase | 15 to 39 days |
| Flowering phase | 40 to 65 days |
| Maturity phase | 66 to 95 days |

| **Heavy soils** | | |
|---|---|---|
| **Stage** | **No. of irrigation** | **Days after sowing** |
| Germination & establishment | 3 | After sowing, Life irrigation -$4^{th}$,$12^{th}$ day |
| Vegetative | 2 | $25^{th}$, $36^{th}$ day |
| Flowering(Irrigate copiously) | 2 | $48^{th}$, $60^{th}$ day |
| Maturity phase (Control irrigation) | 2 | $72^{nd}$, $85^{th}$ day |
| Light soils | | |
| Germination & establishment | 3 | After sowing, Life irrigation -$4^{th}$ ,$12^{th}$day |
| Vegetative Phase | 3 | $22^{nd}$ ,$32^{nd}$ & $40^{th}$ day |
| Flowering phase (Irrigate copiously) | 3 | $50^{th}$ ,$60^{th}$ & $72^{nd}$ day |
| Maturity phase (Controlled irrigation) | 2 | $85^{th}$ , $95^{th}$ day |

**DRIP IRRIGATION TO MAIZE**

Irrigation once in 2 days

Irrigation based on climatological approach Irrigation volume:

= (Pe x Kp x Kc x A x Wp) – Re

Pe – Pan evaporation rate (mm/day) Kp – Pan co-efficient (0.75 to 0.80)

Kc – Crop co-efficient (0.4 – Vegetative stage; 0.75 – Flowering stage; 1.05 – Grain formation stage) A – Area (75 x 30 cm)

Wp – Wetted percentage (80% for maize) Re – Effective rainfall (mm)

$$\text{Irrigation duration} = \frac{\text{Water requirement per plant once in 2 days}}{\text{No. of dripper / plant x Discharge rate (lph)}}$$

**DRIP FERTIGATION TECHNOLOGY**

- Method of planting : paired row planting **(60/90 × 30 cm)**
- Fertilizer dose = 150:75:75 kg NPK per ha
- Drip fertigation with Water soluble fertilizer (WSF)
  - N Polyfeed 19-19-19
  - P MAP 12-61-00
  - K $KNO_3$ 13-00-45

Fertigation Device : Ventury assembly (3/4”) with injector pump (0.5 HP)

**Fertigation schedule for Hybrid maize with Water Soluble Fertilizers at (75 % RDF)**

| Stage (days) | Duration (days) | Fertilizer form | Fertilizer grade | | | Dose / ha/ day | Total Qty (Kg/ha) | Nutrients kg/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | | | N | P | K |
| 6 to 25 | 20 | MAP | 12 | 61 | 0 | 2.813 | 56.25 | 6.75 | 34.31 | 0.00 |
| | 20 | Urea | 46 | 0 | 0 | 0.938 | 18.75 | 8.63 | 0.00 | 0.00 |
| 26-60 | 35 | PolyFeed | 19 | 19 | 19 | 2.143 | 75.00 | 14.25 | 14.25 | 14.25 |
| | 35 | Multi-K | 13 | 0 | 45 | 1.500 | 52.50 | 6.83 | 0.00 | 23.63 |
| | 35 | Urea | 46 | 0 | 0 | 2.143 | 75.00 | 34.50 | 0.00 | 0.00 |
| 61-75 | 15 | PolyFeed | 19 | 19 | 19 | 2.750 | 41.25 | 7.84 | 7.84 | 7.84 |
| | 15 | Multi-K | 13 | 0 | 45 | 1.600 | 24.00 | 3.12 | 0.00 | 10.80 |
| | 15 | Urea | 46 | 0 | 0 | 4.500 | 67.50 | 31.05 | 0.00 | 0.00 |
| | | | | | | | | 112.96 | 56.40 | 56.51 |

**Fertigation schedule for Hybrid maize with Normal Fertilizers (100% RDF)**

| Stage (days) | Duration (days) | Fertilizer form | Fertilizer grade | | | Dose / ha/ day | Total Qty (Kg/ha) | Nutrients kg/ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | | | N | P | K |
| 6 to 25 | 20 | DAP | 18 | 46 | 0 | 5.00 | 100 | 18.0 | 46.0 | 0.0 |
| | 20 | Urea | 46 | 0 | 0 | 2.50 | 50 | 23.0 | 0.0 | 0.0 |
| 26-60 | 35 | DAP | 18 | 46 | 0 | 1.86 | 65 | 11.7 | 29.9 | 0.0 |
| | 35 | Urea | 46 | 0 | 0 | 4.29 | 150 | 69.0 | 0.0 | 0.0 |
| | 35 | MOP | 0 | 0 | 60 | 2.14 | 75 | 0.0 | 0.0 | 45.0 |
| 61-75 | 15 | Urea | 46 | 0 | 0 | 4.13 | 62 | 28.5 | 0.0 | 0.0 |
| | 15 | MOP | 0 | 0 | 60 | 3.33 | 50 | 0.0 | 0.0 | 30.0 |
| | | | | | | | | 150.2 | 75.9 | 75.0 |

**HARVESTING STAGE OF HARVEST**

Observe the following symptoms, taking into consideration the average duration of the crop.

i. The sheath covering the cob will turn yellow and dry at maturity.
ii. The seeds become fairly hard and dry. At this stage the crop is ready for harvest.

**HARVESTING THE CROP**

i. Tear off the cob sheath by using the gunny needle and remove the cobs from the plant.
ii. Carry out harvest operations at a single stage for easy transportation.

**THRESHING THE COBS**

i. Dry the cobs under the sun till the grains are dry.
ii. Use mechanical threshers or by running the tractor over dried cobs to separate the grains from the shank.
iii. Clean the seeds by winnowing
iv. Collect and store the dry grains in gunnies.

**STACKING THE STRAW FOR FEEDING CATTLE**

i. Maize straw can also be used as a good cattle feed when it is green.
ii. Harvest the crop and cut the green straw into bits with a chaff cutter or chopping knife and feed the cattle.

## I. RAINFED MAIZE

### 1. FIELD PREPARATION

Chisel the soil having hard pan formation at shallow depths with chisel plough at 0.5 m interval first in one direction and then in the direction perpendicular to the previous one once in three years. Apply 12.5 t/ha of FYM or compost or composted coir pith besides chiselling, to get an additional yield of about 30% over control.

### 2. APPLICATION OF FYM OR COMPOST

Spread 12.5 t/ha of FYM or compost or composted coir pith evenly on the unploughed field along with 10 packets of Azospirillum (2000 g/ha) and incorporate in the soil.

### 3. APPLICATION OF FERTILIZER

i. Apply NPK as per soil test recommendation as far as possible. If soil test recommendation is not available, adopt a blanket recommendation of 60 : 30 : 30 NPK kg/ha for Alfisols and 40 : 20 : 0 NPK kg/ha for Vertisols.
ii. Apply half of N and full dose of $P_2 O_5$ and $K_2 O$ with enriched FYM as basal along with Azospirillum (10 packets/ha).
iii. Top dress remaining half of N at tasseling.

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yieldtargets. (ready reckoners are furnished )

**Rainfed Maize**

Soil : Red sandy loam (Irugur series)

Target : 4 - 5 t $ha^{-1}$

FN = 3.23 T - 0.42 SN - 0.52 ON

$FP_2O_5$ = 1.51T - 1.98 SP - 0.94 OP

$FK_2O$ = 1.73T - 0.21 SK - 0.48 OK

| **Initial soil test values (kg $ha^{-1}$)** | | | **Yield target – 4 t $ha^{-1}$** | | | **Yield target – 5 t $ha^{-1}$** | | |
|---|---|---|---|---|---|---|---|---|
| | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 10 | 200 | 30* | 16 | 15* | 62 | 31 | 20 |
| 180 | 12 | 220 | 30* | 15* | 15* | 54 | 27 | 15* |
| 200 | 14 | 240 | 30* | 15* | 15* | 46 | 23 | 15* |
| 220 | 16 | 260 | 30* | 15* | 15* | 37 | 19 | 15* |
| 240 | 18 | 280 | 30* | 15* | 15* | 30* | 15* | 15* |

* Maintenance dose ** Maximum dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure inkg $ha^{-1}$.

Apply TNAU MN mixture @ 7.5 kg /ha as Enriched FYM (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture &incubate for one month in shade).

**4. SEED RATE**

Select good quality seeds. Adopt the seed rate @ 20 kg/ha for hybrids and 25 kg/ha for varieties

**5. SPACING**

Adopt a spacing of 45 cm between rows and 20 cm between plants in the row. Population : 10 - 11plants/$m^2$

**6. PRE-TREATMENT OF SEEDS WITH BIOFERTILIZER**

Seeds treated with fungicides may be treated with three packets (600 g/ha) of Azospirillum

**7. SOWING**

Dibble or drill the seeds at a depth of 4 cm.

**8. CROPPING SYSTEMS**

i. Intercropping system of maize + cowpea or maize + blackgram is recommended for higher net returns in the red lateritic soils of Southern districts.

ii. For Vertisols of Southern district, maize + redgram intercropping systems is ideal.

**CROP PHYSIOLOGY**

Foliar spray of TNAU Maize Maxim @ 3 kg/acre in 200 litres of water at tassel initiation and at grain filling stages improves grain filling, grain yield and drought tolerance.

## CROP PROTECTION

## A. PEST MANAGEMENT

| | |
|---|---|
| **Shoot fly,** *Atherigona orientalis* | • Set up TNAU low cost fish meal trap 12 nos./ha till the crop is 30 days old<br>• **Apply any one of the following insecticides/ ha**<br>Carbofuran 3CG 33.3 kg<br>Dimethoate 30EC 1.2 lit<br>Methyl demeton 25EC 1.0 lit<br>Monocrotophos 36SL 625 ml |
| **Stem borer,** *Chilo partellus* | • Release egg parasitoid, *Trichogramma chilonis* @ 12 cc/ha coinciding with egg laying period thrice at weekly interval.<br>• Conserve larval parasitoid, *Cotesia flavipes*<br>• Apply carbofuran 3CG 33.3 kg/ha<br>• If granular insecticides are not used, spray dimethoate 30EC 660 ml/ha |
| **Aphids** *Rhopalosiphum maidis* | • Spray dimethoate 30EC 1.2 lit/ha |
| **Cob borer** *Helicoverpa armigera* | Spray azadirachtin 1% (10000 ppm) 1500 ml/ha |
| **Thrips** | Apply carbofuran 3CG 33.3 kg/ha |
| **Fall armyworm (FAW),** *Spodoptera frugiperda* (invasive pest) | • Apply neem cake @ 250 kg/ha during last ploughing and treat seeds with thiamethoxam 30 FS or *Beauveria bassiana* @ 10 g/ kg<br>• Adopt spacing of 60 x 25 cm for irrigated and 45 x 20 cm for rainfed maize and rogue spacing of 75 cm for every 10 rows<br>• Raise border crop of cowpea, sunflower or gingelly, and intercrop with black gram or green gram to attract and conserve natural enemies<br>• Raise border crop of Bajra Napier for irrigated maize or grain sorghum variety for rainfed maize to attract FAW adults on border crops<br>• Use solar light trap @ one /ha and sex pheromone traps @ 50/ha for mass trapping of adults from 10-15 DAS<br>**Apply any one of the following/ ha**<br>• Early whorl stage (15 – 20 DAS)<br>• Azadirachtin 1% EC 20 ml/10 l<br>• Thiodicarb 75 WP 20 g/10 l<br>• Emamectin benzoate 5 SG 4g/10 l<br>• Late whorl stages (40-45 DAS)<br>• *Metarhizium anisopliae* 80 g/10 l with 1 x $10^8$ cfu/g<br>• Spinetoram 12 SC 5 ml/10 l<br>• Novaluron 10 EC 15 ml/10 l<br>• Tasseling and cob formation stage (60 – 65 DAS) |

| | |
|---|---|
| | • Flubendiamide 480 SC 4 ml/10 l<br>• Chlorantraniliprole 18.5 SC 4 ml/10 l |

## B. Disease Management

**Seed treatment:** Treat the seeds with carbendazim @ 2 g/kg or thiram @ 4 g/kg or metalaxyl @ 3 g/kg of seed

| Name of the Disease | Recommendations |
|---|---|
| **Rust:** *Puccinia sorghi* | **CIB recommendation**<br>• Spray kresoxim-methyl 44.3% SC @ 1 ml/l of water |
| **Downy mildew or Crazy top:** *Peronosclerospora sorghi* | • Sow resistant hybrid TNAU maize hybrid CO-6 and COH (M) 8<br>• Rogue out downy mildew infected plants<br>• Spray metalaxyl + mancozeb @ 1000 g or mancozeb 1000 g/ha at 20 days after sowing<br>**CIB recommendation**<br>• Treat the seeds with metalaxyl-M 31.8% ES @ 2.4 ml/kg seed or with metalaxyl 35% WS @ 700gms with a dilution of 0.75 to 1ltr / 100 kg seeds. |
| **Turcicum leaf blight:** *Exserohilum turcicum* **and *Maydis* leaf blight:** *Helminthosporium maydis* | • Spray mancozeb or zineb @ 2-4 g/l on appearance of the disease and repeat at 10 days interval, if necessary<br>• Seed treatment with *Pseudomonas fluorescens* @ 10g/ kg and spray propiconazole 25% EC @ 0.1% on 35 and 50 DAS<br>**CIB recommendation**<br>• Spray kresoxim-methyl 44.3% SC @ 1 ml/ l of water |
| **Post Flowering Stalk rot:** *Macrophomina phaseolina* | • Follow crop rotation<br>• Avoid water stress at flowering time to reduce the disease incidence<br>• Avoid nutrient stress and apply potash @ 80 kg/ha in endemic areas<br>• Apply *P. Fluorescens* or *T. asperellum* @ 2.5 kg / ha with 50 kg of well decomposed FYM / sand in soil at 30 days after sowing |
| | **CIB recommendation for combined infections**<br>• Spray azoxystrobin 18.2% w/w + cyproconazole 7.3% w/w SC @ 1l/ha to control downy mildew, leaf blights and rust diseases<br>• Spray azoxystrobin 18.2% w/w + difenoconazole 11.4% w/w SC @ 0.1% to control leaf blights and downy mildew diseases |

## MAIZE - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free from volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified seed production, leave a distance of 200 m all around the field from the same and other varieties of maize.

**Pre-sowing seed management**

- Soak the seed in 4 % *Pseudomonas fluorescens* for 8 h at 1 : 1 ratio and dry back the seeds to original seed moisture content under shade.

**Season**

- June - September and November - February.

**Spacing**

- 45 x 10 cm.

**Fertilizer requirement**

- The crop requires NPK @ 150:75:75 kg / ha. Apply NPK @ 40:75:40 kg / ha as basal, 50 kg N at 20 days after sowing and 60:0:35 kg NPK at 40 days after sowing.

**Harvest**

- Harvest the cobs as once over harvest.
- Verify true to type cobs based on kernel and shank colour (cob sorting) variations.
- Remove the diseased cobs.

**Shelling**

- Shell the cobs either by beating with pliable bamboo stick or using maize sheller with required rpm at a seed moisture content of 15 - 18 %.
- Improper shelling leads to pericarp injury up to 48 % and will promote saprophytic fungal growth.
- Estimate mechanical / pericarp injury through 20 % $FeCl_3$ test or using 0.25 % Tetrazolium chloride solution.

**Size grading**

- Grade the seeds using 18 / 64” round perforated sieves.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed using 5 ml of water / kg of seed.
- Dry dress the seeds with halogen mixture @ 3 g / kg of seed ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 for grain cum seed

storage.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 10 to 12 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

## MAIZE - HYBRID SEED PRODUCTION

**Land requirement**

- Select fertile land with good drainage and irrigation.
- Field should not have volunteer plants. Hence, the previous crop should not be the same or different variety / hybrid of maize.

**Isolation**

- All around the field leave 200 m distance from same and other varieties / hybrids of maize.

**Pre-sowing seed treatment**

- Coat the seed with polymer @ 6 g / kg + carbendazim @ 2 g / kg + imidachloprid @ 1 ml / kg + micronutrient mixture @ 3 ml / kg of seed.

**Spacing**

- 60 x 25 cm.

**Planting ratio**

- Sow the female and male parents in the ratio of 6 : 2.

**Border rows**

- Sow four rows of male parent all around the field for effective pollination.

**Fertilizer requirement**

- Apply NPK @ 150: 75: 75 kg / ha in split applications. Three split application 25 kg of N at vegetative,at 5% flowering and 10 days after second application. Apply 18.75 kg of K in two split application at 5% flowering and maturity stages.

**Foliar spray**

- Spray $ZnSO_4$ 0.5 % + boric acid 0.2 % at 50 % flowering stage to enhance the seed set.

# (V) SMALL MILLETS

## CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Sl. No. | Agro ecological zones | Districts | Season | Crops | Varieties |
|---|---|---|---|---|---|
| 1 | North Eastern Zone | Vellore, Thiruvannamalai, Cuddalore, Villupuram, Thiruvallur and Kancheepuram | Feb-March (Masipattam) June-July (Adipattam) Sep-Oct (Puratassipattam) | Tenai | CO (Te) 7 |
| | | | | Samai | ATL 1, CO (Samai) 4, Paiyur 2 |
| | | | | Varagu | CO 3, TNAU 86 |
| | | | | Panivaragu | CO (Pv) 5,TNAU 202 |
| | | | | Kudiraivali | CO (Kv) 2,MDU 1 |
| 2 | North Western Zone | Salem, Namakkal, Dharmapuri and Krishnagiri | Feb-March (Masipattam) June-July (Adipattam) Sep-Oct (Puratassipattam) | Tenai | CO (Te) 7 |
| | | | | Samai | ATL 1, CO (Samai) 4, Paiyur 2 |
| | | | | Varagu | CO 3,TNAU 86 |
| | | | | Panivaragu | CO (Pv) 5,TNAU 202 |
| | | | | Kudiraivali | CO (Kv) 2,MDU 1 |
| 3 | Western Zone | Coimbatore, Erode, Karur, Tiruppur and Dindigul | Feb-March (Masipattam) June-July (Adipattam) Sep-Oct (Puratassipattam) | Tenai | CO (Te) 7 |
| | | | | Samai | ATL 1, CO (Samai) 4, Paiyur 2 |
| | | | | Varagu | CO 3,TNAU 86 |
| | | | | Kudiraivali | CO (Kv) 2,MDU 1 |
| | | | | Panivaragu | CO (Pv) 5,TNAU 202 |
| 4 | Cauvery Delta Zone | Tiruchy, Thanjavur, Thiruvarur, Nagapattinam, Pudukkottai, Perambalur and Ariyalur | Feb-March (Masipattam) June-July (Adipattam) Sep-Oct (Puratassipattam) | Tenai | CO (Te) 7 |
| | | | | Samai | ATL 1, CO (Samai) 4, Paiyur 2 |
| | | | | Varagu | CO 3,TNAU 86 |
| 5 | Southern Zone | Madurai,Theni, Pudukottai, Sivagangai, Virudhunagar, Ramanathapuram, Tirunelveli and Thoothukudi | Feb-March (Masipattam) June-July (Adipattam) Sep-Oct (Puratassipattam) | Tenai | CO (Te) 7 |
| | | | | Samai | ATL 1, CO (Samai) 4, Paiyur 2 |
| | | | | Varagu | CO 3,TNAU 86 |
| | | | | Panivaragu | CO (Pv) 5,TNAU 202 |
| | | | | Kudiraivali | CO (Kv) 2,MDU 1 |
| 6 | Hilly and High Altitude Zone | Ooty | Feb-March (Masipattam) June-July (Adipattam) Sep-Oct (Puratassipattam) | Tenai | CO (Te) 7 |
| | | | | Samai | ATL 1, CO (Samai) 4, Paiyur 2 |
| | | | | Panivaragu | CO (Pv) 5,TNAU 202 |

## II. PARTICULARS OF SMALL MILLET VARIETIES

### TENAI

| PARTICULARS | CO (Te) 7 |
|---|---|
| Year of Release | 2005 |
| Year of Notification | SO.599(E)/25.04.2006 |
| Parentage | CO 5 x ISE 248 |
| Duration (days) | 80-85 |
| Pigmentation | Greenish purple |
| Tillering ability | High |
| Panicles | Long, Compact |
| Grain Character | Yellow |
| Grain Yield (kg/ha)<br>Straw Yield (t/ha) | 1855<br>5.10 |
| Special features | Non lodging and high yielding |

### SAMAI

| PARTICULARS | Paiyur 2 | CO(Samai) 4 | ATL 1 |
|---|---|---|---|
| Year of Release | 2000 | 2006 | 2019 |
| Year of Notification | SO.821(E)/ 13.09.2000 | SO.1178(E)/ 20.07.2007 | SO.3220(E)/ 05.09.2019 |
| Parentage | Pure line selection from PM 295 | CO 2 x MS 1684 | Pedigree selection from the cross<br>CO (Samai) 4 X TNAU 141 |
| Duration (days) | 85 | 75-80 | 85 – 90 |
| Pigmentation | Green | Green | Dark Green |
| Tillering ability | Moderate | High | Moderate |
| Panicles | long, loose panicle | Open and Loose | semi-compact panicles |
| Grain Character | Brown | Grayish yellow | Golden Yellow |
| Grain Yield (kg/ha) Rainfed | 850 | 1567 | 1587 |
| Special features | Short duration, suitable for little millet – horse gram cropping sequence | Short duration, suitable for the existing double cropped rainfed situation of North, North Western and Western zones of Tamil Nadu | Drought tolerant, Non lodging and uniform maturity, Sturdy culm, Suitable for mechanical harvesting, Highly suitable for the districts in the Eastern Ghats such as Dharmapuri, Tiruvannamalai, Vellore, Salem and Krishnagiri. It is very much adaptive in the plains also under rainfed system. |

## VARAGU

| PARTICULARS | CO 3 | TNAU 86 |
| --- | --- | --- |
| Year of Release | 1980 | 2012 |
| Year of Notification | SO.19(E)/14.01.1982 | SO. 2805(E) dt:25.08.2017 |
| Parentage | Selection from Georgia variety | Pure line selection from IPs 85 |
| Duration (days) | 120 | 105 - 110 |
| Pigmentation | Purple stem | Light purple at nodes |
| Tillering ability | High | Profuse tillering (8-12) |
| Panicles | Well exposed clusters and spikelets | Long panicles (7 - 10 cm) and grains are arranged in regular rows |
| Grain Character | Brown & Bold with hard seed Coat | Brown & Bold with oval shape |
| Grain Yield (kg/ha) Rainfed | 1500 - 1800 | 2700 - 3200 |
| Special features | Tolerant to smut, short duration | Tolerant to head smut, sheath blight and brown spot |

## PANIVARAGU

| PARTICULARS | CO(PV) 5 | TNAU 202 |
| --- | --- | --- |
| Year of Release | 2007 | 2011 |
| Year of Notification | SO. 449(E) / 11.02.2009 | SO. 2805(E) dt: 25.08.2017 |
| Parentage | PV 1403 x GPUP 21 | PV 1453 x GPUP 16 |
| Duration (days) | 70 | 70 - 75 |
| Pigmentation | Green | Green |
| Tillering ability | High | High |
| Panicles | Compact, dense with bold grains | Semi-Compact with bold grains |
| Grain character | Golden yellow | Yellow |
| Grain yield (kg/ha) Rainfed | 2400 | 2000 |
| Special features | High tillering, short duration ,fits well in the double cropped rainfed situation | Short duration, no incidence of pest and diseases and nutritive grains suitable for value addition |

## KUDIRAIVALI

| PARTICULARS | CO(KV) 2 | MDU 1 |
| --- | --- | --- |
| Year of Release | 2009 | 2017 |
| Year of Notification | SO.2137(E)/31.08.2010 | SO.1379(E)/ 27.03.2018 |
| Parentage | Pure line selection from EF 79 | Pure line selection from Arupukkottailocal |
| Duration (days) | 95 | 95-100 |
| Pigmentation | Green | Green |
| Tillering ability | High | High (4-9) |
| Panicles | Compact, Pyramidal | Compact, Pyramidal Shape |
| Grain Character | Brownish grey | Yellowish grey |
| Grain Yield (kg/ha) | | |
| Irrigated | - | 2200 – 2500 |

| | | |
|---|---|---|
| Rainfed | 2650 | 1500 – 1700 |
| Special features | Good grain quality | High milling per cent (70%) and iron content (16 mg/ 100g of grain). Good quality and taste. |

## CROP MANAGEMENT

**Package of practices for Tenai Seeds and sowing**

For line planting : 10kg/ha

For sowing : 12.5 kg/ha for use of Gorru or seed drill is recommended.

Seed treatment : Treat 1 kg of seeds with 2 g Thiram or Carbendazim.

Field preparation : Plough the field thoroughly using a small iron plough or country plough to fine tilth. Apply basally FYM/Compost 12.5 t/ha

Fertilizer application :
Nitrogen 44 kg/ha
Phosphorus 22 kg/ha

Spacing : For line planting 22.5 cm x 10 cm (10 cm in between plants)

Weeding : First weeding on 15$^{th}$ DAS and the second on 40$^{th}$ DAS

Thinning : Before 20 DAS

Plant protection : Generally no major problem of pests and diseases

**Package of practices for Samai**

Seeds and sowing : For line planting 10 kg/ha
For broad casting 12.5 kg/ha
use of Gorru or seed drill is recommended.

Seed treatment : Treat 1 kg of seeds with 2 g Thiram or Carbendazim.

Field preparation : Plough the field thoroughly 2 or 3 times using a small iron plough or country plough to fine tilth.

Fertilizer application: Apply basally FYM/COMPOST : 12.5 t/ha
Nitrogen : 44 kg/ha, Phosphours : 22 kg/ha

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yieldtargets. (ready reckoners are furnished )

**Samai**

Soil : Red sandy loam (Irugur series)

Target : 1.5 – 2.0 t $ha^{-1}$

FN = 8.83 T - 0.41 SN - 0.55 ON

$FP_2O_5$ = 3.75 T - 1.10 SP - 0.62 OP

$FK_2O$ = 4.57 T - 0.15SK - 0.48 OK

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 1.5 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 2.0 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 160 | 22* | 14 | 20 | 64 | 33 | 42 |
| 180 | 14 | 180 | 22* | 12 | 17 | 56 | 31 | 39 |
| 200 | 16 | 200 | 22* | 11* | 14 | 48 | 28 | 36 |
| 220 | 18 | 220 | 22* | 11* | 11 | 39 | 26 | 33 |
| 240 | 20 | 240 | 22* | 11* | 8 | 31 | 24 | 30 |

* Maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

Spacing : For line planting 25 x 10 cm (10 cm in between plants)

Weeding : First weeding is done on the 15th DAS and the second weeding on 40th DAS

Thinning : Thinning is done soon after weeding or before 20 DAS Plant

Protection : Usually no major problem of pests and diseases

**Package of practices for Varagu**

Seeds and sowing : For line planting 10 kg/ha; For sowing 12.5 kg/ha Use of Gorru or seed drill is recommended.

Seed treatment : Treat 1 kg of seeds with 2 g Thiram or Carbendazim.

Field preparation : Plough the field thoroughly using a small iron plough or country plough to fine tilth.

Fertilizer application: Apply basally FYM/COMPOST : 12.5 t/ha
Nitrogen : 44 kg/ha, Phosphours : 22 kg/ha

Spacing : For line planting 45 x 10 cm (10 cm in between plants)

Weeding : First weeding is done on the 15th DAS and the second weeding on 40th DAS

Thinning : Thinning is done soon after weeding or before 20 DAS Plant

protection : Generally no major problem of pests and diseases

# 3. WHEAT (*Triticum aestivum.*)

## CROP IMPROVEMENT

### CLIMATE REQUIREMENT

| T_Max$^oC$ | T_Min$^oC$ | Optimum $^oC$ | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 31 - 34 | 3 - 4 | 20 - 25 | 600 - 900 | up to 3300 |

Tropical and Sub tropical cool and dry climate. Grown during *rabi* season and has wide adaptability. Wheat can tolerate severe cold and snow and resume growth with the setting in warm weather in spring. Wheat needs cold and dry climate. Long day plant.

## I. SEASON AND VARIETY

**Suitable Districts**

Plains & adjoining areas near to hills and hills in Theni, Dindigul, Karur, Coimbatore, Erode, Salem, Dharmapuri, Vellore, Thiruvannamalai and Kancheepuram Districts

**Season**

Ideal sowing time is 15$^{th}$ October to 1$^{st}$ week of November. Sowing must be completed within the first fortnight of November.

**Variety** : COW(W)1, TNAU Samba Wheat COW 2

**2. Morphological Description of COW(W) 1**

| **Particulars** | **COW (W) 1** | **COW (W) 2** |
|---|---|---|
| Parentage | HD2646/HW2002A/CPAN3057 | Mutant of NP 200 |
| Duration (days) | 85-90 | 110 |
| Grain yield (Kg /ha) | 2364 | 4040 |
| Stem | Erect | Erect to semi erect |
| Height (cm) | 73 – 78 | 75-80 cm |
| Tillers | 5-6 | 10-12 |
| Days to 50% flowering | 50 days | 73 days |
| Ear size and shape | Fusiform ears | Long & slightly tappering |
| Grain colour | Amber | Raddish |
| 1000 grains weight (g) | 37 | 41 |
| Special features | Non lodging, non shattering; tolerance to stem and leaf rust suitable for chappathi and bread making. | Resistant to rust, heat tolerant |

**3. SEED RATE:** 100 kg/ha

## CROP MANAGEMENT

### 1. FIELD PREPARATION

Plough twice with an iron plough and two to three times with cultivator and prepare the land to a fine tilth.

### 2. APPLICATION OF FYM OR COMPOST

Spread 12.5 t/ha of FYM or compost on the unploughed field and incorporate in the soil.

### 3. SEED TREATMENT WITH FUNGICIDES

Treat the seeds with Carbendazim or Thiram at 2 g/kg of seeds 24 hours before sowing

### 4. FORMING BEDS AND CHANNEL

Form beds size on 10 $m^2$ or 20 $m^2$. The irrigation channels are to be provided sufficiently.

### 5. APPLICATION OF FERTILIZERS

(i) If soil test recommendation is not available, adopt a blanket recommendation of 80:40:40 NPK kg/ha. Apply 37.5 kg $ZnSO_4$, 40 kg S basally for soils having Zn and S deficiencies.

(ii) Apply half of N and full dose of $P_2O_5$ and $K_2O$ basally before sowing and incorporate in the sowing line.

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished )

**Wheat - Hills(1)**

Soil Laterite (Ooty Series)

Target 3.5 – 4.0 t $ha^{-1}$

FN = 7.60 T- 0.55 SN - 0.92 ON

$FP_2O_5$ = 3.59T - 0.26 SP - 0.54 OP

$FK_2O$ = 3.88T - 0.45SK - 0.51 OK

| Initial soil test values ($kg\ ha^{-1}$) | | | Yield target – 3.5 t $ha^{-1}$ | | | Yield target – 4.0 t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | NPK ($kg\ ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK ($kg\ ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
| SN | $SP^a$ | SK | FN | $FP_2O_5$ | $FK_2O$ | FN | $FP_2O_5$ | $FK_2O$ |
| 200 | 200 | 175 | 96 | 49 | 27 | 134 | 67 | 45** |
| 225 | 250 | 200 | 82 | 36 | 16 | 120 | 54 | 35 |
| 250 | 300 | 225 | 69 | 30* | 15* | 107 | 41 | 24 |
| 275 | 350 | 250 | 55 | 30* | 15* | 93 | 30* | 15* |
| 300 | 400 | 275 | 50* | 30* | 15* | 79 | 30* | 15* |

* Maintenance dose ;** Maximum dose;$SP^a$- Bray P

**Wheat - Plains (2)**

| | | |
|---|---|---|
| Soil : | Mixed black calcareous (Perianaickenpalayam series) | FN = 8.83 T- 0.71 SN- 0.88 ON<br>$FP_2O_5$ = 4.52T- 1.75 SP- 0.95 OP |
| Target : | 3.5 – 4.0 t $ha^{-1}$ | $FK_2O$ = 6.05T - 0.20SK - 0.83 OK |

| **Initial soil test values (kg $ha^{-1}$)** | | | **Yield target – 3.5 t $ha^{-1}$** NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | **Yield target – 4.0 t $ha^{-1}$** NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 14 | 300 | 112 | 90** | 60** | 150** | 90** | 60** |
| 220 | 16 | 350 | 98 | 90** | 60** | 142 | 90** | 60** |
| 240 | 18 | 400 | 84 | 90** | 60** | 128 | 90** | 60** |
| 260 | 20 | 450 | 69 | 90** | 60** | 114 | 90** | 60** |
| 280 | 22 | 500 | 55 | 90** | 60** | 99 | 90** | 60** |

** Maximum dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

**6. SOWING**

Draw the lines 20 cm apart and sow the seeds continuously after application of fertilizers to a depth of 5 cm. Avoid deep sowing.

**7. WEED MANAGEMENT**

i. Spray PE Isoproturon 500 g/ha as pre-emergence spray on 3 DAS followed by one hand weeding on 35th DAS.
ii. If herbicide is not applied, give two hand weedings on 20th and 35th DAS.

**8. WATER MANAGEMENT**

The crop requires 4 - 6 irrigations depending on the soil type and rainfall. Wheat crop requires minimum of 5 irrigations at the following critical stages.

I = Immediately after sowing
II = Crown root intiation : 15-20 DAS III =Active tillering stage : 35-40 DAS
IV= Flowering stage : 50-55 DAS
V= Grain filling stage : 70-75 DAS

Crown root initiation and flowering are the most critical stages. Water stagnation should be avoided at the time of germination.

**9. TOP DRESSING**

Apply remaining half of N at crown root initiation stage (15-20 DAS).

**10. HARVESTING**

Harvest the crop when the grains become hard and straw becomes dry and brittle. Thresh and winnow the grains. Use mechanical threshers to reduce the cost of threshing and winnowing.

**CROP PROTECTION**

**Seed treatment:** Treat the seed with any one of the following fungicides Carbendazim @ 2 g/kg of seed, Thiram @ 2 g/kg of seed or Carboxin @ 2 g/kg of seed.

# 4. PULSES

## (i) REDGRAM (*Cajanus cajan (L.) Millsp.* )

### Climate Requirement

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 30 | 17 | 26 - 30 | 600 - 1400 | |

Tropical and subtropical legumes, suitable for rainfed in semiarid areas due to its deep taproot, heat tolerance and fast growing habit. During vegetative growth, prefers a fairly moist and warm climate. During flowering and ripening stage, requires bright sunny weather for proper fruit setting. Highly susceptible to frost at the time of flowering, hardy, widely adaptable, and drought resistant. It has low tolerance of soil salinity and waterlogging.

### CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| District/season | Varieties |
|---|---|
| **Vaigasi Pattam (May-June)**<br>Krishnagiri, Dharmapuri, Salem, Erode, Coimbatore Dindigul, Theni and Madurai | CO(Rg) 7, CO 8, CO 9 |
| **Adi/Avanipattam (June - August)**<br>Vellore, Thiruvannamalai, Salem, Namakal, Perumbalur, Ariyalur, Madurai, Dindigul, Theni, Pudukkottai and Sivaganga<br>June 15th to July 15th sowing | CO 8, CO 9 |
| **Purattasipattam (September – October)**<br>Vellore, Tiruvannamalai, Dharmapuri, Salem, Namakkal, Erode, Coimbatore, Madurai, Dindigul, Theni Pudukkottai, Sivagangai, Perumbalur, Ariyalur | Co (Rg) 7 and VBN(Rg) 3 |
| **Markazhipattam (Winter Irrigated)**<br>All districts except The Nilgiris and Kanyakumari | Co (Rg) 7 and VBN(Rg) 3 |
| **Chithiraipattam (Summer Irrigated)**<br>All districts except The Nilgiris and Kanyakumari<br>Wetland bunds | Co (Rg) 7 and VBN(Rg) 3<br>BSR 1 |

### II.DESCRIPTION OF REDGRAM VARIETIES

| PARTICULARS | CO 8 | CO 9 |
|---|---|---|
| Year of Release | 2017 | 2018 |
| Year of Notification | SO.1379(E)/ 27.03.2018 | SO.3220(E)/05.09.2019 |
| Parentage | APK 1 x LRG 41 | CO6 x IC 525427 |
| 50% flowering(days) | 120-130 | 120-130 |
| Maturity(days) | 170-180 | 170-180 |
| Season | Adi pattam | Adi pattam |
| Grain yield(kg/ha) | | |
| Rainfed | 1600 kg/ha | 1700 kg/ha |
| Irrigated | 1800 cm | - |
| Plant height(cm) | 165-180 | 210-240 cm |
| Plant spread | Erect | Erect |

| | | |
|---|---|---|
| Colour of standard petal | Yellow base with medium pattern of streaks | Yellow base with medium pattern of streaks |
| Colour of pod | Brown streaks | Green with Brown streaks |
| Colour of grain | Cremish brown | Brown |
| 100 seed weight(g) | 10.22 to 11.44g) | 9.9 |
| Pattern of growth | Indeterminate | Indeterminate |

| **Particulars** | **Co (Rg) 7** | **VBN(Rg)3** | **BSR 1** |
|---|---|---|---|
| Year of Release | 2004 | 2005 | 1986 |
| Year of Notification | SO.1177(E)/ 25.08.2005 | SO.1572(E)/ 20.09.2006 | Not notified |
| Parentage | Selection from PB 9825 | Vamban 1 x Gulbarga | Pureline selection from Mayiladumparai |
| 50% flowering(days) | 70-90 | 65-70 | 100-110 |
| Duration (days) | 120-130 | 100-105 | Perennial |
| Grain yield(kg/ha) | | | |
| Rainfed (kg/ha) | 950 | 880 | 0.75 to 1.0 kg of green pods/plant |
| Irrigated (kg/ha) | 1168 | 1530 | - |
| Plant height (cm) | 120-130 | 100-120 | 150-200 |
| Branches | 7-9 | 3-10 | 7-10 |
| Plant spread | Semi spreading | Erect, Semi-determinate and open type | Semi spreading |
| Colour of standard petal | Yellow with light red vein at the base | Yellow with light red vein at the base | Red at dorsal side |
| Colour of pods | Green with purple streaks | Green with purple streaks | Red with diagonal constriction |
| Colour of grain | Reddish brown | Reddish brown | Reddish brown |
| 100 grain wt (g) | 8.5-11.0 | 7.0-8.0 | 12.0 |
| Pattern of growth | Indeterminate | Semi determinate | Indeterminate |

## CROP MANAGEMENT

### SEED RATE

| **System** | **Long duration** | | **Short duration** | |
|---|---|---|---|---|
| | Low Fertility | High Fertility | Low Fertility | High Fertility |
| Sole Crop | 8 | 5 | 13 | 10 |
| Mixed Crop | 3 | 3 | 5 | 5 |
| Bund Crop | 50 g / 100 meter | | | |

Long duration varieties: CO 6, CO 8, Vamban 2, LRG 41
Short duration varieties : CO (Rg) 7, VBN (Rg) 3
Bund Crop : BSR 1

## III. MANAGEMENT OF FIELD OPERATION

### 1. PREPARATION OF THE LAND

Prepare the land to fine tilth and apply 12.5 t FYM/ha or composted coir pith at the time of last ploughing and form ridges and furrows

### 2. SEED TREATMENT

Treat the seeds with Carbendazim or Thiram @ 2 g/kg of seed 24 hours before sowing (or) with talc formulation of *Trichoderma viride* @ 4g/kg of seed (or) *Pseudomonas fluorescens* @ 10 g/kg seed. Bio control agents are compatible with biofertilizers. First treat the seeds with biocontrol agents and then with rhizobium. Fungicides and biocontrol agents are incompatible.

### 3. TREATMENT OF THE SEEDS WITH BIOFERTILIZER

a) Fungicide (or) bio control agents treated seeds should be again treated with bacterial culture after 24 hours. Treat the seeds required for sowing 1 ha with 200g each of Rhizobial culture CPR6 / CPR 9, phosphobacteria and PGPR (*Pseudomonas* sp.) using rice gruel, shade dry it before sowing. (or) Treat one hectare of seeds with 25 g each of powder formulation of *Rhizobium* and AM fungi using binder (polymer), shade dry before sowing.

b) If seed treatment is not carried out, apply 2 kg each Rhizobial culture, Phosphobacteria and PGPR (*Pseudomonas* sp.) with 25 kg of FYM and 25 kg of sand, mix uniformly before sowing.

### 4. APPLICATION OF FERTILIZERS

If soil test is not done, apply fertilizers basally before sowing

a) Apply fertilizers basally before sowing.
Rainfed : 12.5 kg N + 25 kg $P_2O_5$ + 12.5 kg $K_2O$ +10 kg S*/ha Irrigated : 25 kg N + 50 kg $P_2O_5$ + 25 kg $K_2O$ + 20 kg S*/ha
*Note : Applied in the form of gypsum if Single Super Phospate is not applied as a source of phosphorus

b) Soil application of 25 kg $ZnSO_4$/ha under irrigated condition

c) Soil application of TNAU micronutrient mixture @ 5 kg/ha as Enriched FYM (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture &incubate for one month in shade).

### d) Foliar spraying to mitigate moisture stress

Foliar spraying of 2% KCl + 100 ppm Boric acid during dry spell as mid season management practice in black gram during *Rabi* season is recommended to increase the yield over KCl spray alone .

### Nitrogen substitution by organic sources for pulses

50 per cent nitrogen can be substituted through organic source (850 kg of vermicompost per hectare). Lime application is recommended for pulses with soil pH less than 6.0.

**SOWING THE SEEDS**

Dibble the seeds adopting the following spacing.

| Variety | Pure crop | | Mixed crop |
|---|---|---|---|
| | Low fertility | High fertility | |
| CO(Rg) 7 | 45 cm x 30 cm | 60 cm x 30 cm | 120 cm x 30 cm |
| Vamban (Rg) 3, APK 1 | 45 cm x 20 cm | 60 cm x 20 cm | 120 cm x 30 cm |
| CO 6, CO 8, Vamban 2, LRG 41 | 90 cm x 30 cm | 120 - 150 x 30 cm | 240 cm x 30 cm |
| Bund Crop | 60 cm for BSR 1 and 30 cm for others. | | |

**5. Season**

- Long duration varieties (CO 6, CO 8, Vamban 2, LRG 41) : Second fortnight of July and First fortnight of August months.
- Short duration varieties : January - May and September first fort night.
- Note: Sowing season should be planned in such a way that flowering and pod maturity stage does not coincide with rain.

**6. WEED MANAGEMENT**

i) Pre emergence application of Pendimethalin 0.75 kg/ha (2.5 litres/ha) on 3 DAS mixed with 500 litres of water using Backpack/Knapsack/Rocker sprayer using flat fan deflector type of nozzle. Then irrigate the field. Following this, one hand weeding may be given on 30-35 DAS

ii) If herbicide is not given, give two hand weedings on 20 and 35 DAS.

iii) In case of labour problem, apply Pendimethalin 0.75 kg (2.5 lit/ha) on 3 DAS followed by early post emergence application of Imazethapyr @ 60 g ai/ha on 15 DAE of weeds (2 - 3 leaves stage of weeds) and quizalofop ethyl @ 50 g ai/ha on 20 DAE of weeds (2 - 3 leaves of weeds) are recommended for controlling broad leaved and grassy weeds, respectively. If both the weeds are present, tank mix application of Imazethapyr @ 60 g ai/ha and quizalofop ethyl @ 50 g ai/ha at 15 - 20 days after emergence of weeds (2 - 3 leaves stage of weeds) is recommended. Apply PE Pendimethalin 30% EC + Imazethapyr 2% EC (Valor 32% EC; Readymix herbicide) @ 1,.0 kg a.i. $ha^{-1}$ at 3 DAS.

iv) Apply PE metalachlor 1.0 kg $ha^{-1}$ on 3 DAS followed by one hand weeding on 40 DAS. Note: At the time of herbicide application, there should be sufficient soil moisture

**7. WATER MANAGEMENT**

Irrigate immediately after sowing, 3rd day after sowing, bud initiation, 50 % flowering and pod development stages. Water stagnation should be avoided.

**8. FOLIAR APPLICATION**

a) Foliar spray of NAA 40 mg/l once at pre-flowering and another at 15 days thereafter

b) Foliar spray of DAP 20 g/l or urea 20 g/l once at flowering and another at 15 days there after

c) Foliar spray of salicylic and 100 mg/litre once at preflowering and another at 15 days there after

## 9. HARVESTING THE CROP

1) Harvest the whole plants when 80% of the pods mature.
2) Heap for 2 – 3 days
3) Dry and process.

## 10. INTER-CROPPING

a) Raise one row of long duration redgram varieties as inter crop for every six rows of groundnut (6:1) under rainfed situation.

b) Raise one row of short or medium duration redgram as inter crop for every four rows of groundnut (4:1) under rainfed as well as irrigated condition.

c) **Multistoreyed cropping**: For rainfed Vertisols of Virudhunagar, Tirunelveli, Thoothukudi districts recording more than 300 mm of rainfall during the crop growth period, multistoreyed cropping system Agathi + Redgram (Co 5) + Cotton (MCU 10) + Blackgram (Co 5) is highly profitable. (Agathi in I tier with 1 x 1 m spacing - Redgram in II tier with a spacing of 45 x 20 cm - Cotton in the III tier with a spacing of 45 x 15 cm - Blackgram in the IV tier with the spacing of 30 x 10 cm).

For rainfed Vertisols receiving less than 300 mm of rainfall, Agathi + Sorghum (CO 26) + Cotton (MCU 10) + Blackgram (Co 5) system is ideal. (Agathi in I tier with a spacing of 1 x 1 m - sorghum in II tier with a spacing of 45 x 15 cm - cotton in III tier with the spacing of 45 x 15 cm and Blackgram in IV tier with 30 x 10 cm). For both systems, apply 40 kg N and 20 kg $P_2O_5$/ha.

## 11. REDGRAM TRANSPLANTING

- Select only long duration redgram varieties
- Transplant within the month of August either under rainfed condition or under irrigated condition
- Select poly bag with a size of 6x4 inches and 200 micron thickness
- Fill the poly bag with native soil: Sand: FYM @1:1:1 and put 3-4 holes in the bottom to avoid water stagnation
- Soak the seeds in 0.2% Calcium chloride for one hour and dry it under shade for 7 hours to harden the seeds
- Treat the hardened seeds with *T. viride* @ 4g/kg and 100 g Rhizobium and 100 g phosphobacterium. Sow the seeds @2/poly bag at 1 cm depth
- Sow the seeds in polybags 30-45 days prior to transplanting
- Plough the field deeply to get fine tilth followed by 2-3 harrowings at 3 weeks prior to transplanting
- In medium to deep soils for raising long duration varieties, dig 15 sqcm pits at 5’ X 3’ for pure crops and 6’ x 3’ for intercropping under irrigated condition. In rainfed condition dig the pits at a spacing of 5’x3’. For short duration varieties dig 15 sq cm pits at 3’ x 2’ spacing.
- Under water logging condition, form furrows before digging pits
- Apply inorganic fertilizers @ 25:50:25 kg NPK /ha at 20-30 days after planting as urea, DAP and potash around the seedlings
- Apply $ZnSO_4$ @ 25 kg/ ha as basal along with FYM or sand

- Nip (removal of top 5 cm) the plants at 20 – 30 days after planting to arrest the terminal growth
- Foliar Spray of Napthalene aceptic acid (NAA) @ 0.5 ml/litre to control flower dropping in red gram.

**12. NUTRITIONAL DISORDERS**

Redgram / Greengram/Blackgram/Cowpea

Zinc: Symptom appears within a month of sowing. The plants are stripped with yellow or pale green foliage. Veins and mid ribs of the leaves are green although tissue around them becomes yellow and bronzed.

Iron: Reduced concentration of Chlorophyll in leaves - pale leaf colour may be indistinguishable from deficiency of nitrogen or other elements.

**CROP PHYSIOLOGY**

Foliar spray of TNAU Pulse Wonder @ 2 kg/acre in 200 litres of water at flower initiation stage decreases flower shedding, increases yield and offers moisture stress tolerance

**CROP PROTECTION**

**A. Pest management**

| **Pest** | **ETL** |
|---|---|
| Aphids | 20 nos. /2.5 cm shoot length |
| Pod borers | 10% of affected pods |
| Plume moth | 5 larvae /plant |
| Spotted pod borer | 3 larvae /plant |

**Pest Management strategies**

| | |
|---|---|
| **Aphids**<br>*Aphis craccivora* | **Spray any one of the following :**<br>Methyl demeton 25 EC 500 ml/ha<br>Dimethoate 30 EC 500 ml/ha |
| **Pod borers**<br>**Spotted pod borer**<br>*Maruca vitrata*<br>**Gram pod borer**<br>*Helicoverpa armigera*<br>**Plume moth**<br>*Exelastis atomosa*<br>**Pod fly**<br>*Melanagromyza obtusa* | • For pod borers, raise one row of sunflower as intercrop for every 9 rows of pigeon pea and plant maize as border crop.<br>• Pheromone traps for *Helicoverpa armigera* 12/ha<br>• Bird perches 50/ha<br>• Mechanical collection of grown up larva and blister beetle<br>• Ha NPV 3 x$10^{12}$ POB/ha in 0.1% teepol<br>• *Bacillus thuringiensis* var *kurstaki* 5%WP 1000-1250 g/ha<br>(Note : Insecticide / Ha NPV spray should be made when the larvae are upto third instar)<br>**Apply any one of the following insecticides:**<br>Azadirachtin 0.03 % WSP 2.5kg/ha<br>Benfuracarb 40% EC 2.5l/ha<br>Chlorantraniliprole 18.5% SC 150ml/ha<br>Chlorpyriphos 20 EC 1250 ml / ha<br>Emamectin benzoate 5% SG 220 g/ha<br>Ethion 50% EC 1.0 l/ha<br>Flubendiamide 39.35 % SC 100ml / ha<br>Indoxacarb 14.5% SC 350 ml/ha<br>Indoxacarb 15.8% SC 333 ml/ha<br>Lufenuron 5.4% EC 600ml/ha<br>Methomyl 40%SP 750g/ha<br>Monocrotophos 36%SL 625-1250ml/ha<br>Neem oil 2% |

| | |
|---|---|
| | Quinalphos 1.5%DP 23kg/ha<br>Quinalphos 25 %EC 1400ml/ha<br>Spinosad 45%SC 125 ml/ha<br>Thiodicarb 75 WP 625g / ha |
| **Pod bugs** | Dimethoate 30% EC 500ml/ha<br>Methyl demeton 25% EC 500ml/ha |

### B. Disease management

**Seed treatment :** Treat the seeds with *Trichoderma asperellum* @ 4 g or *P. fluorescens* @ 10 g or carbendazim 2 g or thiram @ 4 g/kg of seed

| Disease | Recommendations |
|---|---|
| **Wilt:**<br>*Fusarium udum* | • Apply *P. fluorescens* or *T. asperellum* @ 2.5 kg / ha with 50 kg of well decomposed FYM or sand to soil at 30 days after sowing<br>• Spot drench with carbendazim @ 1 g/ lit |
| **Root rot:**<br>*Rhizoctonia bataticola*<br>*(Macrophomina phaseolina)* | |
| **Sterility Mosaic:**<br>*Pigeonpea sterility mosaic virus*<br>(Vector : *Aceria cajani*) | • Rogue out the virus infected plants in the early stages of growth<br>• Spray fenazaquin @ 1ml/ l soon after appearance of the disease and if necessary repeat after 15 days |

### C. Nematode management

Seed treatment with *Pseudomonas fluorescens* and *Trichoderma viride* @ 5+5 g/kg seed manages population of cyst nematode, *Heterodera cajani*.

## SEED PRODUCTION
## RED GRAM - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be of the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified seed production leave a distance of 100 m all around the field from the same and other varieties of red gram.

**Pre-sowing seed treatment**

- Soak the seeds for 3 h in 100 ppm $ZnSO_4$ (10 g / 100 lit of water) in 1/3 volume before sowing and quickly air dry in shade to their original moisture content.
- Treat the seeds with carbendazim 75 % WP 2 g dissolved in 5 ml of water per kg of seeds and air-dried.
- Pellet the seeds with *Rhizobium* culture (50 g / kg of seed) before sowing.

**Foliar application**

- Spray 2 % DAP at the time of flowering and a second spray at 15 days after the first spray.
- Spray NAA 40 ppm at the time of flowering and a second spray at 15 days after the first spray.

**Pre-harvest sanitation spray**

- Spray (0.05 %) malathion 50 EC 3 - 5 days before harvest to minimize the carryover of bruchid infestation from field to storage.

**Harvest**

- Harvest the pods at physiological maturity stage (approximately 40 days after 50 % flowering).
- Collect the seeds from first and second pickings for quality seeds.

**Drying**

- Dry the pods to about 15 % moisture content.
- Dry the seeds to 10 % moisture content.

**Seed grading**

- Size grade the large seeded varieties using BSS 5 x 5 or BSS 6 x 6 wire mesh sieve.
- Discard the discoloured and broken seeds for seed purpose.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim 2 g using 5 ml of water / kg of seed (or) dry dress the seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder at 5:4:1 ratio @ 3 g / kg of seed.

**Storage**

- Store the seeds with a seed moisture content of 10 - 12 % in gunny or cloth bags for short term storage (8 - 9 months).
- Store the seeds with a seed moisture content of 8 - 9 % in polylined gunny bag for medium term storage (12 - 15 months).
- Store the seeds with a seed moisture content less than 8% in 700 gauge polythene bag for long term storage (more than 15 months)

## RED GRAM HYBRID SEED PRODUCTION

**Land requirement**

- Select fertile land with good drainage and irrigation facilities.
- Field should be free from volunteer plants. Hence, the previous crop should not be the same or different variety / hybrid of redgram.

**Isolation**

- For foundation seed production (parental lines seed production), leave a distance of 200 m all around the field from the same and other varieties / hybrids of redgram.
- For hybrid seed production from the same and other varieties / hybrids of redgram, leave a distance of 100 m all around the field.

**Planting ratio**

- Sow the female and male lines at a ratio of 4:2.

**Border rows**

- Sow 2 rows of the male parent all around the field for effective pollination.

**Spacing**

- 45 x 15 cm.

**Fertilizer**

- Apply NPK @ 25:50:25 kg / $ha^{-1}$ as basal application.

**Roguing**

- Pull out all male fertile plants in female rows for genetic purity maintenance.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g using 5 ml of water / kg of seed.
- Dry dress the seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizia amara*) leaf powder mixed in 5:4:1 ratio @ 3 g / kg of seed.
- Treat the seeds with turmeric rhizome powder (or) neem leaf powder at 1:50 ratio against bruchid infestation as an eco-friendly seed treatment.

## PERENNIAL REDGRAM

| | | |
|---|---|---|
| Variety | : | BSR 1 |
| Economic uses | : | Tender beans are pinkish green in colour and can be cooked as curry or added to Kurma or Sabji. When the beans mature they can be used as Dhal. Recommended for growing in kitchen gardens, backyards, farm road sides, as border crop in sugarcane, banana and betelvine and as a shade crop in turmeric and as a bund crop in paddy double cropped wetlands. |
| Season | : | June – July Height of the plant: 150 - 200 cm<br>Number of branches 7 - 10 |
| Flowering | : | Five months from date of sowing |
| Pit Size | : | Small pits are dug 90 cm apart and the pits are filled with a mixture of well decomposed manure or compost and soil. |
| Fertilizer application | : | Urea 15 g and superphosphate 30 g / pit. |
| Planting methods | : | Two to three seeds are dibbled per pit and watered. When they grow six inches height one plant may be retained in each pit. |
| Irrigation | : | Need based |
| Harvesting | : | If harvested when the pods are tender the beans will be fit for making curry. Each plant will yield two to three kg of green pods at an average seed yield of 750 g to one kg per plant. After the first harvest the branches are pruned and allowed to grow further. In another 45 - 60 days the plants produce the second flush. For pure crop, about 3 kg of seeds may be required. |

## (i) BLACKGRAM ( *Vigna mungo L.*)

### Climate Requirement

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 20 | 27 - 30 | 400 – 600 | 1800 |

Tropical and subtropicalhot and humid growing season. It is generally grown in kharif/rainy and summer season. Heavy rains during flowering stage are harmful to yield of pea crop.

### CROP IMROVEMENT
### 1. SEASON AND VARIETIES

| District/Season | Varieties |
|---|---|
| **Adipattam (June-August)**<br>All districts except Kanyakumari and Nilgiris | VBN 6, VBN 8 |
| **Puratasipattam (September-November)**<br>Vellore, Tiruvannamalai Dharmapuri, Salem, Namakkal, Perambalur, Erode, Coimbatore, Madurai, Dindigul, Theni, Pudukottai,, Sivagangai, Ramanathapuram, Virudhunagar, Thoothukudi and Tirunelveli | VBN 6, MDU 1, CO 6, VBN 8, VBN 10 |
| **Markazhi – Thaipattam(Winter Irrigated)**<br>All districts except Kanyakumari and Nilgiris | VBN 6, CO 6, VBN 8, VBN 10 |
| **Rice fallows (January)** Thanjavur,Tiruvarur, Nagapattinam, Cuddalore, Villupuram and Kanchipuram | ADT 3, ADT 6, KKM 1, VBN 6, VBN 9 |
| **Chithiraipattam (Summer Irrigated)**<br>Thanjavur, Tiruvarur, Nagapattinam, Cuddalore, Villupuram, Tiruchirappalli, Perambalur, Thiruvallur, Kancheepuram, | ADT 5, VBN 8 |

## II. DESCRIPTION OF BLACKGRAM VARIETIES

| **Particulars** | VBN 6 | VBN 8 | VBN 9 | VBN 10 |
|---|---|---|---|---|
| Year of Release | 2011 | 2018 | 2019 | 2019 |
| Year of Notification | SO.1708(E)/ 26.07.2012 | SO.1379(E)/ 27.03.2018 | SO.3220(E)/ 05.09.2019 | SO.3220(E)/ 05.09.2019 |
| Parentage | Vamban 1 x *Vigna mungo silvestris* | Vamban 3 x VBG 04-008 | Mash 114 x Vamban 3 | Vamban 1 x UH 04-04 |
| Maturity duration (days) | 65-70 | 65-70 | 70-75 | 70-75 |
| Grain yield (kg/ha) | - | - | | |
| Rainfed | 850 | 988 | 1230 | - |
| Irrigated | 890 | 871 | - | 1130 |
| Height (cm) | 18.6 | 35-40 | 35-40 | 35-40 |
| Hairiness of pods | Hairy | Hairy | Hairy | Hairy |
| 100 grain wt (g) | 3.8-4.0 | 4.5 – 5.0 | 4.0-5.0 | 4.0-5.0 |
| Special features | Resistant to Yellow Mosaic, synchronized pod maturity | Resistant to Mungbean Yellow Mosaic Virus (MYMV), leaf crinkle and moderately resistant to powdery mildew diseases | Moderately resistant to Mungbean Yellow Mosaic Virus, Urdben Leaf Crinkle Virus, Leaf Curl Virus and Powdery mildew diseases | Resistant to Mungbean Yellow Mosaic Virus, Urdbean Leaf Crinkle Virus, Leaf Curl Virus diseases |

| **Particulars** | CO 6 | ADT 3 | ADT 5 | ADT 6 | MDU 1 | KKM 1 |
|---|---|---|---|---|---|---|
| Year of Release | 2010 | 1982 | 1988 | 2017 | 2014 | 2017 |
| Year of Notification | SO.632(E)/25.03.11 | SO.596(E)/13.08.1984 | SO.793(E)/22.11.1991 | SO.1379(E)/27.03.2018 | SO.1556(E)/11.06.2015 | SO.1379(E)/27.03.2018 |
| Parentage | DU 2 x VB 6 | Pure line selection from Thirunelveli local | Pure line selection from Kanpur | Vamban 1 x VBN 04-006 | ADB 2003 x VBG 66 | COBG 643 X VBN3 |
| Maturity duration (days) | 60-65 | 70-75 | 65-70 | 65-70 | 70-75 | 65-70 |
| Grain yield (kg/ha) | - | - | - | - | - | |
| Rainfed | 880 | 720 (Rice fallow) | - | 740 (Rice fallow) | - | 610 (Rice fallow) |
| Irrigated | - | - | 1545 | - | 790 | - |
| Height (cm) | 30 -35 | 50 | 20-25 | 35-40 | 30-35 | 50 |
| Hairiness of pods | Non Hairy | Hairy | Hairy | Hairy | Hairy | |
| 100 grain wt (g) | 5.0 - 6.2 | 3.5- 4.0 | 3.5-4.5 | 4.0-5.0 | 4.5-5.0 | |
| Special features | Moderately resistant to YMV disease. Field tolerance to aphids, pod borer and synchronized maturity | Yellow mosaic incidence will be less during Markazhi and Thai pattam | After 65 days second sett of flowering starts | Moderately resistant to MYMV, LCV and PMD | Moderately resistant to MYMV, Non shattering and Non Lodging. Suitable for *Rabi* season. Good battering quality. | |

## III. SEED RATE

| VARIETIES | Quantity of seed required kg/ha<br>Pure crop | <br>Mixed crop |
|---|---|---|
| VBN 6, VBN 8, ADT 5, CO 6, MDU 1 | 20 | 10 |
| ADT 3, ADT 6, KKM 1 (Rice fallows) | 25 | .. |

Optimum plant population 3,25,000/ha

**CROP MANAGEMENT**

## IV. MANAGEMENT OF FIELD OPERATIONS

### 1. FIELD PREPARATION

i. Prepare the land to fine tilth and form beds and channels.
ii. Amendments for soil surface crusting: To tide over the soil surface crusting apply lime at the rate of 2t /ha along with FYM at 12.5 t/ha or composted coirpith at 12.5 t/ha to get an additional yield of about 15 - 20%.

### 2. SEED TREATMENT

Treat the seeds with Carbendazim or Thiram @ 2 g/kg of seed 24 hours before sowing (or) with talc formulation of *Trichoderma viride* @ 4g/kg of seed (or) *Pseudomonas fluorescens* @ 10 g/kg seed. Bio control agents are compatible with biofertilizers. First treat the seeds with Biocontrol agents and then with Rhizobium. Fungicides and biocontrol agents are incompatible.

Note: Seed treatment will protect the seedlings from seed borne pathogens, root-rot and seedlings diseases.

### 3. SEED TREATMENT WITH BIOFERTILIZER

a) Treat the seeds required for sowing 1 ha with 200g each of Rhizobial culture COG 15, Phosphobacteria and PGPR (*Pseudomonas* sp.) using rice gruel, shade dry it before sowing. (or) Treat one hectare of seeds with 25 g each of each of powder formulation of *Rhizobium* and AM fungi using binder (polymer), shade dry before sowing.
b) If seed treatment is not carried out, apply 2 kg each Rhizobial culture, Phosphobacteria and PGPR (*Pseudomonas* sp.) with 25 kg of FYM and 25 kg of sand, mix uniformly before sowing.

### 4. FERTILIZER APPLICATION

If soil test is not done, apply fertilizers basally before sowing

a) Apply fertilizers basally before sowing.
   Rainfed : 12.5 kg N + 25 kg $P_2O_5$ + 12.5 kg $K_2O$ +20 kg S*/ha Irrigated : 25 kg N + 50 kg $P_2O_5$ + 25 kg $K_2O$ + 40 kg S*/ha
   *Note : Applied in the form of gypsum if Single Super Phospate is not applied as a source of phosphorus

Soil test crop response based integrated plant nutrition system (STCR- IPNS recommendation may be adopted for prescribing fertilizer doses for specified yield targets (ready reckoners are furnished )

| | | | |
|---|---|---|---|
| Soil | : | Mixed black calcareous (Perianackenpalayam series) | FN = 10.84T-0.39 SN<br>$FP_2O_5$=7.23T-1.00 SP |
| Target | : | 0.9 – 1.0 t $ha^{-1}$ | $FK_2O$=5.20T-0.04 SK |

| **Initial soil test values (kg $ha^{-1}$)** | | | **Yield target – 0.9 t $ha^{-1}$** | | | **Yield target – 1.0 t $ha^{-1}$** | | |
|---|---|---|---|---|---|---|---|---|
| | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 300 | 13* | 25* | 13* | 13* | 28 | 13* |
| 180 | 14 | 325 | 13* | 25* | 13* | 13* | 26 | 13* |
| 200 | 16 | 350 | 13* | 25* | 13* | 13* | 25* | 13* |
| 220 | 18 | 375 | 13* | 25* | 13* | 13* | 25* | 13* |
| 240 | 20 | 400 | 13* | 25* | 13* | 13* | 25* | 13* |

*maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield targe in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

b) Soil application of 25 kg $ZnSO_4$/ha under irrigated condition (or) 12.5 kg $ZnSO_4$ on EFYM.

c) Soil application of TNAU micronutrient mixture @ 5 kg/ha as Enriched FYM. (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture incubate for one month in shade).

   50 kg $FeSO_4$ as EFYM or 10 kg Fe EDTA per ha.

d) Foliar spray of 1% urea for yield improvement in black gram.

   For yield improvement through increasing the physiological, biochemical attributes, foliar spray of urea 1% on 30 and 45 dayas after sowing is recommended. For rice fallow pulses in Delta area, the present recommendation of foliar spray of 2% DAP may be continued.

   Foliar spraying of 0.5% ZnSO4, 1% FeSO4 + 0.1% citric acid at 30, 45 DAS if the plants shown deficiency symptoms. For yield improvement through increasing the physiological, biochemical attributes, foliar spray of urea 1% on 30, 45 days after sowing is recommended. For rice fallow pulses in Delta area, the present recommendation of foliar spray of 2% DAP may be continued.

**e) Foliar spraying to mitigate moisture stress**

Foliar spraying of 2% KCl + 100 ppm Boric acid during dry spell as mid season management practice in black gram during *Rabi* season is recommended to increase the yield over KCl spray alone .

**Economizing the use of micronutrients through seed treatment for blackgram**

Seed coating with biofertilizers and micronutrients viz., Zn, Mo & Co @ 4, 1, 0.5 g/kg of seed is recommended.

**Nitrogen substitution by organic sources for pulses**

50 per cent nitrogen can be substituted through organic source (850 kg of vermicompost pe hectare). Lime application is recommended for pulses with soil pH less than 6.0.

## 5. SOWING OF SEEDS

a) For irrigated crop dibble the seeds adopting 30 x 10 cm spacing
b) For rainfed crop dibble the seeds adopting 25 cm x 10 cm spacing

## 6. WATER MANAGEMENT

Irrigate immediately after sowing, followed by life irrigation on third day. Irrigate at intervals of 7 to 10 days depending upon soil and climatic conditions. Flowering and pod formation stages are critical periods when irrigation is a must. Avoid water stagnation at all stages. Apply KCl at 0.5 per cent as foliar spray during vegetative stage if there is moisture stress.

## 7. FOLIAR APPLICATION

a. Foliar spray of NAA 40 mg/litre once at pre-flowering and another at 15 days thereafterto reduce flower shedding.
b. i) For rice fallow crops foliar spray of TNAU Pulse wonder @ 5 kg/ha once at flowering to decreases flower shedding.
   ii) For irrigated and rainfed crops, foliar spray of TNAU Pulse wonder @ 5 kg/ha once at flowering
c. Foliar spray of salicylic acid 100 mg/litre once at preflowering and another at 15 days there after to improve translocation efficiency and seed yield.

## 8. WEED MANAGEMENT

i) Pre emergence application of Pendimethalin 1.0 litres/ha under irrigated condition, PE application of Pendimethalin 0.75 litres/ha under rainfed condition on 3 days after sowing using Backpack/ Knapsack/Rocker sprayer fitted with flat fan nozzle using 500 litres of water for spraying one ha followed by one hand weeding at 20 DAS (or) EPOE application of quizalofop ethyl @ 50 g ai/ha$^{-1}$ and imazethapyr @ 50 g ai ha$^{-1}$ on 15 – 20 DAS. If herbicides are not applied give two hand weedings on 15 and 30 days after sowing.
ii) Apply PE Pendimethalin 30% EC + Imazethapyr 2% EC (Valor 32% EC; Readymix herbicide) @ 1.0 kg a.i. ha$^{-1}$ at 3 DAS.

## 9. Multi bloom technology

A special technology being practiced in Pattukottai block of Tanjore district for blackgram and greengram. The soil is alluvial and rich in organic matter and nutrients. The crop is sown during early summer (Jan.-Feb.) as normal crop and fertilizer is applied as per the recommendation for irrigated crop. In addition to that, top dressing of Nitrogen is done with an extra dose of 25 to 30 kg through urea. Since pulses are indeterminate growth habit and continue to produce new flashes, the top dressing will be done on 40-45 days after sowing. The crops complete its first flesh of matured pods during 60-65$^{th}$ day, further their second new flesh within 20-25 days. Therefore two fleshes of pods can be harvested at a time within the duration of 100 days.

## CROP PROTECTION

### A. Pest management

**Economic threshold level for important pests**

| Pest | ETL |
|---|---|
| Aphids | 20nos./2.5 cm shoot length |
| Pod borers | 10% of affected pods |
| Spotted pod borer | 3 larvae/plant |
| Stem fly | 10% of affected plants |
| Tobacco caterpillar | 8 egg masses/100 m |

**Pest Management strategies**

| | |
|---|---|
| **Stem fly**<br>*Ophiomyia phaseoli* | Treat seeds with Dimethoate 30% EC 5 ml/kg |
| **Aphids**<br>*Aphis craccivora* | **Spray any one of the following**<br>Methyl demeton 25% EC 500 ml/ha<br>Dimethoate 30% EC 500 ml/ha |
| **Whitefly**<br>*Bemisia tabaci* | **Spray any one of the following**<br>Methyl demeton 25% EC 500 ml/ha<br>Dimethoate 30% EC 500 ml/ha |
| **Tobacco caterpillar**<br>*Spodoptera litura* | ➢ Use of light trap to monitor and kill the attracted adult moths.<br>➢ Set up the sex pheromone trap at 12/ha to monitor the activity of the pest and to synchronize the pesticide application, if need be, at the maximum activity stage.<br>➢ Growing castor along border and irrigation bunds.<br>➢ Removal and destruction of egg masses in castor and cotton crops.<br>➢ Removal and destruction of early stage larvae found in clusters which can be located easily even from a distance.<br>➢ Collection and destruction of shed materials.<br>➢ Hand picking and destruction of grownup caterpillars.<br>**Spray any one of the following insecticides**<br>Chlorpyriphos 20 EC 3750 ml/ha<br>Chlorantraniliprole 18.5% SC @150 ml/ha<br>Flubendiamide 39.35% SC 100ml/ha |
| **Blue butterflies**<br>*Lampides boeticus*<br>*Euchrysops cnejus* | **Spray any one of the following insecticides**<br>Chlorantraniliprole 18.5% SC 100ml/ha<br>Flubendiamide 39.35% SC 100ml/ha<br>Lufenuron 5.4% EC 600ml/ha<br>Monocrotophos 36% SL 625 ml/ha |

| | |
|---|---|
| **Spotted pod borer**<br>*Maruca vitrata* | Thiodicarb 75% WP 625g/ha |

| | |
|---|---|
| **Pod bugs** | Dimethoate 30% EC 500ml/ha<br>Methyl demeton 25% EC 500ml/ha |
| **Storage pests**<br>Bruchid-<br>*Callosobruchus chinensis*<br>*C. maculatus* | Dry the seeds adequately to reduce moisture level to 10 %.<br>Use two-in-one or pitfall traps for monitoring the emergence of field carried over pulse beetle in storage and accordingly sun-dry the produce.<br>Mix Malathion 5% D 1 kg with 100kgs of seed<br>Pack in polythene lined gunny bags for storage |

## B. Disease management

**Seed treatment:** Treat the seeds with *T. asperellum* @ 4 g or *P. fluorescens* @ 10 g or carbendazim @ 2 g or thiram @ 4 g/kg of seed

| Disease | Recommendations |
|---|---|
| **Powdery mildew:**<br>*Erysiphe polygoni* | • Spray NSKE 5% or neem oil 3% twice at 10 days interval from initial disease symptom appearance<br>• Spray 10% Eucalyptus leaf extract at initiation of the disease and 10 days later<br>• Spray carbendazim @ 500 g or wettable sulphur 1500 g/ha or propiconazole 500 ml/ha at initiation of the disease and 10 days later |
| **Rust:**<br>*Uromyces appendiculatus* | Spray mancozeb @ 1000 g or wettable sulphur 1500 g /ha at initiation of the disease and 10 days later |
| **Leaf spot:**<br>*Cercospora canescens* | Spray carbendazim @ 500 g/ha or mancozeb @ 1000g /ha at initiation of the disease and 10 days later |
| **Yellow mosaic** (Geminivirus)<br>**and**<br>**Leaf crinkle**<br>(Vector:<br>*Bemisia tabaci*)<br><br>**Leaf curl** (Tospovirus)<br>(Vector:<br>*Frankliniella schultzii,*<br>*Thrips tabaci,*<br>*Scirtothrips dorsalis*) | **Integrated disease management**<br>• Growing resistant varieties such as VBN 4, VBN 6, VBN 7 and VBN8<br>• Seed treatment with imidacloprid 600FS @ 5 ml/kg of seeds<br>• Installation of yellow sticky traps @ 12 numbers / ha<br>• Rogue out the virus infected plants up to 45 days<br>• Foliar spray of 10% notchi leaf extract at 30 DAS or neem formulation @ 3 ml/l<br>• Spray methyl demeton 25 EC 500 ml/ha or dimethoate 30 EC 500 ml/ha or thiamethoxam 75WG @ 100 g/ha or imidacloprid 17.8 SL @ 250 ml/ha or thiamethoxam 75 WS 1 g /3 lit and repeat after 15 days, if necessary |
| **Root rot:**<br>*Rhizoctonia bataticola*<br>*(Macrophomina phaseolina)* | • Seed treatment with *Trichoderma asperellum* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg<br>• Basal soil application of zinc sulphate 25 kg/ha<br>• Basal soil application of neem cake @ 150 kg/ha<br>• Soil application *P. fluorescens* or *T. asperellum* @ 2.5 kg / ha with 50 kg of well decomposed FYM or sand at 30 days after sowing<br>• Spot drench with carbendazim @ 1 g/ l |

| | |
|---|---|
| **Root rot - stem fly complex** | Seed treatment with *Beauveria bassiana* + *Pseudomonas fluorescens* @ 5g each/kg of seed |

**RICE-FALLOWS**

**VARIETIES AND SEED RATE**

| VARIETIES | Quantity of seed required kg/ha<br>Sole crop | Mixed crop |
|---|---|---|
| ADT 3, ADT 6, KKM 1, VBN 6 (Rice fallows) | 25 | .. |

1. **TIME OF SOWING**

Third week of January –Second week of February

2. **SOWING OF SEEDS**

a) For relay cropping broadcast the seeds in the standing crop 5 to 10 days before the harvest of the paddy crop uniformly under optimum soil moisture conditions so that the seeds should get embedded in the waxy mire.

b) For combined harvesting areas, broadcast the seeds before harvesting the paddy crop with machinerie

3. **FOLIAR APPLICATION**

a. Foliar Spray of NAA 40 mg/litre once at pre-flowering and another at 15 days thereafter

b. Foliar spray of pulse wonder @ 5 kg/ha once at flowering to decreases flower shedding and improve yield.

c. Foliar spary of salicylic acid 100 mg/litre once at prefloweing in another and 15 days there after to improve translocation efficiency and seed yield.

4. **HARVESTING**

i) Picking the matured pods, drying and processing

ii) Uprooting or cutting the whole plants, heaping, drying and processing

**BLACKGRAM - VARIETAL SEED PRODUCTION**

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be of the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production, leave a distance of 5 m all around the field from the same and other varieties of the crop.

**Pre-sowing seed treatment**

- Remove all discoloured seeds and use only normal coloured seeds for seed purpose.
- If the presence of hard seed percentage exceeds more than 10 %, scarify the seeds

with commercial $H_2SO_4$ for 2 min.
- Harden blackgram seeds for garden and dry land ecosystem with 100 ppm $ZnSO_4$ for 3 h in 1/3 volume of solution and dry seeds under shade to the original seed moisture content (8 - 9 %)

**Fertilizer**
- NPK @ 25 : 50 : 25 kg + 5 kg of TNAU micro nutrient mixture / ha.

**Foliar application**
- Spray 2 % DAP at the time of first appearance of flowers and second spray 15 days after first spray for enhanced seed set.
- Spray NAA 40 ppm at first flowering and at fortnight interval to reduce the flower drop.
- Spray 0.1 % brassinoloid on 35$^{th}$ and 45$^{th}$ day after sowing.

**Pre-harvest sanitation spray**
- Spray Malathion 50 EC at 0.05 % three to five days before harvest to minimize the bruchid infestation in storage.

**Harvest**
- Harvest the pods 30 days after 50 per cent flowering. At this stage, the colour of majority of the pods (80 %) will be black. The pod moisture content will be around 17 - 18 %.
- Harvest the pods as pickings, if the flowering period is longer.
- Dry the pods to 13 to 15 per cent moisture content.

**Threshing**
- Thresh the pods either with pliable bamboo stick or pulse thresher.

**Drying**
- Dry the seeds to 8 - 9 per cent moisture content.

**Seed grading**
- Grade the seeds using BSS 7 x 7 wire mesh sieve
- Discard the discoloured and broken seeds for seed purpose.
- Avoid bruchid infected seeds for sowing.

**Pre-storage seed treatment**
- Treat the seeds with carbendazim @ 2 g / kg of seed.
- Treat the seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 3 g / kg of seed as eco-friendly treatment.

**Storage**
- Store the seeds with a seed moisture content of 10 - 12 % in gunny or cloth bags for short term storage (8 - 9 months).
- Store the seeds with a seed moisture content of 8 - 9 % in polylined gunny bag for medium term storage (12 - 15 months).
- Store the seeds with a seed moisture content less than 8 % in 700 gauge polythene bag for long term storage (more than15 months).

# (ii) GREENGRAM ( *Vigna radiata* L. )

## Climate requirement

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 20 | 25 - 32 | 600 - 800 | 2000 |

Tropical and subtropical hot climate. The crop needs a well - distributed rainfall. Heavy rains at flowering are harmful, even moist winds at this stage interfere with fertilization. It can tolerate drought to a great extent. It is considered to be the hardiest pulse among all pulse crops. Day neutral plant.

## CROP IMPROVEMENT
## i. SEASON AND VARIETIES

| District/season | Varieties |
|---|---|
| **Adipattam (June - July)**<br>All districts except Kanyakumari and Nilgiris | CO(Gg) 7, VBN(Gg) 2, VBN(Gg) 3, CO 8, VBN 4 |
| **Puratasipattam (September - October)**<br>Kanchipuram, Tiruvallur, Dharmapuri, Vellore, Tiruvannamalai, Salem, Namakkal, Cuddalore, Villupuram, Thiruchirapalli, Perumbalur, Erode, Coimbatore, Madurai, Dindigul, Theni, Pudukottai, Pudukkottai, Sivagangi, Ramanthapuram, Virudhunagar, Thothukudi and Thirunelveli, | Co(Gg) 7, VBN(Gg) 2, VBN(Gg) 3, CO 8, VBN 4 |
| **Margazhi-Thai Pattam (December – January)**<br>All districts except Kanyakumari and Nilgiris | VBN(Gg)3, CO(Gg) 7, CO 8 |
| **Rice fallows (January - February)**<br>Thanjavur, Tiruvarur, Nagapattinam, Cuddalore, | ADT 3 |
| **Summer (February - March)**<br>Thanjavur, Tiruvarur, Nagapattinam, Cuddalore, Villupuram, Tiruchirapalli, Perambalur, Thiruvallur, Kanchipuram | VBN(Gg) 3, CO(Gg) 7, CO 8, VBN 4 |

## II. DESCRIPTION OF GREENGRAM VARIETIES

| **Particulars** | **Co (Gg) 7** | **CO 8** | **VBN(Gg) 2** | **VBN (Gg) 3** | **ADT 3** | **VBN 4** |
|---|---|---|---|---|---|---|
| Year of Release | 2005 | 2013 | 2001 | 2009 | 1988 | 2019 |
| Year of Notification | SO.1177(E)/25.08.05 | SO.268(E)/28.01.2015 | SO.1197(E)/14.11.2002 | SO.2137(E)/31.08.2010 | SO.793(E)/22.11.1991 | SO.3220(E)/05.09.2019 |
| Parentage | MGG336 x CoGG 902 | COGG 923 x VC 8040A | VGG 4 x MH 309 | CO 1 x Vellore local | H7016 x Rajendran G65 | PDM 139 x BB 2664 |
| Maturity duration (days) | 60-65 | 55- 60 | 65-70 | 65-75 | 70-75 | 65-70 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Grain yield (kg/ha) | | | | | | |
| Rainfed (kg/ha) | 980 | - | 750 | 775 | 500 (rice fallow) | 936 |
| Irrigated (kg/ha) | - | 845 | 900 | 880 | - | 1251 |
| Height (cm) | 30 - 45 | 55-65 | 50-60 | 35-55 | 40-60 | 45-55 |
| Pod Colour at maturity | Brown | Brown | Black | Brown | Black | |
| 100 grain wt (g) | 3.5 – 4.0 | 3.5-4 | 3.6-3.9 | 2.8-3.5 | 2.5-3.5 | 35-40 |
| Special features | High protein content (25.2%), High seed weight and synchroniz ed maturity | Suitable for single/mechani cal harvest. Moderately resistant to MYMV and stem necrosis diseases. Moderately resistant to sucking pests like aphids and stem fly | Moderately resistant to Yellow Mosaic, Synchronize pod maturity | Moderately resistant to powdery mildew and Yellow mosaic Indeterminat e flowering | Suitable only for Rice fallow and Margazhi pattam | Resident to urbean leaf crinkle virus, moderately resistant to yellow mosaic virus and powdery mildew diseases |

## I. SEED RATE

| Particulars | Quantity of seed required kg/ha | |
|---|---|---|
| | Pure crop | Mixed crop |
| All varieties | 20 | 10 |
| Rice fallows - ADT 3 | 30 | -- |

## II. MANAGEMENT OF FIELD OPERATIONS

### 1. FIELD PREPARATION

i. Prepare the land to get fine tilth and form beds and channels.

ii Amendments for soil surface crusting: To tide over the soil surface crusting apply lime at the rate of 2 t/ha along with FYM at 12.5 t/ha or composted coir pith at 12.5 t/ha to get an additional yield of about 15 - 20%.

### 2. SEED TREATMENT

Treat the seeds with Carbendazim or Thiram @ 2 g/kg of seed 24 hours before sowing (or) with talc formulation of *Trichoderma viride* @ 4g/kg of seed (or) *Pseudomonas fluorescens* @ 10 g/kg seed. Bio control agents are compatible with biofertilizers. First treat the seeds with Biocontrol agents and then with Rhizobium. Fungicides and biocontrol agents are incompatible.

### 3. SEED TREATMENT WITH BIOFERTILIZER

a) Treat the seeds required for sowing 1 ha with 200g each of Rhizobial culture COG 15, Phosphobacteria and PGPR (*Pseudomonas* sp.) using rice gruel, shade dry it before sowing. (or) Treat one hectare of seeds with 25 g each of each of powder formulation of *Rhizobium* and AM fungi using binder (polymer), shade dry before sowing.

b) If seed treatment is not carried out, apply 2 kg each Rhizobial culture, Phosphobacteria and PGPR (*Pseudomonas* sp.) with 25 kg of FYM and 25 kg of sand, mix uniformly before sowing.

### 4. FERTILIZER APPLICATION

If soil test is not done ,

Apply fertilizers basally before sowing.

Rainfed : 12.5 kg N + 25 kg $P_2O_5$ + 12.5 kg $K_2O$ +20 kg S*/ha Irrigated : 25 kg N + 50 kg $P_2O_5$ + 25 kg $K_2O$ + 40 kg S*/ha

*Note : Applied in the form of gypsum if Single Super Phospate is not applied as a source of phosphorus

Soil test crop response based integrated plant nutrition system (STCR- IPNS recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished )

| | | | |
|---|---|---|---|
| Soil : | Red sandy loam (Irugur series) | | FN = 25.07 T - 0.71 SN |
| Target | 0.8– 0.9 t $ha^{-1}$ | | $FP_2O_5$ = 15.44 T - 5.48 SP<br>$FK_2O$ = 11.00 T - 0.19 SK |

| Initial soil test values (kg $ha^{-1}$) | | | Yield target –0. 8 t $ha^{-1}$ | | | Yield target – 0.9 t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 160 | 38** | 26 | 18 | 38** | 41 | 29 |
| 180 | 14 | 180 | 33 | 25* | 14 | 38** | 30 | 25 |
| 200 | 16 | 200 | 19 | 25* | 13* | 38** | 25* | 21 |
| 220 | 18 | 220 | 13* | 25* | 13* | 29 | 25* | 17 |
| 240 | 20 | 240 | 13* | 25* | 13* | 15 | 25* | 13 |

* Maintenance dose;** Maximum dose

Note: FN, $FP_2O_5$ and $FK_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{1}$.

c) Soil application of 25 kg $ZnSO_4$/ha or 12.5 kg $ZnSO_4$ as EFYM under irrigated condition

d) Soil application of TNAU micronutrient mixture @ 5 kg/ha as Enriched FYM (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture &incubate for one month in shade).

50 kg $FeSO_4$ as EFYM or 10 by Fe EDTA $ha^{-1}$ for the deficient soils.

**Multi-blooming technology for irrigated green gram in new delta region of Thanjavur**

For higher yield and income, apply 25:50:25:20 kg NPKS/ha.+25 kg N/ha. in 3 equal splits on 30, 45 and 60 days after sowing + 2% DAP spray on 45 and 60 days after sowing.

Foliar spraying of 0.5% $ZnSO_4$ thrice, 1% $FeSO_4$ + 0.1% citric acid thrice can be followed when plants shows deficiency symptoms at 7-10 days intervals.

**e) Foliar spray of 1% urea for yield improvement in green gram**

For yield improvement through increasing the physiological, biochemical attributes, foliar spray of urea 1% on 30 and 45 days after sowing is recommended. For rice fallow pulses in Delta area, the present recommendation of foliar spray of 2% DAP may be continued.

**Economizing the use of micronutrients through seed treatment for greengram**

Seed coating with biofertilizers and micronutrients viz., Zn, Mo & Co @ 4,1,0.5 g/kg of seed is recommended.

## 5. SOWING

Dibble the seeds adopting a spacing of 30 x 10 cm. For bund crop dibble the seeds at 30 cm spacing.

## 6. WATER MANAGEMENT

Irrigate immediately after sowing, followed by life irrigation on third day. Irrigate at interval of 7 to 10 days depending upon soil and climatic conditions. Flowering and pod formation stages are critical periods when irrigation is a must. Avoid water stagnation at all stages. Apply KCl at 2.0 per cent as foliar spray during vegetative stage if there is moisture stress.

## 7. FOLIAR APPLICATION

a. Foliar spray of NAA 40 mg/litre and Salicylic acid 100 mg/litre once at pre-flowering and another at 15 days thereafter to reduce flower shedding.

b. i) For rice fallow crops, foliar spray of TNAU Pulse wonder @ 5 kg/ha once at flowering or DAP 20 g/litre once at flowering and another at 15 days thereafter

   ii) For irrigated and rainfed crops foliar spray of TNAU Pulse wonder @ 5 kg/ha once at flowering or DAP 20 g/litre or urea 20 g/litre once at flowering and another at 15 days thereafter.

c. Foliar spray of salicylic acid 100 mg/litre at preflowering and another at 15 days therafter to improve translocation efficiency and seed yield.

## 8. WEED MANAGEMENT

i) Pre emergence application of Pendimethalin @ 1.0 litres / ha under irrigated condition or PE application of Pendimethalin 0.75 litres per hectare under rainfed condition on 3 days after sowing using Backpack/ Knapsack/Rocker sprayer fitted with flat fan nozzle using 500 litres of water for spraying one ha. After this, one hand weeding on 30$^{th}$ days after sowing gives weed free environment throughout the crop period (or) EPOE application of quizalofop ethyl @ 50 g ai/ha$^{-1}$ and imazethapyr @ 50 g ai ha$^{-1}$ on 15 – 20 DAS.

ii) If herbicide is not applied give two hand weedings on 15 and 30 days after sowing.

iii) Apply PE Pendimethalin 30% EC + Imazethapyr 2% EC (Valor 32% EC; Readymix herbicide) @ 1.0 kg a.i. ha$^{-1}$ at 3 DAS.

iv) For the irrigated blackgram PE isoproturon @ 0.5 kg ha$^{-1}$ followed by one hand weeding on 30 DAS.

## 9. MULTI BLOOM TECHNOLOGY

A special technology being practiced in Pattukottai block of Tanjore district for blackgram and greengram. The soil is alluvial and rich in organic matter and nutrients. The crop is sown during early summer (Jan.-Feb.) as normal crop and fertilizer is applied as per the recommendation for irrigated crop. In addition to that, top dressing of Nitrogen is done with an extra dose of 25 to 30 kg through urea. Since pulses are indeterminate in growth habit and continue to produced new flushes, the top dressing will be done on 40-45 days after sowing. The crop complete its first flushes of matured pods during 60-65$^{th}$ day and put further second new flush within 20-25 days. Therefore two flushes of pods can be harvested at a time within the duration of 100 days.

## CROP PROTECTION

### A. Pest management

**Economic threshold level for important pests**

| **Pest** | **ETL** |
|---|---|
| Aphids | 20/2.5 cm shoot length |
| Pod borers | 10% of affected pods |
| Spotted pod borer | 3/plant |
| Stem fly | 10%of affected plants |
| Tobacco cut worm | 8 egg masses/100 m |

**Pests Management strategies**

| | |
|---|---|
| **Stem fly**<br>*Ophiomyia phaseoli* | Treat seeds with dimethoate 30% EC 5 ml/kg of seed |
| **Aphids**<br>*Aphis craccivora* | **Spray any one of the following**<br>Methyl demeton 25% EC 500 ml/ha<br>Dimethoate 30% EC 500 ml/ha |
| **Whitefly**<br>*Bemisia tabaci* | **Spray any one of the following**<br>Methyl demeton 25% EC 500 ml/ha |

| | |
|---|---|
| | Dimethoate 30% EC 500 ml/ha |
| **Tobacco cut worm**<br>*Spodoptera litura* | ➢ Use of light trap to monitor and kill the attracted adult moths.<br>➢ Set up the sex pheromone trap at 12/ha to monitor the activity of the pest and to synchronize the pesticide application, if need be, at the maximum activity stage.<br>➢ Growing castor along border and irrigation bunds.<br>➢ Removal and destruction of egg masses in castor and cotton crops.<br>➢ Removal and destruction of early stage larvae found in clusters which can be located easily even from a distance.<br>➢ Collection and destruction of shed materials.<br>➢ Hand picking and destruction of grownup caterpillars.<br>**Spray any one of the following insecticides**<br>Chlorpyriphos 20 EC 3750 ml/ha<br>Chlorantraniliprole 18.5% SC @150 ml/ha<br>Flubendiamide 39.35% SC 100ml/ha |
| **Blue butterflies**<br>*Lampides boeticus*<br>*Euchrysops cnejus* | **Spray any one of the following insecticides**<br>Chlorantraniliprole 18.5% SC 100ml/ha<br>Flubendiamide 39.35% SC 100ml/ha<br>Lufenuron 5.4% EC 600ml/ha<br>Monocrotophos 36% SL 625 ml/ha<br>Thiodicarb 75% WP 625g/ha |
| **Spotted pod borer**<br>*Maruca vitrata* | Monocrotophos 36% SL 437 ml/ha<br>Chlorantraniliprole 18.5% SC 100ml/ha |
| **Pod bugs** | Dimethoate 30% EC 500ml/ha<br>Methyl demeton 25% EC 500ml/ha |
| **Storage pests**<br>Bruchid-<br>*Callosobruchus chinensis*<br>*C. maculatus* | Dry the seeds adequately to reduce moisture level to 10 %.<br>Use pitfall traps or two in one model trap to monitor the time of emergence of field carried over pulse beetle in storage and accordingly sun-dry the produce.<br>Mix Malathion 5 D 1 kg for every 100 kg seed<br>Pack in polythene lined gunny bags for storage |

## Disease Management

**Seed treatment:** Treat the seeds with *T. asperellum* @ 4 g or *P. fluorescens* @ 10 g or carbendazim @ 2 g or thiram @ 4 g/kg of seed

| Disease | Recommendations |
|---|---|
| **Powdery mildew:**<br>*Erysiphe polygoni* | • Spray NSKE 5% or neem oil 3% twice at 10 days interval from initial disease symptom appearance<br>• Spray 10% Eucalyptus leaf extract at initiation of the disease and 10 days later<br>• Spray carbendazim @ 500 g or wettable sulphur 1500 g/ha or propiconazole 500 ml/ha at initiation of the disease and 10 days later |
| **Rust:**<br>*Uromyces appendiculatus* | Spray mancozeb @ 1000 g or wettable sulphur 1500 g /ha at initiation of the disease and 10 days later |

| | |
|---|---|
| **Leaf spot:**<br>*Cercospora canescens* | Spray carbendazim @ 500 g/ha or mancozeb @ 1000g /ha at initiation of the disease and 10 days later |
| **Yellow mosaic**<br>(Geminivirus)<br>**and**<br>**Leaf crinkle**<br>(Vector:<br>*Bemisia tabaci*)<br><br>**Leaf curl** (Tospovirus)<br>(Vector:<br>*Frankliniella schultzii,*<br>*Thrips tabaci,*<br>*Scirtothrips dorsalis*) | **Integrated disease management**<br>• Seed treatment with imidacloprid 600FS @ 5 ml/kg of seeds<br>• Installation of yellow sticky traps @ 12 numbers / ha<br>• Rogue out the virus infected plants up to 45 days<br>• Foliar spray of 10% notchi leaf extract at 30 DAS or neem formulation @ 3 ml/l<br>• Spray methyl demeton 25 EC 500 ml/ha or dimethoate 30 EC 500 ml/ha or thiamethoxam 75WG @ 100 g/ha or imidacloprid 17.8 SL @ 250 ml/ha or thiamethoxam 75 WS 1 g /3 lit and repeat after 15 days, if necessary |
| **Root rot:**<br>*Rhizoctonia bataticola (Macrophomina phaseolina)* | • Seed treatment with *Trichoderma asperellum* @ 4 g/kg or *Pseudomonas fluorescens* @ 10 g/kg<br>• Basal soil application of zinc sulphate 25 kg/ha<br>• Basal soil application of neem cake @ 150 kg/ha<br>• Soil application *P. fluorescens* or *T. asperellum* @ 2.5 kg / ha with 50 kg of well decomposed FYM or sand at 30 days after sowing<br>• Spot drench with carbendazim @ 1 g/ l |
| **Root rot - stem fly complex** | Seed treatment with *Beauveria bassiana* + *Pseudomonas fluorescens* @ 5g each/kg of seed |

## RICE-FALLOWS

### VARIETIES AND SEED RATE

| Varieties | Quantity of seed required kg/ha Sole crop | Mixed crop |
|---|---|---|
| ADT 3 | 30 | - |

### 1. TIME OF SOWING

Third week of January –Second week of February

### 2. SOWING OF SEEDS

a) For relay cropping broadcast the seeds in the standing crop 5 to 10 days before the harvest of the paddy crop uniformly under optimum soil moisture conditions so that the seeds should get embedded in the waxy mire.

b) For combined harvesting areas, broadcast the seeds before harvesting the paddy crop with machineries

### 3. FOLIAR APPLICATION

a. Foliar spray of NAA 40 mg/litre once at pre-flowering and another at 15 days thereafter

b. Foliar spray of TNAU pulse wonder @ 5 kg/ha once at flowering or DAP 20 g/lt once at flowering and another at 15 days thereafter

c. Foliar spray of salicylic acid100 mg/litre once at preflowering and anothere at 15 days there after.

4. **HARVESTING**

i) Picking the matured pods, drying and processing

ii) Uprooting or cutting the whole plants, heaping ,drying and processing

## SEED PRODUCTION
## GREEN GRAM - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free from volunteer plants. The previous crop should not be of the same variety or other varieties of the same crop. It can be of the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 5 m all around the field from the same and other varieties of the crop.

**Pre-sowing seed treatment**

- Remove all discoloured seeds and use only normal coloured seeds (olive green) for seed purpose.
- Avoid bruchid infested seeds for sowing.
- If the presence of hard seed percentage exceeds more than 10 %, scarify the seeds with commercial $H_2SO_4$ for 2 min.
- Harden the greengram seeds for garden and dry land ecosystem with 100 ppm $MnSO_4$ for 3 h at the ratio of 1:0.3 ratio and dry back to original seed moisture content (8 - 9 %) under shade.

**Fertilizer**

- NPK @ 25 : 50 : 25 kg + 5 kg TNAU micro nutrient mixture / ha.

**Foliar application**

- Spray 2 % DAP at the time of first appearance of flowers and second spray 15 days after first spray for enhanced seed set.
- Spray NAA 40 ppm at first flowering and at fortnight interval to reduce the flower drop.
- Spray 0.1 % brassinoloid on 35$^{th}$ and 45$^{th}$ day after sowing.

**Pre-harvest sanitation spray**

- Spray (0.05 %) Malathion 50 EC three to five days before harvest to minimize the bruchid infestation in storage.

**Harvest**

- Harvest the pods at 30 days after 50 % flowering when majority of the pods (80 %) are brown in colour.
- Harvest the pods as pickings, if the flowering period is longer.

- Dry the pods to 13 to 15 % moisture content.

**Threshing**

- Thresh the pods either with pliable bamboo stick or pulse thresher.

**ying**

- Dry the seeds to 8 - 9 % moisture content.

**Seed grading**

- Grade the seeds using BSS 7 x 7 wire mesh sieve.
- Discard the discoloured and broken seeds for sowing or storage.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim 2 g / kg of seed.
- Treat the seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg of seed as eco-friendly treatment.

**Storage**

- Store the seeds with a seed moisture content of 10 - 12 % in gunny or cloth bags for short term storage (8 - 9 months).
- Store the seeds with a seed moisture content of 8 - 9 % in polylined gunny bag for medium term storage (12 - 15 months).
- Store the seeds with a seed moisture content less than 8 % in 700 gauge polythene bag for long term storage (more than15 months).

## (iii) COWPEA ( *Vigna unguiculata* (L.) Walp.aggreg.)

### CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 35 | 15 | 20 - 30 | 400 - 600 | 32 |

Cowpea is called the "hungry - season crop" because it is the first crop to be harvested before the cereal crops. Cowpea is tolerant of shading and can be combined with tall cereal plants such as sorghum and maize. It is sensitive to waterlogging, though less than other legumes. High moisture may hinder cowpea crops in the sub - humid tropics due to the many diseases. Frost can damage the plant during flowering period.

### CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| DISTRICT/SEASON | VARIETIES |
|---|---|
| **Adipattam (June-August)**<br>For all districts except Kanyakumari and Nilgiris | Co(CP) 7 |
| **Purattasipattam (September - November)**<br>Vellore, Thiruvannamalai, Dharmapuri, Salem, Namakkal, Perembalur, Erode, Coimbatore, Madurai, Dindigul, Theni and Virudhunagar | Co(CP) 7, VBN 3 |
| **Margazhi - Thaipattam (December – February)**<br>Kanchipuram, Thiruvallur,Vellore, Thiruvannamalai, Dharmapui,Salem,Namakkal, Coimbatore, Erode, Madurai, Dindigul, Theni, Tiruchirappalli, Perambalur, Ariyalur, Karur, Pudukkottai, Tirunelveli and Thoothukudi | Co(CP) 7, VBN 3 |

### I. Description of Cowpea varieties

| Particulars | Co (CP) 7 | VBN 3 |
|---|---|---|
| Year of Release | 2002 | 2017 |
| Year of Notification | SO.1177(E)/25.08.2005 | S.O. 6318(E) / 26.12.2018 |
| Parentage | Gamma mutant of Co 4 (20 Kr) | TLS 38 x VCP 16-1 |
| 50%flowering(days) | 40 – 45 | 50-55 |
| Duration (days) | 70 – 75 | 75-80 |
| Grain yield(kg/ha) | | |
| Rainfed | 1000 | 1010 |
| Irrigated | 1600 | - |
| Plant height (cm) | 40 – 55 | 65 - 70 |
| Stem, branches | Green with purple ring at fruiting nodes, 5 – 8 branches | Determinate plant type, synchronized maturity |
| Leaves | The terminal leaflet has sub hastate shape | The terminal leaflet has sub globose shape |

| | | |
|---|---|---|
| Colour of pods | Green | Creamy white colour and glabrous pods |
| Dry | Light brown | Light brown |
| Colour of grain | Brownish white and square shape. | Light brown and kidney shape |
| 100 grain wt (g) | 12 – 14 | 12.5 – 13.5 |

## III. SEED RATE

Seed rate (pure crop) : 25 kg/ha

## CROP MANAGEMENT

## IV. MANAGEMENT OF FIELD OPERATIONS

### 1. FIELD PREPARATION

Prepare the land to fine tilth and form beds and channels.

### 2. SEED TREATMENT

Treat the seeds with Carbendazim or Thiram 2 g/kg of seed 24 hours before sowing (or) with talc formulation of *Trichoderma viride* @ 4g/kg of seed (or) *Pseudomonas fluorescens* @ 10 g/kg seed.

- Biocontrol agents are compatible with biofertilizers.
- First treat the seeds with biocontrol agents and then with Rhizobium.
- Fungicides and biocontrol agents are incompatible.

### 3. SEED TREATMENT WITH BIOFERTILIZER

a) Fungicide-treated seeds, should be again treated with a bacterial culture. There should be an interval of atleast 24 hours between fungicidal and biofertilizer treatments.

b) The improved rhizobial strain COC 10 is more effective in increasing the yield. Treat the seeds with one packet (200 g/ha) of Rhizobial culture (COC 10) and one packet (200 g/ha) of Phosphobacteria developed at TNAU using rice kanji as binder. If the seed treatment is not carried out apply 10 packets (2 kg/ha) of Phosphobacteria with 25 kg of FYM and 25 kg of soil before sowing. Dry the biofertilizer treated seeds in shade for 15 minutes before sowing.

### 4. FERTILIZER APPLICATION

a) Apply fertilizers basally before sowing.
Rainfed : 12.5 kg N + 25 kg $P_2O_5$ + 12.5 kg $K_2O$ +10 kg S*/ha Irrigated : 25 kg N + 50 kg $P_2O_5$ + 25 kg $K_2O$ + 20 kg S*/ha
*Note : Applied in the form of gypsum if Single Super Phosphate is not applied as a source of phosphorus

b) Soil application of 25 kg $ZnSO_4$/ha along with 50 kg FYM or sand under irrigated condition

c) Soil application of 10 kg borax, 0.25 kg Ammonium molybdate can be followed if the soil is deficient.

5. **SOWING**

Dibble the seeds adopting the following spacing.

| Varieties | Spacing |
|---|---|
| VBN 3 | 30 cm X 15 cm |
| CO(CP) 7 | 45 cm x 15 cm |

6. **WATER MANAGEMENT**

Irrigate immediately after sowing followed by life irrigation on third day. Irrigate at interval of 7 to 10 days depending upon soil and climatic conditions. Flowering and pod formation stages are critical periods when irrigation is a must. Avoid water stagnation at all stages. Apply KCl at 2.0 per cent as foliar spray during vegetative stage if there is moisture stress.

7. **FOLIAR APPLICATION**

a. Foliar spray of DAP 20 g/litre or urea 20 g/litre once at flowering and another at 15 days thereafter to enhance flower number and pod setting
b. Foliar spray of NAA 40 mg/litre once at flowering and another at 15 days thereafter to reduce flower drop
c. Foliar spray of salicylic acid 100 mg/litre once at flowering and another at 15 days ther after to improve seed yield.

8. **WEED MANAGEMENT**

i) Pre emergence application of Pendimethalin @ 0.75 litre / ha on 3 days after sowing using Backpack/ Knapsack/Rocker sprayer fitted with flat fan nozzle using 500 lit of water for spraying one hectare followed by one hand weeding on 30 days after sowing gives weed free environment throughout the crop period.
ii) If herbicide is not applied, give two hand weeding on 15 and 30 days after sowing.

## CROP PROTECTION

## A. Pest management

| **Pests** | **ETL** |
|---|---|
| Aphids | 20nos. /2.5 cm shoot length |
| Spotted pod borer | 3larvae /plant |
| Stem fly | 10% of affected plants |

**Pests Management strategies**

| | |
|---|---|
| **Stem fly**<br>*Ophiomyia phaseoli* | Seed treatment with dimethoate 30 EC 5 ml/kg of seed |
| **Aphids**<br>*Aphis craccivora* | **Spray any one of the following**<br>Methyl demeton 25 EC 500 ml/ha |

| | |
|---|---|
| **Whitefly**<br>*Bemisia tabaci* | Dimethoate 30 EC 500 ml/ha |
| **Blue butterflies**<br>*Lampides boeticus*<br>*Euchrysops cnejus* | Chlorantraniliprole 18.5% SC 100ml/ha |
| **Spotted pod borer**<br>*Maruca vitrata* | • Thiodicarb 75% WP 750g/ha |
| **Storage pests**<br>Bruchid-<br>*Callosobruchus chinensis*<br>*C. maculatus* | • Dry the seeds adequately to reduce moisture level to 10 %.<br>• Use pitfall traps or two in one model trap to assess the time of emergence of field carried over pulse beetle in storage and accordingly sun-dry the produce.<br>• Mix Malathion 5 D 1 kg for every 100 kg seed<br>• Pack in polythene lined gunny bags for storage |
| **Pod bug** | • Dimethoate 30% EC 500ml/ha<br>• Methyl demeton 25% EC 500ml/ha |

**B. Disease Management**

**Seed treatment:** Treat the seeds with *T. asperellum* @ 4 g or *P. fluorescens* @ 10 g/kg or carbendazim @ 2 g/kg or thiram @ 4 g/kg of seeds

| Disease | Recommendations |
|---|---|
| **Rust:**<br>*Uromyces appendiculatus* | Two sprays of chlorothalonil 0.1% or one spray with 0.1% chlorothalonil followed by 3% neem oil after the appearance of disease |
| **Root rot:**<br>*Macrophomina phaseolina*<br>*(Rhizoctonia bataticola)* | • Soil application of *P. fluorescens* or *T. asperellum* @ 2.5 kg/ ha with 50 kg of well decomposed FYM or sand<br>• Spot drenchwith carbendazim @ 1 g /l |
| **Aphid borne mosaic:**<br>(Potyvirus)<br>(Vector: *Aphis craccivora, A. fabae, A. gossypii* and *Myzus persicae)* | Roguing out the virus infected plants in the early stage of growth up to 30 days and spraying twice at fortnightly intervals with methyl demeton 25 EC @ 500 ml/ha or dimethoate 30 EC 500 @ ml/ha or imidacloprid 17.8 SL @ 250ml/ha |

## SEED PRODUCTION

## COWPEA - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be of the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 5 m all around the field from the same and other varieties of cowpea.

**Season**

- September - October and June - July.

**Intercultural operation**

- Clip the tendrils for promotion of flower production.
- Up root and destroy the plants exhibiting severe symptoms of mosaic in the early stages of growth.
- Spray NAA 40 ppm (40 mg in 1 litre) at first flowering to reduce flower drop.
- Spray 2 % DAP at flower initiation and at peak flowering to promote pod setting.

**Harvesting**

- Seeds attain physiological maturity 27 - 30 days after anthesis. At this stage the seed moisture content will be around 18 per cent.
- Harvest the pods as they turn light straw in colour and the seeds turn brown or mottled.
- Harvest the pods as picking (4 - 5 nos.) at 10 days interval.
- Shade dry the pods for 1 - 2 days and then sundry until they become brittle.
- Beat the pods with pliable bamboo stick or pulse thresher by adjusting the cylinder speed to avoid splitting and cracking of seeds.

**Seed grading**

- Grade the seeds with 10 / 64" or 12 / 64" round perforated sieves.

**Drying**

- Remove the broken and immature seeds.
- Dry the seeds to 8 - 10 % moisture content

**Pre- storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed along with carbaryl 200 mg / kg of seed.
- Treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg as eco-friendly treatment.

**Storage**

- Store the seeds with a seed moisture content of 10 - 12 % in gunny or cloth bags for short term storage (8 - 9 months).
- Store the seeds with a seed moisture content of 8 - 9 % in polylined gunny bag for medium term storage (12- 15 months).
- Store the seeds with a seed moisture content less than 8 % in 700 gauge polythene bag for long term storage (more than15 months).

## (iv) HORSEGRAM (*Macrotyloma uniflorum* )

### CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 42 | 20 | 25 - 32 | 200 - 700 | 800 |

Tropical crops. Extremely drought - resistant crop. Moderately warm, dry climatic conditions are suitable for its optimum growth. It does not grow well on higher altitudes because of cool and wet climate.

### I. SEASON AND VARIETIES

| DISTRICT/SEASON | VARIETIES |
|---|---|
| **November (Winter season) (Rainfed)**<br>All districts except<br>The Nilgiris and Kanyakumari | Paiyur 2 |

### II. Description of Horsegram varieties

| Particulars | Paiyur 2 |
|---|---|
| Year of Release | 1998 |
| Year of Notification | SO.425(E)/08.06.1999 |
| Parentage | Gamma irradiation of<br>Co 1 |
| 50%<br>flowering(days) | 45-50 |
| Maturity Duration (days) | 100-105 |
| Grain yield(kg/ha) | |
| Rainfed | 870 |
| Plant height (cm) | 40-45 |
| Branches | 2 -3 branches |
| Colour of grain | Pale brown |
| 100 grain wt (g) | 3.5 |

### III. SEED RATE

For a pure crop 20 kg/ha is needed.

## MANAGEMENT OF FIELD OPERATIONS

1. **FIELD PREPARATION**
   Prepare the land to fine tilth.

2. **SEED TREATMENT WITH FUNGICIDES**
   Treat the seeds with any one of the following fungicides. Carbendazim or Thiram at 2 g/kg seed.

3. **FERTILIZER RECOMMENDATION**
   Apply basally 12.5 t/ha FYM/Compost, 12.5 kg/ha nitrogen, 25 kg/ha phosphorus , 12.5 kg/ha potassium if soil is deficient in NPK status. Application of 25 kg $ZnSO_4$, 25 kg $FeSO_4$ + FYM can be followed if the soil is deficient in Zn and Fe. `

4. **SEED TREATMENT WITH BIOFERTILIZER**
   Treat the seeds with one packet (200 g/ha) of Rhizobial culture and one packet (200 g/ha) of Phosphobacteria developed at TNAU using rice kanji as binder. If the seed treatment is not carried out apply 10 packets of Phosphobacteria with 25 kg of FYM and 25 kg of soil before sowing. Dry the biofertilizer treated seeds in shade for 15 minutes before sowing.

4. **SOWING**
   Dibble the seeds with a spacing of 30 x 10 cm.

5. **WEED MANAGEMENT**
   Give one weeding and hoeing on 25-30 days after sowing

6. **HARVESTING**
   Harvest the matured whole plant, thresh and extract seeds

### CROP PROTECTION

**Seed treatment:** Treat the seeds with carbendazim @ 2 g/kg or thiram @ 4 g/kg

## HORSE GRAM - SEED PRODUCTION
## VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be of the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 10 m all around the field from the same and other varieties of horsegram.

**Season**

- October - November.

**Pre-sowing seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed.
- Priming the seeds with 100 ppm $ZnSO_4$ @ 1:1 seed to solution ratio for 3 hours and drying back to original moisture content.

**Crop management**

- Foliar spray of 0.5 % $ZnSO_4$ at 50 % flowering for enhancing the productivity
- Spray magnesium chloride against any chlorotic symptom @ 6 g / litre with a power sprayer for 2 - 3 times at 5 days interval.

**Intercultural operation**

- Clip the tendrils to promote flower production.

**Harvesting**

- Harvest the pods at once when 75 - 80 % of the pods turned into yellowish brown in colour.
- Timely harvest is essential; care to be taken not to expose the pods to rain or very moist weather which may change the seed coat colour from light brown to dark brown or light black.

**Seed grading**

- Grade the seeds with round perforated metal sieves having 8 / 64" diameter.
- Remove the discoloured seeds.

**Storage**

- Store the seeds with a seed moisture content of 8 - 9 % in gunny or cloth bags for short term storage (8 - 9 months).
- Store the seeds with a seed moisture content of 7 - 8 % in poly lined gunny bag for medium term storage (12 - 15 months).
- Store the seeds with a seed moisture content less than 7 % in 700 gauge polythene bag for long term storage (more than15 months).

# (v) BENGALGRAM (*Cicer arietinum L.*)

## CLIMATE REQUIRMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 35 - 45 | 6 - 8 | 20 - 25 | 500 - 800 | 2500 |

Tropical and subtropical winter season crop. The field should have loose tilth and good drainage. Long day plant. Severe cold and frost at the time of flowering causes detrimental effect to gram seed development.

## CROP IMPROVEMENT

### i. SEASON AND VARIETIES

| District /Season | Varieties |
|---|---|
| November (Winter season) Rainfed<br>Vellore, Tiruvannamalai, Salem, Namakkal, Tiruchirapalli, Perambalur, Karur, Dharmapuri, Pudukottai, Erode, Coimbatore, Madurai, Dindigul, Theni, Virudhunagar, Ramanathapuram, Sivagangai, Tirunelveli, Thoothukudi | CO 4 |

### II. Description of chickpea variety

| **Particulars** | **CO 4** |
|---|---|
| Year of Release | 1998 |
| Year of Notification | SO. 425 (E) / 08.06.1999 |
| Parentage | Cross derivative of ICC 42 x ICC 12237 |
| 50% flowering | 40 |
| Duration (days) | 85 |
| Grain yield (kg/ha) | |
| Rainfed | 1150 |
| Height (cm) | 35-40 |
| Branches | 3-5 |
| Flower colour | Light pink & veined |
| Colour of grain | brown |
| 100 grain wt (g) | 30-32 |

**(iii) SEED RATE**

- CO 3 - 90 kg/ha.
- CO 4 - 75 kg/ha.

## CROP MANAGEMENT

### ii. MANAGEMENT OF FIELD OPERATIONS

**1. FIELD PREPARATION**

Prepare the land to fine tilth and apply 12.5 t FYM/ha

## 2. SEED TREATMENT

Treat the seeds with Carbendezim (or) Thiram @ 2g/kg of seed 24hrs before sowing (or) with talc formulation of *Trichoderma viride* @ 4 g/kg seed (or) *Pseudomonas fluorescens* @ 10 g/kg seed. Biocontrol agents are compatible with biofertilizers. First treat the seeds with biocontrol agents and then with Rhizobium. Fungicides and biocontrol agents are incompatible. The above seed treatment will protect the seedlings from seed borne pathogens in the early stages.

## 3. SEED TREATMENT WITH BIOFERTILIZER

Treat the seeds with one packet (200 g/ha) of Rhizobial culture and one packet (200 g/ha) of Phosphobacteria developed at TNAU using rice kanji as binder. If the seed treatment is not carried out apply 10packets of Rhizobium (2 kg/ha) and 10 packets(2 kg) of Phosphobacteria with 25 kg of FYM and 25 kg of soil before sowing. Dry the biofertilizer treated seeds in shade for 15 minutes before sowing.

## 4. FERTILIZER APPLICATION

a) Apply fertilizers basally before sowing.
Rainfed : 12.5 kg N + 25 kg $P_2O_5$ + 12.5 kg $K_2O$ +10 kg S*/ha Irrigated : 25 kg N + 5 kg $P_2O_5$ + 25 kg $K_2O$ + 20 kg S*/ha
*Note : Applied in the form of gypsum, if Single Super Phospate is not applied as a source of phosphorus

## 5. SOWING

Dibble the seeds by adopting a spacing of 30 cm x 10 cm.

## 6. WEED MANAGEMENT

i) Pre emergence application of Pendimethalin @ 0.75 litres / ha on 3rd day after sowing using Backpack/ Knapsack/Rocker sprayer fitted with flat fan nozzle using 500 litres of water for spraying one ha followed by one hand weeding on 25 - 30 days after sowing.

ii) If herbicide is not applied give two hand weedings on 15th and 30th day after sowing.

## 7. INTERCROPPING IN BENGALGRAM

Bengalgram in paired row planting with one or two rows of Coriander as intercrop would give the highest return. Wheat can also be intercropped in deep black cotton soil in Coimbatore, Erode, Salem, Namakkal and Dharmapuri districts.

## CROP PROTECTION

## A. Pest management

### Economic threshold level for important pests

| Pest | ETL |
|---|---|
| Gram caterpillar | 2 early instar larvae/plant<br>5-8 eggs/plant |
| Aphids | 20/2.5 cm shoot length |

### Pest Management strategies

| | |
|---|---|
| **Aphid**<br>*Aphis craccivora* | **Spray any one of the following :**<br>Methyl demeton 25 EC 500 ml/ha<br>Dimethoate 30 EC 500 ml/ha |
| **Gram caterpillar**<br>*Helicoverpa armigera* | • Pheromone traps for *Helicoverpa armigera* 12/ha<br>• Bird perches 50/ha<br>• Mechanical collection of grown up larva and blister beetle<br>• Ha NPV 3 x$10^{12}$ POB/ha in 0.1% teepol<br>• *Bacillus thuringiensis* var *kurstaki* 5%WP 1000-1250 g/ha<br>(Note : Insecticide / Ha NPV spray should be made when the larvae are upto third instar)<br>**Apply any one of the following insecticides:**<br>Azadirachtin 0.03 % WSP 2.5kg/ha<br>Benfuracarb 40% EC 2.5l/ha<br>Chlorantraniliprole 18.5% SC 150ml/ha<br>Chlorpyriphos 20 EC 1250 ml / ha<br>Emamectin benzoate 5% SG 220 g/ha<br>Ethion 50% EC 1.0 l/ha<br>Flubendiamide 39.35 % SC 100ml / ha<br>Indoxacarb 14.5% SC 350 ml/ha<br>Indoxacarb 15.8% SC 333 ml/ha<br>Lufenuron 5.4% EC 600ml/ha<br>Methomyl 40%SP 750g/ha<br>Monocrotophos 36%SL 625-1250ml/ha<br>Neem oil 2%<br>Quinalphos 1.5%DP 23kg/ha<br>Quinalphos 25 %EC 1400ml/ha<br>Spinosad 45%SC 125 ml/ha<br>• Thiodicarb 75 WP 625g / ha |
| **Storage pests** | • Dry the seeds adequately to reduce moisture level to 10 %.<br>• Use pitfall traps or two in one model trap to assess the time of emergence of field carried over pulse beetle in storage and accordingly sun-dry the produce.<br>• Mix Malathion 5 D 1 kg for every 100 kg of seed<br>• Pack in polythene lined gunny bags for storage |

## Disease Management

**Seed treatment:** Treat the seeds with *T. asperellum* @ 4 g or *P. fluorescens* @ 10 g/kg or carbendazim @ 2 g/kg or thiram @ 4 g/kg of seeds

| Disease | Recommendations |
|---|---|
| **Wilt:** *Fusarium oxysporum* f. sp. *ciceri* | Soil application with P. *fluorescens* @ 2.5 kg/ha with 50 kg of well decomposed FYM or sand |
| **Root rot:** *Macrophomina phaseolina (Rhizoctonia bataticola)* | • Soil application of *P. fluorescens* or *T. asperellum* @ 2.5 kg / ha with 50 kg of well decomposed FYM or sand<br>• Spot drench with carbendazim @ 1 g/l |

## BENGAL GRAM - SEED PRODUCTION

**Land requirements**

- Land should be free of volunteer plants. The previous crop should not be of the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 5 m all around the field from the same and other varieties of bengal gram.

**Pre-sowing treatment**

- Soak the seeds in 1 % $KH_2PO_4$ for 3 h in 1/3$^{rd}$ volume of solution and shade dry the seeds to bring back to original seed moisture content.
- Avoid bruchid infested seed for seed purpose.

**Harvesting**

- Harvest the crop at once when 70 - 80 % of pods are creamy yellow in colour.

**Seed grading**

- Grade the seeds using 13 / 64” or 18 / 64" sieves depending on the variety.
- Dry the seeds to 8 - 10 % moisture content

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed.
- Treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in a ratio of 5:4:1@ 3 g / kg of seed as eco-friendly treatment.

**Storage**

- Store the seeds with a seed moisture content of 9 - 10 % in gunny or cloth bags for short term storage (8 - 9 months).
- Store the seeds with a seed moisture content of 8 - 9 % in polylined gunny bag for medium term storage (12 - 15 months).
- Store the seeds with a seed moisture content less than 8 % in 700 gauge polythene bag for long term storage (more than 15 months).

## (VII) GARDEN LAB LAB (AVARAI)

**(*Lab lab purpureus* (L.) var. *typicus*. )**

### CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 42 | 14 | 22–28 | 650 - 3000 | 2000 - 2400 |

Tropical and sub tropical crop. Lablab is a summer - growing annual or occasionally short - lived perennial forage legume. Lablab tolerates some flooding but does not withstand poor drainage or prolonged waterlogging. Lablab does better in full sunlight.

### CROP IMPROVEMENT
### i. SEASON AND VARIETIES

| District/season | Varieties |
|---|---|
| **Adipattam (July - Aug)**<br>Kanjipuram,Tiruvallur,Dharmapuri,Coimbatore,Madurai,Dindigul,Theni,Vellore,Tiruvannamali,Ramanathapuram,Virudhunagar,Sivagangai, Tirunelveli, Thoothukudi, Salem, Namakkal, Thanjavur, Tiruvarur, Nagapattinam, Tiruchirapalli, Perambalur,Karur,Pudukkottai,Kanyakumari Erode | CO (Gb) 14 |
| **Puratasipattam (September - November)**<br>Kanchipuram, Tiruvallur,Tiruchirapalli,Perambalur, Karur,Vellore,Tiruvannamalai, Cuddalore,Villupuram, Dharmapuri, Salem, Namakkal, Pudukkottai, Erode,Coimbatore, Madurai,Dindigul, Theni, Ramanathapuram, Sivagangai, Virudhunagar, Tirunelveli, Thoothukudi, Thanjavur, Tiruvarur, Nagapattinam, | CO (Gb) 14<br>CO (Gb) 14<br>CO (Gb) 14 |
| **Summer (April)**<br>Kanjipuram,Tiruvallur,Vellore,Tiruvannamali,Cuddalore,Villuppuram Dharmapuri, Salem, Namakkal, Thanjavur, Tiruvarur,<br>Nagapattinam, Kanyakumari,Pudukkottai,<br>Erode,Coimbatore,Madurai,Dindigul,Theni,Ramanathapuram, Virudhunagar, Tirunelveli, Thoothukudi, Sivagangai, | CO (Gb) 14<br>CO (Gb) 14<br>CO (Gb) 14 |

### II.DESCRIPTION OF AVARAI VARIETY

| PARTICULARS | CO (Gb)14 |
|---|---|
| Parentage | Cross derivative of CO 9 X CO 4 |
| Year of release | 2007 |
| 1 st flowering(days) | 35-40 |
| Duration (days) | 80-85 days(seed to seed)<br>70-75 days(vegetable type) |
| Grain yield(kg/ha) | |

| | |
|---|---|
| Irrigated (kg/ha) | 7584 Green pod |
| Habit | Dwarf ,bushy without tendrils |
| Height (cm) | 56-62 |
| Colour of Flowers | white |
| Colour of pod | Green |
| Shape of pod | flat |
| Colour of grain | Reddish brown |
| 100 seed weight (g) | 34-36 |

## I. SEED RATE

| Particulars | Quantity of seed required kg/ha Sole crop | Mixed Crop |
|---|---|---|
| CO (Gb) 14 | 25 | - |

## CROP MANAGEMENT

## II. MANAGEMENT OF FIELD OPERATIONS

### 1. FIELD PREPARATION

Prepare the land to fine tilth. Form beds and channels for bushy types.

### 2. SEED TREATMENT WITH FUNGICIDES

Treat the seeds with Carbendezim (or) Thiram @ 2g/kg of seed 24hrs before sowing (or) with talc formulation of *Trichoderma viride* @ 4 g/kg seed (or) *Pseudomonas fluorescens*@ 10 g/kg seed. Biocontrol agents are compatible with biofertilizers. First treat the seeds with biocontrol agents and then with Rhizobium. Fungicides and biocontrol agents are incompatible.

### 3. SEED TREATMENT WITH BACTERIAL CULTURE

Fungicide treated seeds should be again treated with bacterial culture. There should be an interval of atleast 24 hours between fungicidal and bacterial culture treatments. Three packets of bacterial culture are sufficient for treating seeds required for one ha. The bacterial culture slurry may be prepared with rice kanji. Dry the inoculated seeds in shade for 15 minutes before sowing.

### 4. FERTILIZER APPLICATION

(a) Apply fertilizers basally before sowing.

Rainfed : 12.5 kg N + 25 kg $P_2O_5$ + 12.5 kg $K_2O$ +10 kg S*/ha Irrigated : 25 kg N + 50 kg $P_2O_5$ + 25 kg $K_2O$ + 20 kg S*/ha

*Note : Applied in the form of gypsum if Single Super Phospate is not applied as a sourceof phosphorus

(b) Soil application of 25 kg $ZnSO_4$/ha 10 kg borax, 5 kg $CuSO_4$ under irrigated condition if the soil is deficient in respective nutrients.

### 5. SOWING

Dibble the seeds adopting the following spacing. Varieties

CO (Gb) 1 : 45 cm X 30 cm

**6. WEED MANAGEMENT**

Pre emergence application of Pendimethalin @ 0.75 litres/ha on 3 days after sowing using Backpack/ Knapsack/Rocker sprayer fitted with flat fan nozzle using 500 litres of water for spraying one ha. After this, one hand weeding on 40-45 days after sowing gives weed free environment throughout the crop period.

If herbicide is applied give two hand weedings on 25 and 45days after sowing.

**7. WATER MANAGEMENT**

Irrigate immediately after sowing, followed by life irrigation on third day. Irrigate atinterval of 7 to 10 days depending upon soil and climatic conditions. Flowering and pod formation stages are critical periods when irrigation is a must. Avoid water stagnation at all stages. Apply KCl at the rate of 0.5 per cent as foliar spray during vegetative stage if there is moisture stress.

**8. PRUNING TECHNIQUE**

A spacing of about 10 feet between lines and four feet between plants are adopted. Pits are dug and two to three seeds are sown in the middle of the pit. One healthy seedling is allowed to grow and the rest removed. The vine is propped with a stick. When the vine reaches the pandal, the terminal bud is nipped. Allow the branches to trail over the pandal. Each branch may be pruned at three feet length so that the pandal is covered with vines. Branches arising on the main vine below the pandal are removed. When flowering starts, prune the tip of the branches bearing inflorescence having three nodes from the productive axil. Continue this procedure throughout the reproductive phase.

**9. HARVESTING**

Pick the pods when they are completely dry. Thresh the pods and clean the beans. Pick the tender pods once in a week for vegetable purpose.

## CROP PROTECTION

### A. Pest management

**Economic threshold level for important pests**

| Pest | ETL |
|---|---|
| Aphids | 20 numbers per 2.5 cm shoot length |
| Spotted pod borer | 3 larvae per plant |
| Gram caterpillar | 10% of affected pods |

**Pest management strategies**

| Pests | Management strategies |
|---|---|
| **Aphid** *Aphis craccivora* | **Spray any one of the following :**<br>Methyl demeton 25 EC 500 ml/ha<br>Dimethoate 30 EC 500 ml/ha |
| **Spotted pod borer** *Maruca vitrata* | Thiodicarb 75% WP 750g/ha |

| | |
|---|---|
| **Gram caterpillar**<br>*Helicoverpa armigera* | • Pheromone traps for *Helicoverpa armigera* 12/ha<br>• Bird perches 50/ha<br>• Mechanical collection of grown up larva and blister beetle<br>• Ha NPV 3 x$10^{12}$ POB/ha in 0.1% teepol<br>• *Bacillus thuringiensis* var *kurstaki* 5%WP 1000-1250 g/ha<br>(Note : Insecticide / Ha NPV spray should be made when the larvae are upto third instar)<br>**Apply any one of the following insecticides:**<br>Azadirachtin 0.03 % WSP 2.5kg/ha<br>Benfuracarb 40% EC 2.5l/ha<br>Chlorantraniliprole 18.5% SC 150ml/ha<br>Chlorpyriphos 20 EC 1250 ml / ha<br>Emamectin benzoate 5% SG 220 g/ha<br>Ethion 50% EC 1.0 l/ha<br>Flubendiamide 39.35 % SC 100ml / ha<br>Indoxacarb 14.5% SC 350 ml/ha<br>Indoxacarb 15.8% SC 333 ml/ha<br>Lufenuron 5.4% EC 600ml/ha<br>Methomyl 40%SP 750g/ha<br>Monocrotophos 36%SL 625-1250ml/ha<br>Neem oil 2%<br>Quinalphos 1.5%DP 23kg/ha<br>Quinalphos 25 %EC 1400ml/ha<br>Spinosad 45%SC 125 ml/ha<br>Thiodicarb 75 WP 625g / ha |
| **Pod bug**<br>*Riptortus pedestris*<br>*Clavigralla gibbosa* | • Dimethoate 30% EC 500ml/ha<br>• Methyl demeton 25% EC 500ml/ha |
| **Storage pests**<br>Bruchid - *Callosobruchus chinensis* | Dry the seeds adequately to reduce moisture level to 10%.<br>Use pitfall traps or two in one model trap to assess the time of emergence of field carried over pulse beetle in storage and accordingly sun-dry the produce.<br>Mix Malathion 5 D 1 kg for every 100 kg seed<br>Pack in polythene lined gunny bags for storage |

## DISEASE MANAGEMENT

**Seed treatment:** Treat the seeds with *T. asperellum* @ 4 g or *P. fluorescens* @ 10 g/kg or carbendazim @ 2 g/kg or thiram @ 4 g/kg of seeds

| Disease | Recommendations |
|---|---|
| **Anthracnose and die-back:**<br>*Colletotrichum lindemuthianum* | Spray mancozeb @ 1000g or carbendazim @ 250 g/ha soon after the appearance of the disease and if necessary, spray once again a fortnight later |

# GARDEN LAB LAB (AVARAI) - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be of the same variety or other varieties of the same crop. It can be of the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified seed production leave a distance of 5 m all around the field from the same and other varieties of the crop.

**Pre-harvest sanitation spray**

- Spray 0.07 % malathion before harvesting the pods to avoid bruchid infestation.

**Harvest**

- Harvest the pods when they turn straw yellow in colour.
- Discard the terminal pods for seed purpose as they contain immature seeds.
- Dry the pods to 15 - 18 % moisture content.

**Drying**

- Dry the seeds to 8 - 10 % moisture content.

**Seed grading**

- Grade the seeds using 18 / 64" round perforated sieves.
- Remove the broken and immature seeds.
- Dry the seeds to 7 to 8 per cent moisture content.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim at 2 g / kg of seed along with carbaryl at 200 mg / kg of seed.
- Treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg as eco-friendly treatment.

**Storage**

- Store the seeds with a seed moisture content of 9 - 10% in gunny or cloth bags for short term storage (8-9 months).
- Store the seeds with a seed moisture content of 8 - 9 % in polylined gunny bag for medium term storage (12 - 15 months).
- Store the seeds with a seed moisture content less than 8 % in 700 gauge polythene bag for long term storage (more than15 months).

# (vi) FIELD LAB-LAB (MOCHAI)

**( *Lab lab purpureus* (L.) var. *ignosus* )**

**CLIMATE REQUIREMENT**

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 35 | 4 - 6 | 18 - 30 | 800 - 1000 | 1800 - 3000 |

Tropical and sub tropical crop. Hot weather and drought stress are damaging to peas during the flowering period. Field peas can be grown as a winter crop in warm and temperate areas because pea seedlings have considerable frost resistance. High humidity is harmful to pea crop due to incidence of disease. Short day plant.

## CROP IMPROVEMENT

| District /Season | Varieties |
|---|---|
| All districts except Nilgiris<br>All throughout the year | CO 2 |

### II. Description of mochai variety

| PARTICULARS | Co 2 |
|---|---|
| Year of Release | 1984 |
| Year of Notification | SO.596(E)/13.08.1984 |
| Parentage | Derivative of Co 8 X Co 1 |
| 50% flowering(days) | 35-45 |
| Duration (days) | 105 |
| Grain yield(kg/ha) | |
| Rainfed | 900 |
| Irrigated | 1400 |
| Habit | Erect and bushy determinate photo insensitive |
| Hight (cms) | 60 |
| Colour of Flowers | Purple |
| Colour of pod | Green |
| Shape of pod | flat |
| Colour of grain | Black |
| 100 seed weight (g) | 20.0 |

### I. SEED RATE

| Particulars | Quantity of seed required kg/ha<br>Sole crop | Mixed crop |
|---|---|---|
| CO 1 | 20 | 10.0 |
| CO 2 | 25 | 12.5 |

## CROP MANAGEMENT
## II. MANAGEMENT OF FIELD OPERATIONS

**1. FIELD PREPARATION**

Prepare the land to fine tilth.

**2. SEED TREATMENT WITH FUNGICIDES**

Treat the seeds with Carbendezim (or) Thiram @ 2g/kg of seed 24hrs before sowing (or) with talc formulation of *Trichoderma viride* @ 4 g/kg seed (or) *Pseudomonas fluorescens* @ 10 g/kg seed.

- Biocontrol agents are compatible with biofertilizers.
- First treat the seeds with biocontrol agents and then with Rhizobium.
- Fungicides and biocontrol agents are incompatible

**3. SEED TREATMENT WITH BACTERIAL CULTURE**

Fungicide treated seeds should be again treated with bacterial culture. There should be an interval of atleast 24 hours between fungicidal and bacterial culture treatments. Three packets of bacterial culture are sufficient for treating seeds required for one hectare. The bacterial culture may be prepared with rice kanji. Dry the inoculated seeds in shade for 15 minutes, before sowing.

**4. FERTILIZER APPLICATION**

Apply 20 kg N and 80 kg $P_2O_5$ and 40 kg $K_2O$ per ha 40 kg of S as gypsum (220 kg/ha)/ ha as basal dressing. Soil application of 25 kg $ZnSO_4$/ha,10 kg borax, 25 kg $FeSO_4$ + FYM under irrigated condition if the soil is deficient in respective nutrients.

**5. FOLIAR APPLICATION**

i. Foliar spray of NAA 40 mg/litre and Salicylic acid 100 mg/litre once at pre-flowering and another at 15 days thereafter to reduce flower drop and enhance seed set.

ii. Foliar spray of DAP 20 g/litre or urea 20 g/litre once at flowering and another at 15 days thereafter to enhance flower number and pod set

**6. SOWING**

Dibble the seeds, adopting the following spacing. Strain Sole crop Mixed crop

| | | |
|---|---|---|
| CO 1 | 90 cm x 30 cm | 200 cm x 30 cm |
| CO 2 | 45 cm x 15 cm | 200 cm x 15 cm |

**7. WEED MANAGEMENT**

i) Pre emergence application of Pendimethalin @ 2 litres/ha on 3 days after sowing using Backpack/ Knapsack/Rocker sprayer fitted with flat fan nozzle using 500 l of water for spraying one ha. After this, one hand weeding on 40-45 days after sowing gives weed free environment throughout the crop period.

ii) If herbicides are not applied, give two hand weedings on 25th and 45th days after sowing.

## 8. WATER MANAGEMENT

Irrigate immediately after sowing, followed by life irrigation on third day. Irrigate at interval of 7 to 10 days depending upon soil and climatic conditions. Flowering and pod formation stages are critical periods when irrigation is a must. Avoid water stagnation at all stages. Apply KCl at 0.5 per cent as foliar spray during vegetative stage if there is moisture stress.

## 9. HARVESTING

Dry pods may be collected for grain purposes. Green mature pods may be collected for vegetable purpose.

# CROP PROTECTION

**Seed treatment:** Treat the seeds with *T. asperellum* @ 4 g or *P. fluorescens* @ 10 g/kg or carbendazim @ 2 g/kg or thiram @ 4 g/kg seeds

| Disease | Recommendations |
|---|---|
| **Anthracnose and die-back:** *Colletotrichum lindemuthianum* | Spray mancozeb @ 1000 g or carbendazim @ 250 g/ha soon after the appearance of the disease and if necessary, spray once again a fortnight later |

# (ix) SOYABEAN (*Glycine max* (L.) Merr.)

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 10 | 25 - 32 | 600 - 750 | 2000 |

Tropical and subtropical warm and moist climate. Short day plant. It can withstand short periods of waterlogging and short drought.

## CROP IMPROVEMENT

## 1. SEASON AND VARIETIES

| DISTRICT/SEASON | VARIETIES |
|---|---|
| **Adipattam** (June - July)<br>**Purattasipattam** (Sep. - Oct.)<br>**Masipattam** (February - March)<br>**Rice fallows** | Co(Soy)3 |

## II. Description of soybean varieties

| Particulars | Co (Soy) 3 |
|---|---|
| Year of Release | 2005 |
| Year of Notification | SO.599(E)/25.04.2006 |
| Parentage | Cross derivative of UGM 69 x JS 335 |
| 50% flowering | 39 – 41 days |
| Duration (days) | 90-100 |
| Grain yield (Kg/ha) | |
| Rainfed | - |
| Irrigated | 1700 |
| Height (cm) | 53.5 |
| Branches | 5 - 6 |
| Flower colour | Pink |
| Colour of grain | Creamy yellow with brown hilum |
| 100 seed weight (g) | 10.95 – 11.75 |

## 2. SEED TREATMENT WITH FUNGICIDES

a) Treat the seeds with Carbendezim or Thiram @ 2g/kg of seed 24hrs before sowing or with talc formulation of *Trichoderma viride* @ 4 g/kg seed (or) *Pseudomonas fluorescens* @ 10 g/kg seed.

- Biocontrol agents are compatible with biofertilizers.
- First treat the seeds with biocontrol agents and then with Rhizobium.
- Fungicides and biocontrol agents are incompatible.

b) Coat the seeds with $ZnSO_4$ @ 300 mg/kg using 10% maida solution as adhesive (250 ml/ kg) or gruel and arappu leaf powder (250 g/kg) as carrier to increase the field stand.

3. **SEED TREATMENT WITH BIOFERTILIZER**

a) Treat the seeds atleast 24 hours before sowing.

Treat the seeds with 3 packets (600 g/ha) of Rhizobial culture (COS-1) and 3 packets (600 g/ha) of Phosphobacteria developed at TNAU using rice kanji as binder. If the seed treatment is not carried out apply 10 packets of Rhizobium (2000 g/ha) and 10 packets (2000 g) of Phosphobacteria with 25 kg of FYM and 25 kg of soil before sowing. Dry the bacterial culture treated seeds in shade for 15 minutes before sowing.

4. **FERTILIZER APPLICATION**

i) Apply 20 kg N and 80 kg $P_2O_5$ and 40 kg $K_2O$ per ha 40 kg of S as gypsum (220 kg/ha) as basal dressing. Soil application of 25 kg $ZnSO_4$, 25 kg $MnSO_4$/ha under irrigated condition if the soil is deficient.

ii) Foliar spray of NAA 40 mg/litre and Salicylic acid 100 mg/litre once at pre-flowering and another at 15 days thereafter

iii). Foliar spray of DAP 20 g/litre or urea 20 g/litre once at flowering and another at 15 days thereafter

iv). Foliar spraying of 1% $FeSO_4$ + 0.1% citric acid thrice at 7-10 days interval.

5. **SOWING**

Dibble the seeds at a depth of 2 - 3 cm adopting a spacing of 30 x 5 cm. In Erode district, Soybean + Castor (60 cm apart) cropping system gives high net return.

6. **WATER MANAGEMENT**

Irrigate immediately after sowing. Give life irrigation on 3rd day. Further irrigation at intervals of 7 - 10 and 10 - 15 days during summer and winter season respectively to be given depending on soil and weather conditions. Soyabean is very sensitive to excess moisture and the crop is affected, if water stagnates in the fields. The crop should not suffer due to water stress from flowering to maturity. To alleviate moisture stress spray of either Kaolin 3% or liquid paraffin at 1% on the foliage. In Erode district cultivate Soybean + Castor with irrigation at 0.60 IW/CPE ratio (once in 10 to 12 days) is recommended.

7. **WEED MANAGEMENT**

i) Pendimethalin 1.0 litre /ha after sowing followed by one hand weeding on 30 days after sowing.

ii) If herbicide spray is not given two hand weedings on 20 and 35 days after sowing may be given.

iii) Early Post emergence application of Imazythypur @ 50 g / ha may be applied as post emergence on 20 DAS with one hand weeding on 30 days after sowing.

8 **HARVESTING**

Yellowing of leaves and shedding, indicate the maturity of the crop. Cut the entire plant when most of the pods have turned yellow, drying and processing.

## SOYABEAN IN RICE FALLOWS

Soyabean can be sown in rice fallows from middle of January to middle of March. Seeds can be dibbled at 75 kg/ha.

**SPECIAL SITUATIONS**

1. Optimum time of sowing Soyabean CO 1 - 2nd fortnight of June in Kharif
2. Intercropping of Soyabean CO 2 in Sugarcane is recommended for North Western Zone.
3. Intercropping of Soyabean in coconut gardens of more than 10 years is recommended.
4. Vermipelleting (50 g/kg) and adopting spacing of 30 x 10 cm and two foliar sprays of 2% DAP during flowering is recommended to achieve higher yield.

## RAINFED SOYABEAN

**i. VARIETIES**

CO 1

**ii. SEASON**

The crop can be grown in South-West and North-East monsoon seasons. The middle of July is the optimum time of sowing for rainfed Soyabean in North Western Zone.

**3. SEED TREATMENT WITH THE FUNGICIDES AND BIOFERTILIZERS**

a) Treat the seeds with Carbendezim or Thiram @ 2g/kg of seed 24hrs before sowing or with talc formulation of *Trichoderma viride* @ 4 g/kg seed or *Pseudomonas fluorescens* @ 10 g/kg seed.

- Biocontrol agents are compatible with biofertilizers.
- First treat the seeds with biocontrol agents and then with Rhizobium.
- Fungicides and biocontrol agents are incompatible.

b) Treat the seeds required for ha. with three pockets of Rhizobium and 3 packets of Phosphobacteria

**4. FERTILIZER APPLICATION**

i) Apply NPK as per soil test recommendation as far as possible. If soil test recommendation is not available adopt blanket recommendation of 20:40:20:20 NPKS kg/ha, if adequate moisture is available.

ii) Apply entire dose of N, P, K and S as basal.

**5. SPACING**

Adopt a spacing of 30 cm between rows and 5 cm between plants in the row.

**6. SOWING**

Dibble or drill the seeds.

**7. WEED MANAGEMENT**

i) If sufficient moisture is available, Pendimethalin 1.0 litre/ha after sowing followed by one hand weeding on 30 days after sowing.

ii) If herbicide spray is not given, two hand weeding on 20 and 35th day after sowing.

iii) Early Post emergence application of Imazythypur @ 40 g ai/ha applied as per amergence on 20 days after sowing with one hand weeding on 30 DAS.

## CROP PROTECTION

| | |
|---|---|
| *Spodoptera, Helicoverpa*, *Spilosoma*, Semilooper, Leaf miner, Stem fly | *Bacillus thuringiensis* var. *Kurstaki*, Bio-tech. International @ 500-750 g/ha<br>Chlorantraniliprole 18.5% SC @150 ml/ha<br>Ethion 50% EC @1500ml/ha<br>Flubendiamide 39.35% SC 150ml/ha<br>Indoxacarb 15.8%EC 330ml/ha<br>Profenophos 50%EC 1.0 l/ha<br>Spinetorum 11.7% SC 450ml/ha |
| Girdle beetle | Profenophos 50%EC 1.0 l/ha<br>Thiacloprid 21.7% SC750ml/ha |
| Leaf weevil | Malathion 50% EC @1500ml/ha<br>Quinalphos 1.5DP 16kg/ha<br>Quinalphos 25%EC 1.0 l/ha |

**Seed treatment:** Treat the seeds with *T. asperellum* @ 4 g or *P. fluorescen s*@ 10 g/kg or carbendazim @ 2 g/kg or thiram @ 4 g/kg of seeds

| Disease | Recommendations |
|---|---|
| **Rust:** *Phakopspora pachyrhizi* | Spray triadimefon @ 0.1 % or propiconazole @ 0.1% or hexaconazole @ 0.1% at flowering stage or at the onset of disease |
| **Virus diseases**<br>**Yellow mosaic** (Gemini virus)<br>(Vector –*Bemisia tabaci*)<br>**Bud blight** (Ilarvirus)<br>(Vector- *Thrips palmi*) | • Rogue out the virus infected plants up to 30 days<br>• Two sprays with thiamethoxam 25 WG @ 100 g/ha or methyl demeton @ 800 ml/ha or imidacloprid 17.8 SL @ 250 ml/ha at 30 and 45 days after sowing to control the vector |

## SOYABEAN - SEED PRODUCTION
## VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be of the same variety or other varieties of the same crop. It can be of the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 3 m all around the field from the same and other varieties of the crop.

**Harvest**

- Harvest the pods as they turn yellow in colour.

**Threshing**

- Thresh the pods either manually or mechanically using pliable bamboo sticks.

**Seed grading**

- Grade the seeds using 14 / 64" or 12 / 64" sieves based on the varieties.

**Drying**

- Dry the seeds to 7- 8 % moisture content.

**Pre-storage seed treatment**

- Treat with carbendazim @ 2 g / kg of seed along with carbaryl @ 200 mg / kg of seed.
- Treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg as eco-friendly treatment.

**Storage**

- Store the seeds with a seed moisture content of 10 - 12 % in gunny or cloth bags for short term storage (8 - 9 months).
- Store the seeds with a seed moisture content of 8 - 10 % in polylined gunny bag for medium term storage (12 - 15 months).
- Store the seeds with a seed moisture content less than 7 % in 700 gauge polythene bag for long term storage (more than15 months).

# (x) SWORD BEAN ( *Canavalia gladiata L.*)

**CLIMATE RQUIREMENT**

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 38 | 10 | 15 - 30 | 700 - 4200 | 1500 |

Tropical and subtropical warm and moist climate. It is widely cultivated in the humid tropics.tolerates salinity and waterlogging. This crop can grow in light shade under trees to serve as a nitrogen - fixing cover crop.

## CROP IMPROVEMENT

Sword bean SBS 1 is an introduction and is one of the vegetables with photo-insensitivity. It matures in 110 - 120 days. It can be grown throughout the year and gives good response to irrigation. Tender pods are ready for harvest from 75 days after sowing. As a pure crop it gives an average grain yield of 1356 kg/ha and green pod yield of 7500 kg/ha. This can also be grown as border crop, intercrop and a shade crop.

## I. SEASON

June - July (Rainfed), September - October (Rabi), February - March (Summer).

## II. DESCRIPTION OF VARIETY - SBS 1

| | |
|---|---|
| Year of release | 1990 |
| Plant habit | Dwarf, erect, bushy |
| Pigmentation | Green |
| Branches (No) | 4 - 6 |
| Inflorescence | Axillary raceme |
| Flower | Bold, light purple |
| Pods | Long, pendulous, green, flat and fleshy (for vegetable use). Becomes very hard on maturity. |
| 100 seed weight (g) | 131.6 |
| Seed colour | Milky white |
| Days to 50% bloom | 45 - 50 |
| Salient features | Early duration (110 - 120 days) Vegetable cum grain crop<br>Free from beany odour<br>Highly nutritious and delicious (25.9% protein) No major pests and diseases |

## III. MANAGEMENT OF FIELD OPERATIONS

- Seed rate (kg/ha) : 110-120 (Pure crop)
- Fertilizers (kg/ha) : 25 N 50 $P_2O_5$
- Spacing : 45 x 30 cm (irrigated), 30x20 cm rainfed

## INTEGRATED PEST MANAGEMENT FOR PULSE PESTS

1. **Stem fly**
   - It attacks blackgram, greengram and cowpea.
   - Adult fly is blackish and lay eggs on the young leaves
   - Affected plants get dried
   - Immature stage will be inside the stem
   - Economic threshold level is 10% damage
2. **Aphids**
   - Attacks blackgram, greengram, lab lab, cowpea and redgram.
   - Congregated on the growing shoots, leaves, flowers and pods.
   - Affected plants will be weak and stunted
   - Because of honeydew ant movements will be there
3. **Whiteflies**
   - Attacks blackgram, greengram, cowpea and soyabean
   - Act as vector for yellow mosaic virus disease
4. **Bugs**
   - Desap the flowers and pods
   - Affected pods show shriveled grains
5. **Pod borers**
   - Gram pod borer, spotted pod borer, blue butterflies, pod fly and blister beetles are the major borers
   - Blister beetles feed on flower buds, flowers and young pods
   - Spotted pod borers web the flowers and young pods
   - Gram pod borer, plume moth and blue butterflies bore into the pods
   - Pod fly feed on the seeds of redgram.

   **IPM**
   - Take up the sowing of blackgram from September to November with increased seed rate (25 kg/ha) in stem fly endemic areas.
   - Remove alternate hosts
   - Use of pheromone traps @ 12/ha for Gram pod borer
   - Spray insecticides like methyl demeton or dimethoate or monocrotophos @ 500ml/ha to reduce the sucking insects
   - Spray Neem seed kernel extract (25 kg/ha) against pod borers
   - Avoid insecticidal spray when parasitoids and predators activity is high.

6. **Storage pests**
   - Dry the seeds adequately to reduce moisture level to 10 %.
   - Use pitfall traps or two in one model trap to assess the time of emergence of field carried over pulse beetle in storage and accordingly sun-dry the produce.
   - Seed: **Mix any one of the following for every 100 kg** : Activated kaolin 1 kg Malathion 5 D 1 kg TNAU Neem oil 60 EC (C) 1lit. Pungam oil 1lit.
     Monocrotophos 36 SL 400 ml
   - Pack in polythene lined gunny bags for storage

# 5. OILSEEDS

## (i) GROUNDNUT (*Arachis hypogaea* )

### CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 15 | 25 - 35 | 500 - 700 | 1160 |

Tropical crop, wide spectrum adoptable crop which grown in all 3 seasons. Flowering and seed setting affected by cloudy weather. Day neutral plant. Resists drought and tolerate flooding for one week once it establish.

### CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone/ District/Season | Sowing Month | Varieties |
|---|---|---|
| **I. Western Zone (Irrigated)** | | |
| **Coimbatore, Tiruppur** | | |
| **Chithiraipattam** | April-May | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Erode,Theni,Dindigul** | | |
| Margazhipattam | Dec- Jan | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Western Zone (Rainfed)** | | |
| **Coimbatore,Tiruppur, Erode, Theni, Dindigul** | | |
| Anippattam | June- July | TMVGn 13, VRIGn 7, CO 6, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **II. Southern Zone (Irrigated)** | | |
| **Ramanathapuram, Thirunelveli** | | |
| Thaippattam | Jan- Feb | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Karur, Pudukkottai, Madurai, Virudhunagar** | | |
| Margazhipattam | Dec- Jan | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Sivagangai** | | |
| Ayppasipattam | Oct- Nov | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Southern Zone (Rainfed)** | | |
| **Karur, Pudukkottai, Madurai, Sivagangai** | | |
| Anippattam | June-July | TMVGn 13, VRIGn 6, VRI Gn 7, VRI 8, CO 6, CO 7, TMV 14, BSR 2 |
| **Virudhunagar** | | |
| Adippattam | July-Aug | TMVGn 13, VRI 8, CO 7, TMV 14, BSR 2 |
| **Ramanathapuram, Thirunelveli** | | |
| Purattasipattam | Sep- Oct | TMVGn 13, VRI Gn 7, VRI 8, CO 6, CO 7, TMV 14, BSR 2 |
| **Thoothukudi** | | |
| Karthigaipattam | Nov- Dec | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **III. North Eastern Zone (Irrigated)** | | |

| | | |
|---|---|---|
| **Villupuram** | | |
| Chithiraipattam | April-May | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Thiruvallur, Kancheepuram** | | |
| Margazhipattam | Dec- Jan | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Cuddalore** | | |
| Ayppasipattam | Oct- Nov | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Vellore, Thiruvannamalai** | | |
| Karthigaipattam | Nov- Dec | TMVGn 13, VRIGn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Thiruvallur, Cuddalore, Vellore** | | |
| Anippattam | June-July | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Kancheepuram** | | |
| Adippattam | July-Aug | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Thiruvannamalai** | | |
| Purattasipattam | Sep- Oct | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Villupuram** | | |
| Karthigaipattam | Nov- Dec | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **IV. North Western Zone (Irrigated)** | | |
| **Perambalur, Ariyalur** | | |
| Margazhipattam | Dec- Jan | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Namakkal, Dharmapuri** | | |
| Vaigasipattam | May- June | CO 6, VRI GN 7 |
| **Salem, Krishnagiri** | | |
| Karthigaipattam | Nov- Dec | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **North Western Zone (Rainfed)** | | |
| **Namakkal** | | |
| Vaigasipattam | May- June | CO 6, VRI Gn 7, BSR 2 |
| **Salem, Dharmapuri, Krishnagiri** | | |
| Anippattam | May- June | TMVGn 13, CO 6, VRI Gn 7, BSR 2 |
| **Perambalur, Ariyalur** | | |
| Adippattam | July-Aug | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **V. Delta Zone (Irrigated)** | | |
| **Thiruchirapalli, Thanjavur, Thiruvarur, Nagapattinam** | | |
| Margazhipattam | Dec- Jan | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Delta Zone (Rainfed)** | | |
| **Thiruchirapalli** | | |
| Anippattam | June-July | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |
| **Thanjavur, Nagapattinam** | | |
| Margazhipattam | Dec- Jan | TMVGn 13, VRI Gn 6, VRI 8, CO 7, TMV 14, BSR 2 |

Bunch varieties: :TMV Gn13, TMV 14, VRI Gn 6, VRI 8, CO7, BSR Semi spreding varieties: :VRI Gn 7, CO6
Suitable varieties for irrigated: VRI 8, BSR 2, CO 7
Suitable varieties for rainfed **:** TMV Gn13, TMV 14, BSR 2, CO 6, CO7 and VRI 7
Bold variety (Gujarat) : GG 7
TMV 14 and BSR 2 are alternate varieties for TMV 7

## II. DESCRIPTION OF GROUNDNUT VARIETIES

| Particulars | TMVGn 13 | VRIGn 6 |
|---|---|---|
| Year of Release | 2006 | 2007 |
| Year of Notification | SO.1178(E)/20.07.2007 | SO.449(E)/11.02.2009 |
| Parentage | Selection from Pollachi red | Derivative of ALR 2 X VG 9513 |
| Duration (days) | 100-105 | 120-125 |
| Average Yield of Pods kg/ha | | |
| Rainfed | 1613 | 1916 |
| Irrigated | 2580 | 2403 |
| Shelling % | 71.4 | 75 |
| 100-seed weight (g) | 44 | 36 |
| Oil content % | 50 | 50 |
| Special features | Red kernel, high yield and tolerant to terminal drought | Small pods, moderately resistant to late leaf spot, rust and PBND diseases. Resistant to early season drought, high harvest index (34.6%) |
| Growth habit | Bunch | Bunch |
| Leaf colour | Green | Light green |
| Seed colour | Red | Light Rose |

| Particulars | VRIGn 7 | BSR 2 |
|---|---|---|
| Year of Release | 2008 | 2019 |
| Year of Notification | SO.2187(E)/27.08.2009 | SO.3220(E)/05.09.2019 |
| Parentage | Derivative of TMV 1 X JL 24 | VR12 x TVG 0004 |
| Duration (days) | 120-125 | 105-110 |
| Average Yield of Pods kg/ha | | - |
| Rainfed | 1865 | 2222 |
| Irrigated | - | 2360 |
| Shelling % | 72 | 70.2 |
| 100-seed weight (g) | 46 | 40-43 |
| Oil content % | 48 | 45.01 |
| Special features | Moderately resistant to late leaf spot and rust diseases. Moderately resistant to leaf miner | One or two seeded, usually two seeded, medium sized pods, Moderately resistant to late leaf spot and rust diseases |
| Growth habit | Semi-spreading | Bunch |
| Leaf colour | Dark green | Green |
| Seed colour | Rose | Tan |

| Particulars | VRI 8 | TMV 14 |
|---|---|---|
| Year of Release | 2016 | 2018 |
| Year of Notification | SO.2805(E)/25.08.2017 | SO.1498(E)/01.04.2019 |
| Parentage | ALR 3 x AK 303 | VRI Gn 6 x R 20012 |
| Duration (days) | 105-110 days | 95-100 days |

| | | |
|---|---|---|
| Average Yield of Pods kg/ha | | |
| Rainfed | 2130 | 2124 |
| Irrigated | 2700 | 2286 |
| Shelling % | 70 | 70.6 |
| 100-seed weight (g) | 45-50 | 38.0 |
| Oil content % | 49 | 48.0 |
| Special features | Moderately resistant to sucking pest and defoliators. Moderately resistant to foliar fungal disease. Medium bold kernel suitable for confectionary/table purpose | Higher dry pod yield than VRI ( Gn) 6 & TMV (Gn) 13; Higher shelling percentage than VRI Gn 6 Less incidence of *Spodoptera*, thrips and leaf miner compared to VRI (Gn) 6 and TMV (Gn) 13 under field conditions; Moderately resistant to late leaf spot and rust disease under field conditions |
| Growth habit | Bunch | Bunch |
| Leaf colour | Light green | Green |
| Seed colour | Rose | Rose |

| Particulars | TNAU CO 6 | CO 7 |
|---|---|---|
| Year of Release | 2010 | 2013 |
| Year of Notification | SO.1708(E)/26.07.2012 | SO.2680(E)/01.10.2015 |
| Parentage | Derivative of CS 9 X ICGS 5 | Derivative of ICGV 87290 X ICGV 87846 |
| Duration (days) | 125-130 | 100 -105 |
| Average Yield of Pods kg/ha | | |
| Rainfed | 1914 | 2300 |
| Irrigated | - | 2806 |
| Shelling % | 73.5 | 71 |
| 100-seed weight (g) | 48.5 | 35 - 44 |
| Oil content % | 49.5 | 51 |
| Special features | Dark green foliage, tolerant to foliar diseases | High oil, moderately tolerant to Rust and Late leaf spot , tolerant to Drought |
| Growth habit | Semi- spreading | Spanish Bunch |
| Leaf colour | Dark green | Green |
| Seed colour | Tan testa | Tan testa |

## CROP MANAGEMENT

## I. Rainfed

### 1. FIELD PREPARATION

i) Plough with tractor using a disc followed by harrow, once or twice with iron plough or 3 - 4 times with country plough till all the clods are broken and a fine tilth is obtained.

ii) Chiselling for soils with hard pan: Chisel the soils having hard pan formation at shallow depth with chisel plough first at 0.5 m interval in one direction and then in the direction perpendicular to the previous one, once in three years. Apply 12.5 t/ha of FYM or composted coir pith besides chiselling.

iii) Amendments for soil surface crusting: a) To tide over the surface crusting, apply lime @ 2 t/ha along with FYM or composted coir pith @ 12.5 t/ha. b) Coir pith at 12.5 t/ha converted to compost by inoculating with *Pleurotus* and applied serves as a good source of nutrients.

**2. APPLICATION OF FERTILIZERS**

Apply NPK fertilizers as per soil test recommendation. If soil test is not done, follow the blanket recommendation.

| N | P | K | |
|---|---|---|---|
| 10 | 10 | 45 | Kg/ha |

For rainfed groundnut –castor intercropping system, apply the recommended dose of 10:10: 45 kg NPK $ha^{-1}$ to the main crop of groundnut and for castor apply the recommended dose of 40 kg N

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished )

**Rainfed Groundnut**

Soil : Red sandy clay loam (Somayanur series)

Target : 1.0-1.2 t $ha^{-1}$

FN = 7.50 T - 0.33 SN - 0.45 ON

$FP_2O_5$ =3.50 T - 1.67 SP - 0.55 OP

$FK_2O$ = 6.78 T - 0.31 SK - 0.43OK

| **Initial soil test values (kg $ha^{-1}$)** | | | **Yield target – 1.0 t $ha^{-1}$** | | | **Yield target – 1.2 t $ha^{-1}$** | | |
|---|---|---|---|---|---|---|---|---|
| | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 160 | 5* | 5* | 23* | 15** | 8 | 23* |
| 180 | 14 | 180 | 5* | 5* | 23* | 11 | 5* | 23* |
| 200 | 16 | 200 | 5* | 5* | 23* | 5* | 5* | 23* |
| 220 | 18 | 220 | 5* | 5* | 23* | 5* | 5* | 23* |
| 240 | 20 | 240 | 5* | 5* | 23* | 5* | 5* | 23* |

* Maintenance dose;** Maximum dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure inkg $ha^{-1}$.

**3. FORMING BEDS**

i) Form beds of size 10 $m^2$ to 20 $m^2$ depending upon the slope of the land and type of soil.

ii) Wherever tractor is engaged, bed former may be used.
Or Ridges and furrows may be laid at 60cm spacing between ridges and sowing taken on both sides of the ridge

Or Raised bed with a width of 60cm and with a furrow of 15cm on either side may be formed and sowing taken on the raised bed

**4. APPLICATION OF MICRONUTRIENTS**

Apply TNAU MN mixture @ 7.5 kg /ha as Enriched FYM (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture &incubate for one month in shade). Broadcast evenly on the soil surface immediately after sowing. Do not incorporate micronutrient mixture in to the soil.

**5. NUTRITIONAL DISORDER**

**Zinc deficiency**: Apply 25 kg $ZnSO_4$/ha as basal.

If soil analysis shows less than 1.2 ppm of zinc, soil application of 25 kg $ZnSO_4$ is recommended. Reduce $ZnSO_4$ application from 25.0 kg $ha^{-1}$ to 12.5 kg $ha^{-1}$ if FYM is applied @ 12.5 t $ha^{-1.}$ For the standing crop, less than 39.4 ppm of zinc in leaves, foliar spray of 0.5% $ZnSo_4$ is recommended.

**Iron deficiency**: Foliar of spray 1% $FeSO_4$ + 0.1% citric acid thrice on 30, 40 and 50 days after sowing.

**Boron deficiency**: Application of Borax 10 kg

**Sulphur deficiency:** Gypsum 400 kg/ha as soil application at $45^{th}$ day after sowing.

**6. SEED RATE**

Use 120 kg/ha of kernels, 175 kg/ha of kernels for bold seeded varieties.

**7. SPACING**

Adopt a spacing of 30 cm between rows and 10 cm between plants. Wherever groundnut ring mosaic (bud necrosis) is prevalent, adopt a spacing of 15cm x 15 cm.

**8. SEED TREATMENT**

i) Treat the seeds with talc formulation of *Trichoderma viride* @ 4 g/kg seed or *Pseudomonas fluorescens* @ 10 g/kg seed.
Biocontrol agents are compatible with biofertilizers.
Treat the seeds with biocontrol agents first and then with *Rhizobium*.
Fungicides and biocontrol agents are incompatible.

ii) Treat the seeds with *Trichoderma* @ 4g/kg. This can be done just before sowing. It is
compatible with biofertilizers. SUCH SEEDS SHOULD NOT BE TREATED WITH FUNGICIDES (or)

iii) Treat the seeds with Thiram or Mancozeb @ 4 g/kg of seed or Carboxin or Carbendazim at 2 g/kg of seed.

iv) Treat one hectare of seeds with 125 ml of *Rhizobium* (TNAU 14) and 125 ml of Phosphobacteria, shade dry it for 30 minutes before sowing

**9. SOWING**

- Use Kovai seed drill/gorru to sow the seeds in lines.
- Put one seed in each hole. Protect the seeds from crows and squirrels.

**10. INTERCROPPING**

i) Raise one row of cowpea for every five rows of groundnut wherever red hairy caterpillar is endemic.

ii) Raise intercrops like redgram, blackgram, sunflower, gingelly or other pulses.

iii) Cumbu can be raised as intercrop.

iv) Groundnut + Gingelly or Groundnut + Blackgram in the ratio of 4:1 or Groundnut + Cowpea at 6:1 ratio and Groundnut + Sunflower at 6:2 ratio may be raised.

**11. WEED MANAGEMENT**

i) **Pre-emergence**: Pendimethalin @ 1.0 litre/ha applied through flat fan nozzle with 500 l of water/ha. After 35 - 40 days one hand weeding may be given.

ii) If no herbicide is applied two hand weeding may be given on 20$^{th}$ and 40$^{th}$ day after sowing.

**12. EARTHING UP**

Accomplish earthing up during second hand weeding/late hand weeding (in herbicide application).

NOTE: i) Earthing up provides medium for the peg development ii) Use the improved hoe with long handle which can be worked more efficiently in a standing position. iii) Do not disturb the soil after 45$^{th}$ day of sowing as it will affect pod formation adversely.

**13. APPLICATION OF CALCIUM SULPHATE (GYPSUM)**

i) Apply gypsum @ 400 kg/ha by the side of the plants on 40th to 70th day depending upon soil moisture.

ii) Apply gypsum, hoe and incorporate it in the soil and then earth up.

iii) Avoid gypsum in calciferous soils.

iv) Gypsum is effective in soils deficient in calcium and sulphur.

*NOTE: Application of gypsum encourages pod formation and better filling up of the pods.*

Application of gypsum at the rate of 50 % basal both in rainfed and irrigated condition reduces Khadhasty malady and pod scab nematode

**Combined nutrient spray**

Pod filling is a major problem especially in the bold seed varieties. To improve pod filling spraying of nutrient solution is to be given. This can be prepared by soaking DAP 2.5 kg, Ammonium sulphate 1 kg and borax 0.5 kg in 37 lit of water overnight. The next day morning it can be filtered and about 32 litre of mixture can be obtained and it may be diluted with 468 lit of water so as to made up to 500 litre to spray for one ha. Planofix at the rate of 350 ml. can also be mixed while spraying. This can be sprayed on 25$^{th}$ and 35$^{th}$ day after sowing.

**14. HARVESTING**

i) Observe the crop, considering its average duration. Drying and falling of older leaves and yellowing of the top leaves indicate maturity.

ii) Pull out a few plants at random and shell the pods. If the inner shell is brownish black and not white, then the crop has matured.

iii) Irrigate prior to harvest, if the soil is dry, as this will facilitate easy harvesting. If there is enough moisture in the soil, there is no need for irrigation for harvesting.

iv) If water is not available for irrigating the field prior to harvest, work a mould board plough or work a country plough, so that the plants are uprooted. Engage labour to search pods left out in the soil, if necessary.

*NOTE: Do not keep the pulled out plants in heaps when they are wet, especially the bunch varieties, as the pods will start sprouting.*

v) Strip off the pods from the plants. Groundnut stripper developed by TNAU can be used.

vi) Dry the pods in the sun for 4 or 5 days. Repeat drying for 2 or 3 more days after an interval of 2 or 3 days to ensure complete drying. When temperature is very high, avoid direct sun drying. Collect the pods in gunnies and store on the ground over a layer of sand to avoid any moisture coming in contact with dry pods.

**I. Irrigated**

**1. FIELD PREPARATION**

i) Plough with tractor using a disc followed by harrow, once or twice with iron plough or 3 - 4 times with country plough till all the clods are broken and a fine tilth is obtained.

ii) Chiselling for soils with hard pan: Chisel the soils having hard pan formation at shallow depth with chisel plough first at 0.5 m interval in one direction and then in the direction perpendicular to the previous one, once in three years. Apply 12.5 t/ha FYM or composted coir pith besides chiselling.

iii) Amendments for soil surface crusting: a) To tide over the surface crusting, apply lime @ 2 t/ha along with FYM or composted coir pith @ 12.5 t/ha. b) When coir pith at 12.5 t/ha is converted into compost by inoculating with *Pleurotus* and applied, it serves as a good source of nutrien

**2. APPLICATION OF FERTILIZERS**

If soil test is not done, follow the blanket recommendation.

| N | P | K |
|---|---|---|
| 25 | 50 | 75 kg/ha |

80 kg S as gypsum on 45 DAS

For calcareous soil, application of 40 kg S elemental sulphur along with either 50 kg $FeSO_4$ + 12.5 t FYM or 5 kg Fe EDTA can be used. For sulphur deficient calcareous soil, application of 60 kg S/ha elemental sulphur as basal application is recommended. Growing CO7, ALR3 and CO2 can be recommended in calcareous soils tolerate lime induced iron chlorosis while CO4, TMV2 and ALG320 were highly sensitive to iron deficiency.

N and K in three splits *viz.,* 50 % N & K as basal + 25 % N and K at 20 DAS + 25 % N and K at 45 DAS is recommended.

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished )

**Groundnut (1)**

Soil : Red sandy loam (Irugur series)

Target : 2.0 - 2.5 t $ha^{-1}$

$FN = 6.54T - 0.56\ SN - 0.69\ ON$

$FP_2O_5 = 3.80T - 3.32\ SP - 0.77\ OP$

$FK_2O = 8.35T - 0.65SK - 0.87\ OK$

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 2.0 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 2.5 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 160 | 13* | 25* | 38* | 34 | 35 | 65 |
| 180 | 14 | 180 | 13* | 25* | 38* | 23 | 29 | 52 |
| 200 | 16 | 200 | 13* | 25* | 38* | 13* | 25* | 39 |
| 220 | 18 | 220 | 13* | 25* | 38* | 13* | 25* | 38* |
| 240 | 20 | 240 | 13* | 25* | 38* | 13* | 25* | 38* |

* Maintenance dose

**Groundnut (2)**

Soil : Red sandy clay loam (Somayanur series)

Target : 2.0- 2.5 t $ha^{-1}$

$FN = 6.54T - 0.51SN - 1.10\ ON$

$FP_2O_5 = 4.19\ T - 2.95SP - 0.77\ OP$

$FK_2O = 5.47\ T - 0.33SK - 0.87\ OK$

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 2.0 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 2.5 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 160 | 13* | 28 | 38* | 38** | 49 | 44 |
| 180 | 14 | 180 | 13* | 25* | 38* | 32 | 43 | 38* |
| 200 | 16 | 200 | 13* | 25* | 38* | 22 | 38 | 38* |
| 220 | 18 | 220 | 13* | 25* | 38* | 13* | 32 | 38* |
| 240 | 20 | 240 | 13* | 25* | 38* | 13* | 26 | 38* |

* Maintenance dose;** Maximum dose

**Groundnut (3)**

Soil : Low level Laterite

Target : 2.0- 2.5 t $ha^{-1}$

$FN = 5.97\ T - 0.45\ SN$

$FP_2O_5 = 3.80\ T - 3.32\ SP$

$FK_2O = 7.08\ T - 0.58\ SK$

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 2.0 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 2.5 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 160 | 12 | 120 | 13* | 25* | 38* | 37 | 35 | 67 |
| 180 | 14 | 140 | 13* | 25* | 38* | 28 | 29 | 56 |
| 200 | 16 | 160 | 13* | 25* | 38* | 19 | 25* | 44 |
| 220 | 18 | 180 | 13* | 25* | 38* | 13* | 25* | 38* |
| 240 | 20 | 200 | 13* | 25* | 38* | 13* | 25* | 38* |

* Maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure inkg $ha^{-1}$.

**3. Forming Beds**

Form beds of size 10 m land and type of soil to 20 m depending upon the availability of water, slope of the

- Wherever tractor is engaged, bed former may be used. or
- Ridges and furrows may be laid at 60cm spacing between ridges and sowing taken on both sides of the ridge
- Raised bed with a width of 60cm and with a furrow of 15cm on either side may be formed and sowing taken on the raised bed

**4. POLYTHENE FILM MULCHING**

Broad beds and furrows method of groundnut cultivation is a proven technology from ICRISAT. Considering the favourable environment in the Broad beds and furrows system for the development of groundnut pods, with a little modification in the size, beds are to be formed for the polyethylene film mulched groundnut. Make the beds at a width of 60 cm, leaving 15 cm on the either side for the furrows. In a plot size of 4.5 m x 6.0 m, five beds can be made. After the formation of the bed and fertilizer application, spread black polythene sheet (90 cm width) over the soil surface. The edges of the polyethylene can be sheet Seven micron polythene film sheet @50 kg/ha is required. Holes can be made at required spacing of 30 x10 cm before spreading of the sheets. The seed requirement is similar to normal groundnut cultivation

**5. APPLICATION OF MICRONUTRIENTS**

- Apply TNAU MN mixture @ 12.5 kg /ha as Enriched FYM . (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture &incubate for one month in shade).
- Broadcast evenly on the soil surface immediately after sowing. Do not incorporate the micronutrient mixture to the soil.
- To increase flower retention, pod filling and to induce drought tolerance apart from yield improvement, 2 sprays of TNAU groundnut rich @ 5.0 kg/ha (for each spray) at 35 DAS ( 50 per cent flowering) and 45 DAS (Pod developing stage) in 500 litres of water is recommended

**6. NUTRITIONAL DISORDER**

**Zinc deficiency**: Apply 25 kg $ZnSO_4$/ha as basal.

If soil analysis shows less than 1.2 ppm of zinc, soil application of 25 kg $ZnSo_4$ is recommended. Reduce $ZnSO_4$ application from 25.0 kg $ha^{-1}$ to 12.5 kg $ha^{-1}$ if FYM is applied @ 12.5 t $ha^{-1.}$ For the standing crop, less than 39.4 ppm of zinc in leaves, foliar spray of 0.5% $ZnSo_4$ is 4 recommended.

**Iron deficiency** : Foliar spray of 1% $FeSO_4$ + 0.1% citric acid on 30, 40 and 50 days after sowing. Apply 50 kg $FeSO_4$ + 12.5 t FYM basally.

**Boron deficiency**: Application of Borax 10 kg basally (or) 0.2% boric acid twice on 40, 50 DAS.

**For multinutrient deficiency:** Apply 25 kg $ZnSO_4$ + 10 kg borax + 20kg S as Gypsum.

**Copper deficiency:** Basal application of 10 kg $CuSO_4$ or 0.2% $CuSO_4$. Spray twice after observing plant nutrient deficiencies.

## 7. SEED RATE

Use 125 kg/ha of kernels. Increase the seed rate by 15% in the case of bold seeded varieties.

## 8. SPACING

Adopt a spacing of 30 cm between rows and 10 cm between plants. Wherever groundnut ring mosaic (bud necrosis) is prevalent, adopt a spacing of 15cm x 15 cm.

## 9. SEED TREATMENT

i) Treat the seeds with *Trichoderma viride* @ 4 g/kg seed or *Pseudomonas fluorescens* @ 10 g/kg seed.
**Biocontrol agents are compatible with biofertilizers.**
**First treat the seeds with biocontrol agents and then with *Rhizobium*.**
**Fungicides and biocontrol agents are incompatible.**

ii) Treatment with *Trichoderma* can be done just before sowing. SUCH SEEDS SHOULD
NOT BE TREATED WITH FUNGICIDES. (or)

iii) Treat the seeds with Thiram or Mancozeb @ 4 g/kg of seed or Carboxin or Carbendazim at 2 g/kg of seed.

iv) Treat the seeds with 3 packets (600 g)/ha of Rhizobial culture TNAU14 developed at TNAU using rice kanji as binder. If the seed treatment is not carried out, apply 10 packets/ha (2000 g) with 25 kg of FYM and 25 kg of soil before sowing.

*Seed treatment will protect the young seedlings from root-rot and collar rot infection.*

## 10. SOWING

a) Dibble the seeds at 4 cm depth along with fertilizer.

## 11. WEED MANAGEMENT

i. **Pre-emergence**: Pendimethalin @ 1.0 litre/ha applied on third day after sowing through flat fan nozzle with 500 litres of water/ha followed by irrigation. After 35 - 40 days one hand weeding may be given.

ii. Spray Early post emergence application of Imazethapyr @ 50 ml/ha at 20-30 days after sowing based on weed density as post emergence spray

iii. If no herbicide is applied two hand hoeing may be given on $20^{th}$ and $40^{th}$ day after sowing.

iv. Apply, PE Oxyfluorfen @ 200 g/ha on $3^{rd}$ DAS and followed by one hand weeding on 40-45 DAS

v. Apply, PE Oxadiazon @ 0.8 kg $ha^{-1}$ followed by one earthing up using hoes (or) working star type weeder

**12. EARTHING UP:**

Accomplish earthing up during second hand weeding/late hand weeding (in herbicide application).

NOTE: i) Earthing up provides medium for the peg development. ii) Use the improved hoe with long handle which can be worked more efficiently in a standing position. iii) Do not disturb the soil after the $45^{th}$ day of sowing as it will affect pod formation adversely.

**13. APPLICATION OF CALCIUM SULPHATE (GYPSUM)**

- Apply gypsum @ 400 kg/ha by the side of the plants on the $40^{th}$ to $45^{th}$ day of sowing. Apply gypsum, hoe and incorporate in the soil and then earth up.
- Avoid gypsum in calciferous soils.
- Gypsum is effective in soils deficient in calcium and sulphur.

*NOTE: Application of gypsum encourages pod formation and better filling up of the pods.*

Application of gypsum at the rate of 50 % basal both in rainfed and irrigated condition reduces Khadhasty malady and pod scab nematode

**Combined nutrient spray**

Pod filling is a major problem especially in the bold seed varieties. To improve pod filling spraying of nutrient solution is to be given. This can be prepared by soaking DAP 2.5 kg, Ammonium sulphate 1 kg and borax 0.5 kg in 37 lit of water overnight. The next day morning it can be filtered and about 32 litre of mixture can be obtained and it may be diluted with 468 lit of water so as to made up to 500 litre to spray for one ha. Planofix at the rate of 350 ml. can also be mixed while spraying. This can be sprayed on $25^{th}$ and $35^{th}$ day after sowing. or Spray TNAU Groundnut Rich @ 5.5 kg/ha for 2 sprays (50 per cent flowering and pod developing stage) to increase flower retention and pod filling.

**14. WATER MANAGEMENT**

Schedule the irrigation at 0.40 and 0.60 IW/CPE ratio during vegetative and reproductive phase respectively. Regulate irrigation as per the growth phase of the crop. Pre-flowering phase : 1 to 25 days Flowering phase : 26 to 60 days Maturity phase: 61 to 105 days Regulate irrigation based on physiological growth phases. Pegging, flowering and pod development phases are critical for irrigation during which period adequate soil moisture is essential. Irrigate as follows:

i) Sowing or pre-sowing
ii) Life irrigation, 4 - 5 days after sowing.
iii) 20 days after sowing
iv) At flowering give two irrigations
v) At pegging stage give one or two irrigations
vi) In pod development stage, 2 - 3 irrigations depending on the soil type

*Note: Spraying 0.5% Potassium chloride during flowering and pod development stages* *will aid to mitigate the ill effects of water stress. Sprinkler irrigation will save water to the tune of about 30%. Borderstrip irrigation is recommended in command areas in light textured soils. Composted coir pith increases moisture availability and better drainage in heavy textured soil.*

**15. HARVESTING**

i) Observe the crop, considering its average duration. Drying and falling of older leaves and yellowing of the top leaves indicate maturity.

ii) Pull out a few plants at random and shell the pods. If the inner shell is brownish black and not white, then the crop has matured.

iii) Irrigate prior to harvest, if the soil is dry, as this will facilitate easy harvesting. If there is enough moisture in the soil, there is no need for irrigation for harvesting.

iv) If water is not available for irrigating the field prior to harvest, work a mould board plough or work a country plough, so that the plants are uprooted. Engage labour to search pods left out in the soil, if necessary.

*NOTE: Do not keep the pulled out plants in heaps when they are wet, especially the bunch varieties, as the pods will start sprouting.*

v) Strip off the pods from the plants. Groundnut stripper developed by TNAU can be used.

vi) Dry the pods in the sun for 4 or 5 days. Repeat drying for 2 or 3 more days after an interval of
2 or 3 days to ensure complete drying. When temperature is very high, avoid direct sun drying. Collect the pods in gunnies and store on the ground over a layer of sand to avoid any moisture coming in contact with dry pods.

**CROP PHYSIOLOGY**

Foliar spray of TNAU Groundnut Rich @ 2 kg/acre in 200 litres of water at peak flowering and at pod development stages increases flower retention, pod filling and improves moisture stress tolerance and pod yield.

## CROP PROTECTION

## Economic threshold level for important pests

| **Pest** | **ETL** |
|---|---|
| Leaf miner | Leaf miner 1 larva / m row |
| Tobacco caterpillar | 8 egg masses/100 m row |

**Pests Management strategies**

| | |
|---|---|
| **Red hairy caterpillar,** *Amsacta albistriga* | • Dig out and destroy the pupae from field bunds and shady spots prior to summer rains.<br>• In rain fed crop set up 3 to 4 light traps and bonfires immediately after rains to attract and kill the moths.<br>• Collect and destroy gregarious, early instar larvae on lace-like leaves of intercrops such as redgram |

| | |
|---|---|
| | and cowpea.<br>• Collect and destroy egg masses in the cropped area.<br>• Dig a trench 30 cm deep and 25 cm wide with perpendicular sides around the infested fields to avoid larval migration.<br>• Spray Aa NPV<br>• Apply quinalphos 1.5 DP 25 kg/ha |
| **Virus multiplication**<br>Collect medium sized larvae of *Amsacta albistriga* from the field and starve them over night. Make a pure suspension of virus with the nucleus culture in water. Dip *Calotropis* leaves in virus suspension, shade dry and feed them to starved larvae for 1 or 2 days. From third day, normal, untreated leaves can be fed to these larvae. From 5$^{th}$ day, the treated larvae will start dying. Virus infected larvae can be diagnosed by their pinkish ventral surface, their head hanging downwards with white body contents oozing out through ruptured body wall in the late stage. Collect the dying larvae, keep in fresh potable water for a few days, grind the larvae and filter through several layers of fine cloth and collect filtrate (Crude virus suspension). Use virus suspension obtained from 750 medium sized larvae for spraying one hectare along with a sticker 250 ml or Triton in 350 l of water. Use potable water for mixing and spray in the evening hours. | |
| Tobacco caterpillar**,** *Spodoptera litura* | • Grow castor as border or intercrop in groundnut fields to serve as indicator or trap crop.<br>• Monitor the emergence of adult moths by setting up light trap and pheromone traps.<br>• Collect egg masses and destroy.<br>• Collect the gregarious larvae and destroy them as soon as the early symptoms of lace-like leaves appear on castor, cowpea and groundnut.<br>• Spray Methomyl 40 SP 750ml / ha to control the early instar (1st to 3rd instar) larvae.<br>• Spray NSKE 5%<br>• Apply Nuclear Polyhedrosis Virus 1.5 x $10^{12}$ POBs/ha with crude sugar 2.5 kg/ha and Teepol 250 ml/ ha. |
| **Leafhopper,** *Empoasca kerri* | Intercrop lab lab with groundnut 1:4 ratio<br>**Spray any one of the following insecticides / ha**<br>Imidacloprid 17.8 SL 100 ml<br>Quinalphos 25 EC 1400 ml |
| **Leafminer / Leaf webber,** *Aproaerema modicella* | Set up light trap between 8 and 11 pm at ground level<br>**Spray any one of the following insecticides / ha**<br>Methyl demeton 25 EC 1000 ml<br>Quinalphos 25 EC 1400 ml |
| **Podborer (Earwig)** *Anisolabis stali* | Apply Carbofuran 3 CG 50 kg/ha<br>to the soil prior to sowing in endemic areas.<br>Repeat soil application of any formulations on the 40th day of sowing and incorporate in the soil during the earthing up. |
| **Whitegrubs**<br>*Holotrichia consanguinea, H. serrata* | Apply Carbofuran 3 CG 33.3 kg/ha |

| | |
|---|---|
| **Aphid**<br>*Aphis craccivora* | **Apply anyone of the following insecticides/ha**<br>Imidacloprid 17.8 SL 100 ml<br>Methyl demeton 25 EC 1000 ml |
| **Thrips**<br>*Scirtothrips dorsalis* | Apply Quinalphos 1.5 DP 23.3kg/ha<br>Spray Quinalphos 25 EC 1400 ml/ha |
| **Termites** | Apply Thiamethoxam 75 SG@125 g/ha |

## DISEASE MANAGEMENT

**Seed treatment :** Treat the seeds with carbendazim @ 2 g/kg or *Trichoderma asperellum* @ 4 g /kg or *Pseudomonas fluorescens* @ 10 g/kg of seeds

| Disease | Recommendations |
|---|---|
| **Rust:** *Puccinia arachidis* | Spray mancozeb @ 1000 g /ha or chlorothalonil @ 1000 g /ha or wettable sulphur @ 2500 g /ha. If necessary, repeat the spray 15 days later. |
| **Early leaf spot:** *Cercopora arachidicola* (*Mycosphaerella arachidis*)<br><br>**Late leaf spot:** *Phaeoisariopsis personata* (*Mycosphaerella berkeleyii*) | Spray carbendazim @ 500 g/ha or mancozeb @ 1000 g/ha or chlorothalonil @ 1000 g/ha. If necessary, repeat the spray 15 days later.<br><br>**CIB Recommendation**<br>• Spray hexaconazole 5% EC @ 1500ml/ha or metiram 70% WG 2 kg/ha or propiconazole 25% EC @ 500 ml/ha or pyraclostrobin 20% WG @ 500g/ha or sulphur 40% WP @ 5.65-7.50 kg/ha or sulphur 80% WP @ 2.5-5.0 kg/ha or sulphur 85% DP @ 15-20 kg/ha or carbendazim 12% + mancozeb 63% WP @ 500 g/ha or fluxapyroxad 167 g/l + pyraclostrobin 333 g/l SC @ 300 ml/ha or pyraclostrobin 133g/l + epoxiconaxole 50g/l SE @ 500/ha<br><br>**For combined infection of leaf spot and rust**<br>• Spray bitertanol 25% WP @ 1 kg/ha or chlorothalonil 75% WP @ 1.5 g/l or mancozeb75% WP @ 1.5 to 2 kg/ha or tebuconazole 25.9% m/m EC @0.50-0.75 l/ha<br><br>**For combined infection of leaf spot and stem rot**<br>• Spray carbendazim 25% + flusilazole 12.5% SE @ 640-800 g/ha<br>**For collar rot, seed rot, root rot and stem rot**<br>• Treat the seeds with carboxin37.5% + thiram 37.5% DS @ 3g/kg of seeds<br>**For the management of termites, thrips, jassids, root grubs, collar rot and stem rot**<br>• Spray imidacloprid 18.5% + hexaconazole 1.5 % FS @ 200 ml/ha |

| | |
|---|---|
| **Combined infection of rust and leaf spot** | Spray 10% *Calotropis* leaf extract or spray carbendazim @ 250 g + mancozeb 1000 g/ha or chlorothalonil @ 1000g/ha. If necessary, give the second spray 15 days later. |
| **Root rot:** *Macrophomina phaseolina* (*Rhizoctonia bataticola*) | • Soil application of *P. fluorescens* @ 2.5 kg /ha with 50 kg of well decomposed FYM / sand at 30 DAS.<br>• Spot drench with carbendazim @ 1 g / l |
| **Groundnut bud necrosis:** (*Groundnut bud nercrosis virus*) (Vector: *Thrips tabaci, Frankliniella schultzeii*) | • Antiviral principles (AVP) from sorghum or coconut leaves. AVPs are extracted as follows: Sorghum or coconut leaves are collected, dried, cut into small bits and powdered. To one kg of leaf powder two litres of water is added and heated to 60°C for one hour. It is then filtered through muslin cloth and diluted to 10 litres and sprayed. To cover one hectare area 500 l of fluid will be required. Two sprays at 10 and 20 days after sowing will be needed.<br>• For vector management, apply quinalphos 1.5 DP 23.3kg/ha or spray quinalphos 25 EC @ 1400 ml/ha |

## GROUNDNUT – VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production, leave a distance of 3 m all around the field from the same and other varieties of the crop.

**Season**

- June - July and December - January.

**Spacing**

- 25 x 15 cm.

**Pre-sowing seed hardening**

- Harden the graded seeds by soaking in 0.5 % $CaCl_2$ (50 % seed volume) for 6 h. After 6 h soaking, incubate the seeds in between moist gunny bags for 12 -18 h. Observe the sprouting of radicle periodically at 2 h interval after 12 h of incubation.
- Separate the seeds with sprouted radicle (just visible expression of radicle) and dry under shade.

**Fertilizer requirement**

- Apply NPK @ 25:50:75 kg / ha as blanket.

- Apply borax as basal application @ 10 kg / ha in boron deficient soils.
- Apply gypsum @ 400 kg / ha at peg formation stage and at earthing.

**Foliar application**

- NAA@ 200 ppm at 60 days after sowing to arrest late formed flowers and increase the seed yield in groundnut.

**Pre-harvest spray to arrest *in situ* germination**

- Spray 1250 ppm MH (Maleic Hydrazide) at 60 days after sowing.

**Harvest**

- Harvest the pods as and when the colour of the inner side of the shell turns black and dry to 10 - 12 per cent moisture.

**Drying**

- Stake the plants as the pods are exposed outside for easy drying of pods.
- Dry the pods to 15 - 20 % moisture content under sun.

**Decortication**

- Dry the pods to 16 per cent moisture content and decorticate either manually or using hand operated decorticator with proper adjustment.
- Dry the kernels to 7 to 8 per cent moisture.
- Practice pod verification based on varietal characteristic before grading to remove genetically impure seeds.
- Remove all discoloured pods.
- Reject mechanically injured pods for seed purpose.

**Pre-storage seed treatment**

- Treat the pods with carbendazim @ 2 g / kg at 6 - 7 % moisture content.

**Seed storage**

- Store the pods in gunny bags with calcium chloride @ 250 g / 30 kg of pods.
- Store the seeds in gunny for short term storage (8 - 9 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 6 - 8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 5 %.

# (ii) SESAME (*Sesamum indicum*)

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 20 | 25 - 35 | 450 - 500 | up to 1600 |

Tropical crop. It needs fairly high temperature for good growth. Can with stand drought, survive well with winter dew. Short day plant.

## CROP IMPROVEMENT

## I. SEASON AND VARIETIES

| Zone/ District/Season | Sowing Month | Varieties |
|---|---|---|
| **I. Western Zone (Irrigated)** | | |
| **Coimbatore, Thiruppur, Erode** | | |
| Masipattam | Feb- March | VRI (Sv) 2, TMV 7, VRI 3 |
| **Western Zone (Rainfed)** | | |
| **Coimbatore,Thiruppur, Erode, Dindigul** | | |
| Anippattam | June- July | TMV 7 |
| **Theni** | | |
| Karthigai | Nov- Dec | VRI(Sv) 2, TMV 7 |
| **II. Southern Zone (Irrigated)** | | |
| **Thirunelveli, Karur** | | |
| Chithiraipattam | Apr- May | VRI (Sv) 2, TMV 7 |
| **Pudukkottai** | | |
| Margazhi | Dec- Jan | VRI (Sv) 2, TMV 7, VRI 3 |
| **Southern Zone (Rainfed)** | | |
| **Madurai** | | |
| Anipattam | June-July | TMV 7 |
| **Virudhunagar, Pudukkottai,** | | |
| Adippattam | July-Aug | TMV 7 |
| **Karur** | | |
| Purattasipattam | Sep- Oct | VRI(Sv) 2, TMV 7 |
| **Ramanathapuram, Sivagangai, Thirunelveli, Thoothukudi** | | |
| Karthigaipattam | Nov- Dec | VRI(Sv) 2, TMV 7 |
| **III. North Eastern Zone (Irrigated)** | | |
| **Kancheepuram, Cuddalore, Vellore** | | |
| Margazhipattam | Dec- Jan | VRI (Sv) 2, TMV 7, VRI 3 |
| **Thiruvannamalai** | | |
| Masipattam | Feb- March | VRI (Sv) 2, TMV 7, VRI 3 |
| **Villupuram** | | |
| Chithiraipattam | Apr- May | VRI (Sv) 2, TMV 7 |
| **Thiruvallur** | | |
| Anipattam | June-July | TMV 7 |
| **North Eastern Zone (Rainfed)** | | |

| | | |
|---|---|---|
| **Vellore, Thiruvannamalai** | | |
| Anippattam | June-July | TMV 7 |
| **Kancheepuram, Cuddalore** | | |
| Adippattam | July-Aug | TMV 7 |
| **Thiruvallur** | | |
| Purattasipattam | Sep- Oct | VRI (Sv) 2, TMV 7 |
| **Villupuram** | | |
| Karthigaipattam | Nov- Dec | VRI (Sv) 2, TMV 7 |
| **IV. North Western Zone (Irrigated)** | | |
| **Namakkal** | | |
| Margazhipattam | Dec- Jan | VRI (Sv) 2, TMV 7, VRI 3 |
| **Salem, Perambalur, Ariyalur** | | |
| Masipattam | Feb- March | VRI (Sv) 2, TMV 7, VRI 3 |
| **North Western Zone (Rainfed)** | | |
| **Salem,Namakkal, Dharmapuri, Krishnagiri** | | |
| Anippattam | June-July | TMV 7 |
| **Perambalur, Ariyalur** | | |
| Adippattam | July-Aug | TMV 7 |
| **V. Delta Zone (Irrigated)** | | |
| **Thanjavur, Thiruchirapalli** | | |
| Masipattam | Feb- March | VRI (Sv) 2, TMV 7, VRI 3 |
| **Thiruvarur** | | |
| Chithiraipattam | Apr- May | VRI (Sv) 2, TMV 7 |
| **Delta Zone (Rainfed)** | | |
| **Thanjavur, Thiruvarur, Nagapattinam** | | |
| Thaippattam | Jan- Feb | TMV 7 |
| **Thiruchirapalli** | | |
| Purattasipattam | Sep- Oct | VRI (Sv) 2, TMV 7 |

Suitable Varieties for Irrigated **:** VRI 2, VRI 3, TMV 4, TMV 6, TMV 7
Suitable Varieties for Rainfed :TMV 6, TMV 7
Suitable Varieties for Rice fallow :VRI 1

## II Description of sesame varieties

| Particulars | VRI(Sv) 2 | TMV 7 | VRI 3 |
|---|---|---|---|
| Year of Release | 2005 | 2009 | 2017 |
| Year of Notification | SO.599(E)/ 25.04.2006 | SO.2137(E)/ 31.08.2010 | SO.1379(E)/ 27.03.2018 |
| Parentage | Derivative of VS 9003 X TMV 6 | Derivative of SI 250 X ES 22 | Derivative of SVPR 1 x TKG 87 |
| Duration (days) | 80-85 | 80-85 | 75-80 |
| Average Yield (kg/ha) | | | |
| Rainfed | 650-700 | 850 | - |

| | | | |
|---|---|---|---|
| Irrigated | 700-750 | 920 | 995 (Margazhipattam) 1055 (Masi pattam) |
| Oil content % | 51.9 | 50 | 50 |
| Habit | Profuse branching | Erect, indeterminate, with Profuse | Erect, indeterminate with Profuse branching |
| Capsules | 4 loculed | 4 loculed | 4 loculed |
| Seeds | Reddish brown | Brown | white |

## CROP MANAGEMENT

## 1. FIELD PREPARATION

a) Plough the field with tractor twice or with mould board plough thrice or five times with a country plough.

b) Break the clods in between ploughings and bring the soil to a fine tilth to facilitate quick germination as the seeds are small.

c) Chiselling for soils with hard pan: Chisel the soils having hard pan formation at shallow depth with chisel plough first at 0.5 m interval in one direction and then in the direction perpendicular to the previous one once in three years. Apply 12.5t FYM/composted coir pith besides chiselling.

d) For irrigated gingelly, form beds of size 10 $m^2$ or 20 $m^2$ depending upon the availability, inflow of water and slope of the land. Level the beds perfectly without any depressions to prevent water stagnation, which will affect the germination adversely.

e) In rice fallows, field is ploughed once with optimum moisture, seeds are sown immediately and covered with one more ploughing.

## 2. APPLICATION OF FERTILIZERS

i) Spread FYM or composted coir pith or compost @ 12.5 t/ha evenly on the unploughed field and plough it in.

ii) If the manure is not applied before commencement of ploughing, spread 12.5 t/ha of FYM or compost evenly on the field before the last ploughing and incorporate in the soil.

iii) If soil tests are not available, follow the blanket recommendations. **Rainfed:** Apply 23:13:13 kg NPK/ha or 17:13:13 kg NPK/ ha + 3 packets of Azospirillum (600 g/ha) and 3 packets (600 g/ha) of Phosphobacteria or 6 packets of Azophos (1200 g/ha). **Irrigated:** Apply 35:23:23 kg NPK/ha or 21:23:23 kg NPK/ha + 3 packets of Azospirillum (600 g/ha) and 3 packets (600 g/ha) of Phosphobacteria or 6 packets of Azophos (1200 g/ha)

Soil : Black alluvium (Adanur series) $FN = 13.7 T - 0.46 SN$

Target : 1.00 - 1.25t $ha^{-1}$ $FP_2O_5 = 6.3T - 1.79 SP$

$FK_2O = 12.8T - 0.47 SK$

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 1.00t $ha^{-1}$ | | | Yield target – 1.25 t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 180 | 12 | 180 | 23 | 22 | 13 | 53** | 35** | 35** |
| 200 | 14 | 200 | 18* | 12* | 12* | 24 | 22 | 26 |
| 220 | 16 | 220 | 18* | 12* | 12* | 18* | 18 | 17 |
| 240 | 18 | 240 | 18* | 12* | 12* | 18* | 15 | 12* |
| 260 | 20 | 260 | 18* | 12* | 12* | 18* | 12* | 12* |

* Maintenance dose **Maximum dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure inkg $ha^{-1}$. Open furrows to a depth of 5 cm and 30 cm apart and place the fertilizer mixture along the furrows and cover to a depth of 3 cm with soil before sowing.

iv) If furrow application is not done, broadcast the fertilizer mixture evenly on the beds before sowing.

v) Apply TNAU MN mixture @ 7.5 kg/ha as enriched FYM for rainfed sesame and TNAU MN mixture @ 12.5 kg/ha as enriched FYM for irrigated sesame. (Prepare enriched FYM at 1:10 ratio of MN mixture and FYM; mix at friable moisture and incubate for one month in shade)

**3. APPLICATION OF AZOSPIRILLUM**

a) Treat one hectare of seeds with 600 g of *Azospirillum* and 600g of phosphobacteria (or) 600g of Azophos. Apply 2 kg of *Azospirillum* and 2 kg of phosphobacteria (or) 2 kg of Azophos with 25 kg of FYM and 25 kg of sand, mix uniformly before sowing as soil application.

b) Liquid formulation Treat one hectare of seeds with 125 ml of *Azospirillum* and 125 ml of Phosphobacteria, shade dry it for 30 minutes before sowing.

**4. NUTRITIONAL DISORDERS**

a) **Manganese deficiency** : Leaves develop interveinal chlorosis, chlorotic tissue, later develop light brown or husk coloured necrotic lesions. Mix 10 kg $MnSO_4$ /ha with 45 kg of soil and broadcost evely in the beds after sowing.

b) **Zinc deficiency**: Middle leaves develop chlorosis in the interveinal areas and necrosis along the apical leaf margins. Apply 25 kg Zinc sulphate with 45 kg of soil and broadcast evenly in the beds after sowing.

*Note: Do not incorporate the micronutrient in the soil.*

5. **SEED RATE**

Adopt a seed rate of 5 kg/ha.

6. **SPACING**

a) Give a spacing of 30 cm between rows and 30 cm between plants. b) For rice fallows, seeds are broadcasted and thinned to maintain 11 plants/$m^2$

7. **QUALITY OF SEEDS**

Select mature, good quality seeds free from pest and fungal damage.

8. **SEED TREATMENT**

Treat the seed with *Trichoderma*@ 4g/kg. This can be done just before sowing. SUCH SEEDS SHOULD NOT BE TREATED WITH FUNGICIDES or treat the seed with Thiram 4 g or Carbendazim at 2 g/kg of seeds before sowing.

9. **SOWING**

a) Sow the seeds preferably in lines.
b) Mix the seeds with four times its volume of dry sand and drop the mixture evenly along the furrows in which fertilizers are applied.
c) Sow the seeds to a depth of 3 cm and cover with soil.
d) The optimum time of sowing for VRI (SV) 1 sesame is second fortnight of February to first fortnight of March under summer irrigated conditions.

10. **WATER MANAGEMENT**

i) Irrigate at sowing and give life irrigation 7 days after sowing depending on the soil and climatic condition and allow excess water to percolate.
ii) Give one pre-flowering irrigation (25 days): One at flowering and one or two at pod setting. An irrigation at flowering period is critical.

*NOTE: The critical stage for moisture requirement is the flowering phase i.e, between 35th to 45th days of sowing. During the maturity phase, moisture status should be low. If more water is given during this phase, maturity of seeds is affected and filling up of the capsules will be poor. Therefore, stop irrigation after 65 days of sowing.*

11. **THINNING**

Thin out the seedlings to a spacing of 15 cm between the plants on the 15th day of sowing and 30 cm on 30th day of sowing. This operation is very important for the crop in order to induce basal branches.

12. **WEED MANAGEMENT**

i. Apply, PE application of Pendimethalin 1.0 litre /ha followed by one hand weeding on 25$^{th}$ DAS

13. **HARVESTING**

a) **Decide when to harvest**

i. Observe the crop, considering the average duration of the crop.
ii. Twenty five per cent of the leaves from the bottom are shed and the top leaves

loose their colour and turn yellow at maturity.

iii. The colour of the stem turns yellow.
iv. The colour of the capsules turn yellow upto the middle.
v. Harvest before the bottom capsules turn brown.
vi. Examine the 10th capsule from the bottom by opening. If the seeds attained the full color of the variety harvest may be taken up.
vii. If harvest is delayed/ the capsules will dehisce resulting in yield reduction.

**b) Harvest**

i. Pull out the plants from the bottom.
ii. Stack in the open, one over the other in a circle with the stems pointing out and the top portion pointing inside.
iii. Cover the top with straw, so that humidity and temperature increases.
iv. Cure like this for 3 days, shake the plants. About 75 per cent of the seeds will fall off.
v. Dry the plants for one more day and again shake the plants. All the mature seeds will fall off.
vi. Winnow the seeds and dry in the sun for 3 days. Stir once in 3 hours to give uniform drying.
vii. Collect the seeds and store in gunnies.

## CROP PROTECTION

## A. Pest management

**Economic threshold level for important pests**

| Pest | ETL |
|---|---|
| Shoot & capsule borer | 10 larvae/ $m^2$ in the vegetative stage and 2 larvae / $m^2$ in the reproductive stage |

**Pest Management strategies**

| | |
|---|---|
| Shoot & capsule borer**,** *Antigastra catalaunalis* | **Spray any one of the following**<br>Neem seed kernels extract 5%<br>Neem oil 2%<br>Spray Quinalphos 25 EC 2000 ml/ha |
| **Pod borer,** *Elasmolomus (= Aphanus) sordidus*<br>**Gall fly,** *Asphondylia ricini*<br>**Whitefly,** *Bemisia tabaci***,** *A. dispersus* | **Spray any one of the following neem based insecticide**<br>NSKE 5%<br>Neem oil 2% |
| **Leafhopper,** *Emposca devastans* | **Spray any one of the following**<br>NSKE 5%<br>Neem oil 2%<br>Methyl demeton 25 EC 1200 ml/ha<br>Quinalphos 25 EC 2000 ml/ha |
| **Storage pests**<br>*Tribolium castaneum*<br>*Corcyra cephalonica* | Mix one kg of activated clay with 100 kg of seeds after adequate drying of seeds |

## DISEASE MANAGEMENT

| Disease | Recommendations |
|---|---|
| **Powdery mildew:** *Erysiphe cichoracearum* | Apply sulphur dust @ 25 kg/ha or spray 0.2% wettable sulphur |
| **Alternaria blight:** *Alternaria sesami* | Spray mancozeb @ 1000 g/ha |
| **Cercospora leaf spot:** *Cercospora sesami* | Spray mancozeb @ 1000 g/ha |
| **Root rot:** *Macrophomina phaseolina* *(Rhizoctonia bataticola)* | • Soil application of *P. fluorescens* or *T. asperellum* @ 2.5 kg / ha with 50 kg of well decomposed FYM or sand at 30 days after sowing.<br>• Spot drench with carbendazim @ 1 g/ l |
| **Phyllody:** Phytoplasma (Vector: *Orosius albicinctus*) | • Remove and destroy infected plants.<br>• To control vector, spray NSKE @ 5% or neem oil @ 2% or methyl demeton 25 EC @ 1200 ml/ha or quinalphos 25 EC @ 2000 ml/ha or dimethoate 30 EC 500 ml/ha combined with intercropping of sesamum + redgram (6 : 1) |

## SESAME - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified quality seed production, leave a distance of 200 m all around the field from the same and other varieties of the crop.

**Pre- sowing seed treatment**

Pellet the seeds with neem leaf powder @ 760 g + 120 g Azotobacter + 120 g phosphobacteria for 1 kg seed to enhance the productivity.

**Fertilizer**

- Apply NPK @ 50:25:25 kg / ha and Manganese sulphate @ 5 kg / ha as basal application.

**Foliar application**

- Spray 1 % DAP at the time of first flowering and 10 days after the first spray.

**Harvest**

- Harvest the crop when 75 - 80 % of the pods started yellowing and bottom 1 or 2 pods have dehisced. At this stage, the pod moisture content will be 50 - 60 % and seed moisture content will be 25 - 30 % and the seeds will be chocolate brown colour.
- Stake the plants in inverted position and cure them for 3 - 4 days.

**Threshing**

- Beat the staked plants with pliable bamboo stick for removal of seeds.

**Seed grading**

- Grade the seeds with 4 / 64” round perforated sieve.

**Drying**

- Dry the seeds to 7- 8 % moisture content.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg along with carbaryl 200 mg / kg of seed.
- Treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara)* leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 6 - 7 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with seed moisture content less than 5 %.

# (iii) CASTOR (*Ricinus communis*)

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 38 – 40 | 10 - 15 | 20 - 25 | 350 - 600 | up to 2500 |

Tropical and requires moderately high temperature 20 to 27°C with low humidity throughout the growing season. It grows best in areas where there are clear warm sunny days. Prolonged cloudy weather with high temperature at the time of flowering resulted in poor seed setting, which is known as sex reversion. High temperature above 41°C at flowering time even for as short period results in blasting of flowers. Very resistant to drought but evenly distributed rainfall is required. Heavy rainfall at flowering reduces the yield. Very susceptible to frost but grow even an altitudes of 1200 to 2100 m, if sown in March- April, perennial varieties are grown at still higher altitude for shade in coffee estates.

## CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| DISTRICT/SEASON | VARIETIES | | |
|---|---|---|---|
| **A. Rainfed** | | | |
| **1. Adipattam (Jun-July)** | | | |
| All districts | Variety | : | TMV 5, TMV 6 |
| | Hybrid | : | YRCH 1, YRCH 2 |
| **B. Irrigated** | | | |
| **1. Vaigasi pattam (May - June)** | | | |
| All districts | Hybrid | : | YRCH 1, YRCH 2 |
| **2. Karthigaipattam (Nov - Dec)** | | | |
| All districts | Hybrid | : | YRCH 1, YRCH 2 |
| **3. Panguni pattam (March- Apr)** | | | |
| All districts | Hybrid | : | YRCH 1, YRCH 2 |
| **C. Gardenland (border)** | | | |
| **1. Perennial** | | | |
| All districts | Variety | : | YTP 1 |

## DESCRIPTION OF CASTOR VARIETIES

| Particulars | CO 1 | TMV 5 | TMV 6 | Hybrid | Hybrid | Variety |
|---|---|---|---|---|---|---|
| | | | | YRCH 1 | YRCH 2 | YTP 1 |
| Year of Release | | 1984 | 1997 | 2009 | 2017 | 2019 |
| Year of Notification | | SO.832(E)/ 18.11.1985 | SO.647(E)/ 09.09.1997 | SO.2137(E)/ 31.08.2010 | SO.399(E)/ 24.01.2018 | |
| Parentage | Pureline selection from Anamalai | Derivative of SA 2 X S248/2 | Derivative of VP 1 X RC 962 | DPC 9 X TMV5 | M 619-1 X SKI 215 | Cross Derivative of TMV 6 x Salem Local |
| Duration (days) | perennial | 120 | 160 | 150-160 | 170-180 | 115-120 |
| Yield (kg/ha) | | | | | | |
| Rainfed (mixed crop) | - | | 500 | | | |
| Rainfed | 2.5 | 850 | 950 | 2000 | 2300 | 1456 kg/ha |
| (pure crop) | kg/tree/y ear | | | | | |
| Irrigated (pure crop) | - | - | - | 3000 | 3500 | 3kg/plant/ year |
| Oil content (%) | 57 | 50 | 51.9 | 49 | 49 | 49 |
| Special features | | | | | | Suitable for perennial system. |
| Stem colour | Pinkish green | Rose | Red | Light red | Red | Red |
| Bloom | No bloom | Triple | Double | Triple | Triple | Triple |
| (waxy coat) | | | | | | |
| Receme/ | Bold, sparse | Spiny, non | Medium, | Spiny, non | Semi spiny, non | Long, Conical, Semi compact |
| capsule | setting, non | dehiscent, | lengthy , | dehiscent, | dehiscent, | Bold, dehiscent, |
| | dehiscent | resistant to | spiny | resistant to leaf | resistant to capsule borer, leaf hopper, | resistant to capsule borer, leaf hopper, |
| | | leaf hopper | capsule | hopper | Semilooper, spodoptera | |
| Suitability | Pure and mixed crop | Pure and mixed crop | Pure and mixed crop | Pure and mixed crop | Pure and mixed crop | Pernennial Pure Border crop & mixed crop |

| | | | | | | |
|---|---|---|---|---|---|---|
| Other features | - | - | - | - | Resistant to wilt, high basal branching and proportion of female flowers more than 95 percent. Resistant to lodging, fertilizer responsive and suitable for rainfed situation and areas of limited irrigation. | Resistant to Semilooper , *Spodoptera*, Thrips and Capsule borer |

## CROP MANAGEMENT

### 1. PREPARATION OF THE FIELD

Plough two-three times with country or mould board plough.

### 2. APPLICATION OF FERTILIZERS

Spread 12.5 t/ha of FYM or compost evenly on the main field before last ploughing and incorporate in to soil by working a country plough. Apply 30 kg sulphur/ ha through gypsum at the time of last ploughing for higher castor yield.

NOTE: Do not leave FYM or compost exposed to sunlight as nutrients will be lost.

### 3. SEED RATE

Adopt a seed rate of 10 kg/ha for varieties and 5 kg/ha for hybrids.

### 4. SPACING

Adopt the following spacing.

| | Rainfed situation | Irrgiation situation |
|---|---|---|
| Varieties | 90 cm x 60 cm | 90 cm x 90 cm |
| YTP 1 | 3mx3m | 3mx3m |
| Hybrids | | |
| YRCH 1 | 120 cm x 90 cm | 150 cm x 120 cm |
| YRCH2 | 180 cm x 150 cm | 180 cm x 150 cm |

Under, irrigated conditions, for clay soils wider spacing of 150 cm x 150 cm for YRCH 1 can also be adopted.

For TMV 5 short duration variety 60 x 30 cm may be adopted.

### 5. APPLICATION OF FERTILIZERS

Apply NPK fertilizers basally as per soil test recommendations as far as possible. If soil test recommendations are not available, follow the blanket recommendation as follows

| **Rainfed conditions** | **Recommended NPK kg/ ha** |
|---|---|
| Varieties | 45 : 15 : 15 NPK kg / ha |
| Hybrids – YRCH 1 | 60 : 30 : 30 NPK kg / ha |
| YRCH 2 | 70 : 35 : 35 NPK kg / ha |
| **Irrigated condition** | |
| Varieties | 60 : 30 : 30 NPK kg / ha |
| Hybrids - YRCH1 | 90 : 45 : 45 NPK kg / ha |
| YRCH 2 | 135 : 65 : 65 NPK kg / ha |

YRCH 1: In rainfed situations apply 100% P & 50% N&K basally & remaining quantity may be applied in one or two top dressings based on the soil moisture availability.
YRCH 2: In rainfed situations, apply 35 kg P & 37.5 kg N & 17.5 kg K basally and remaining quantity of 37.5 kg N & 17.5 kg K may be applied in one or two top dressings based on the soil moisture availability.

YRCH 1: In irrigated situations, apply 100% P & 50% N&K as basal & remaining quantity N&K may be applied in two equal splits at $30^{th}$ & $60^{th}$ DAS.
YRCH 2: under irrigated condition, apply 65 kg P & 67.5 kg N & 32.5 kg K as basal and remaining quantity of 67.5 kg N & 32.5 kg K may be applied in two equal splits at 30 $^{th}$ & 60 $^{th}$ day after sowing (DAS).

Apply 12.5 kg $ZnSO_4$ $ha^{-1}$ (If the soil available Zn is < 1.2 ppm) and 25 kg $FeSO_4$ $ha^{-1}$ (if the soil available Fe is < 3.7 ppm for non calcareous soil and < 6.3 ppm for calcareous soil). If soil test values are not available.

| **Rainfed conditions** | **Recommended TNAU MN mixture kg/ha** |
|---|---|
| Varieties | 7.5 |
| Hybrids | 10.0 |
| **Irrigated conditions** | |
| Varieties | 12.5 |
| Hybrids | 15.0 |

(Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture &incubate for one month in shade).

**6. PRE TREATMENT OF SEEDS**

a) Treat the seeds with Thiram or carbendazim @ 2g / kg of seeds or with *Trichoderma viride* @ 4g/kg of seeds. Treat the seed 24 hours prior to sowing. Soaking the seeds with water for 10 hours enhances the germination.

b) In rainfed situations, seed priming with 1% KCl for 3 hours and sowing a week before onset of monsoon is recommended.

**7. SOWING**

a) Sow the seeds adopting the recommended spacing. b) Place the seeds at depth 4 - 6 cm. c) Put two seeds in each hole and retain only one healthy seedling by thinning out of weaker seedling/pistillate plant at 20 DAS.

**Selective mechanization**

Selective mechanization in castor *viz*., sowing with tractor drawn seed drill with a spacing of 120 cm x 90 cm, inter cultivation with power weeder on 20 and 40 DAS, need based plant protection with boom sprayer, harvesting by secateurs and threshing and shelling by castor thresher increased the kernel yield and net return & benefit cost ratio

**8. GAP FILLING**

Gap fill on the 15$^{th}$ day of sowing and simultaneously thinning may be done leaving one healthy plant.

**9. WEED MANAGEMENT**

Apply pre emergence herbicide Pendimethalin @ 1 litre/ha or Fluchloralin @ 1 litre/ha on 3 DAS followed by hand weeding twice on 20$^{th}$ & 40$^{th}$ DAS.

**10. CASTOR PGR CONSORTIA (CASTOR GOLD)**

Foliar application of plant growth regulator consortia @ 0.05 % (0.5 ml/litre of water) on 25 and 60 days after sowing for increasing pistillate flower production, seed setting per cent and seed yield.

**11. NIPPING**

For perennial castor variety YTP 1, nipping of primary shoot at 10$^{th}$ internode using secateurs is recommended for tripling the productive branches.

**12. INTERCROPPING**

Raise one row of castor for every six rows of groundnut. In the case of late receipt of monsoon blackgram + castor at 6:1 ratio is recommended. Or Intercropping of castor with Blackgram or Greengram in 1:2 ratio is recommended for rainfed situation.

Intercropping of castor with small onion in 1:2 ratio by adopting 1.5 m x 1.0 m spacing is recommended for irrigated situation.

For hilly areas of Tamil Nadu *viz*., Kalrayan hills, Javadhu hills and Yelagiri hills, Samai (10kg/ha) + Castor 1.0 kg/ha) @ 10:1 ratio-line sowing (25cm x10 cm) with 50 % organic (FYM @ 8.0t/ha) and 50 % inorganic nutrient (22:11 kg N & P/ha) is recommended for realizing maximum profit.

**13. HARVESTING THE CROP**

Observe the crop considering the average duration of the variety. i) One or more capsules show sign of drying. ii) Cut the matured racemes without damaging the secondaries. iii) Dry the capsule in the sun without heaping it in the shade. iv) Use castor sheller to separate the seeds or beat the dried capsule with wooden planks, winnow and collect the seeds.

For YRCH 1, first harvest has to be done on 90 DAS, subsequently second and third harvest is to be carried out on 120 and 150 DAS, respectively.

For YRCH 2, first harvest has to be done on 110 DAS followed by second and third harvest is to be taken on 140 and 170 DAS, respectively.

The harvested spike should be sun dried and dried capsules can be shelled in the sheller.

**CROP PROTECTION**

| **CROP PROTECTION**<br>**A. Pest Management** | |
|---|---|
| **Pests** | **Management strategies** |
| **Defoliators:**<br>**Semiloopers**<br>*Achaea janata*<br>*Paralellia algira* | • Encourage the activity of the larval parasitoid, *Microplitis maculipennis*<br>• Spray Azadirachtin 0.03% 1000 ml<br>• Spray any one of the following insecticides at fifteen days interval<br>Chlorpyrifos 20EC @ 1250 ml/ha<br>Profenophos 50 EC @ 500ml/ha<br>Thiodicarb 75 WP @ 500g/ha<br>Acephate 75SP @ 780 g/ha<br>Flubendiamide 39.35 SC @ 100ml/ha<br>Chlorantraniliprole 18.5 SC @ 150ml/ha |
| **Tobacco caterpillar**<br>*Spodoptera litura* | • Use of light trap to monitor and kill the attracted adult moths<br>• Set up the sex pheromone trap @ 12/ha to monitor the activity of the adults and to synchronize the pesticide application<br>• Mechanical collection and destruction of egg masses and early stage larvae found in clusters which can be located easily even from a distance.<br>• Hand picking and destruction of grownup of grown up caterpillars.<br>• Spray NSKE 5 % or Azadirachtin 1 % EC (10000 ppm) 2 ml/ lit. or apply *Bacillus thuringiensis* 2g/lit. during evening hours.<br>• Spraying nuclear polyhedrosis virus at 1.5 x $10^{12}$ POB per ha and virus in the evening<br>• Apply Poison bait in the soil helps in killing the grown up larvae hide in soil during day time. Poison bait ( 1 kg carbaryl+10 kg rice bran+ 1 kg jiggery+ 1 litre of water to make the bait in to pellets for one hectare)<br>• Spray any one of the following insecticides at fifteen days interval. Spraying of insecticides should be done either in the early morning or in the evening<br>Chlorpyrifos 20EC @ 1250 ml/ha |

| | |
|---|---|
| | Profenophos 50 EC @ 1000 ml/ha<br>Thiodicarb 75 WP @ 500g /ha<br>Acephate 75SP @ 780 g/ha<br>Flubendiamide 39.35 SC @ 100ml/ha<br>Chlorantraniliprole 18.5 SC @ 150ml/ha |

| | |
|---|---|
| **Other defoliators**<br>**Hairy caterpillars**<br>*Euproctis fraternal*<br>*Porthesia scintillans*<br>**Slug caterpillar**<br>*Parasa lepida*<br>**Woolly bear**<br>*Pericallia ricini*<br>**Spiny caterpillar**<br>*Ergolis merione*<br>**Tussock caterpillar**<br>*Orgyia postica* | • Spray Azadirachtin 0.03% 1000 ml<br>• Spray *Bacillus thuringiensis* var *kurstaki* 5%WP 1000-1250 g/ha<br>• Spray any one of the following insecticides<br>Profenofos 50EC@ 500ml/ha<br>Chlorpyrifos 20EC @ 1250 ml/ha<br>Flubendiamide 39.35 SC @ 100ml/ha<br>Chlorantraniliprole 18.5 SC @ 150ml/ha |
| **Serpentine leaf miner**<br>*Liriomyza trifolii* | • Spray any one of the following plant products<br>Neem seed kernel extract 5%<br>Neem oil 3 %<br>• Spray any one of the following insecticides at fifteen days interval<br>Chlorpyrifos 20EC @ 1250 ml/ha<br>Malathion 50 EC @ 1000 ml/ha |
| **Sucking pests**<br>**Green leaf hopper**<br>*Empoasca flavescens* | • Spray any one of the following insecticides at fifteen days interval<br>Dimethoate 30EC @ 825 ml/ha<br>Acetamiprid 20SP @ 100 g/ha<br>Thiamethoxam 25WG @ 200 g/ha<br>Clothianidin 50WDG @ 50 g/ha |
| **White fly**<br>*Trialeurodes ricini* | • Monitor the activities of the adult white flies by setting up yellow pan traps and sticky traps smeared with grease or sticky oil @ 25 / acre at 1 foot height above the plant canopy<br>• Collection and removal of white fly infested leaves those which were shed due to severe attack<br>• Spray any one of the following plant products<br>Neem seed kernel extract 5%<br>Neem oil 3 %<br>• Spray Fish oil rosin soap 25g / lit of water<br>• Spray any one of the following insecticides at fifteen days interval<br>Imidacloprid 17.8 SL 125 ml/ha<br>Dimethoate 30 EC @ 825 ml/ha<br>Acetamiprid 20%SP 100g /ha |

| | |
|---|---|
| | Thiamethoxam 25WG @ 200 g/ha<br>Profenophos 50%EC 1000 ml/ha<br>Thiacloprid 21.7%SC 600ml/ha |
| **Flower thrips**<br>*Retithrips siriacus*<br>*Scirtothrips dorsalis* | • Spray any one of the following insecticides at fifteen days interval<br>Imidacloprid 17.8 SL 125 ml/ha<br>Dimethoate 30 EC @ 825 ml/ha |
| **Shoot and Capsule borer**<br>*Conogethus punctiferalis* | • Spray Neem oil 3% twice at 15 days interval during flowering stage to prevent the adults to lay eggs<br>• Spray any one of the following insecticides from flowering at fifteen days interval<br>Profenofos 50EC@500ml/ha<br>Malathion 50 EC @ 1000ml/ha<br>Indoxacarb 15.8EC @ 500ml/ha<br>Spinosad 45SC@75 ml/ha<br>Thiodicarb 75WP@ 500g/ha |

**B.Disease Management**

| Disease | Recommendations |
|---|---|
| **Grey mold: *Botrytis ricini*** | • Remove and destroy the infected spikes<br>• During cloudy weather and rainy season, give prophylactic spray with carbendazim @ 2 g/l twice at 15 days interval or prophylactic spray of *P. fluorescens* @ 2g/l and second spray after a fortnight. |
| ***Fusarium* Wilt** | • Seed treatment with carbendazim @ 2gram/ kg of seed<br>• Soil drenching with carbendazim @ 2gram / litre of water. |

## CASTOR – VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified quality seed production, leave a distance of 300 m all around the field from the other varieties / hybrids of the crop.

**Season**

- June - July and September - October.

**Pre-sowing seed treatment**

- Seed hardening with 2 % $KH_2PO_4$ for 16 h (seed to solution ratio 1:1) and dry back to original moisture content.

**Fertilizer requirement**

- Apply NPK @ 90:70:70 kg / ha as basal.

**Spacing**

- 90 x 30 cm.

**Harvesting**

- Harvest the crop as once over harvest when 80 % of the capsules turn into brown colour.

**Threshing**

- Thresh the capsules either using power operated thresher or manually by trampling or beating with pliable bamboo stick.

**Seed grading**

- Grade the seeds at 10 % moisture content using 18 / 64" round perforated sieve.
- Discard the broken and immature seeds for seed purpose.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed.
- Treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 7 - 8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 5 %.

## CASTOR - HYBRID SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified quality seed production, leave a distance of 300 m all around the field from the other varieties / hybrids of the crop.

**Planting ratio**

- Sow the female and male parents in the ratio of 3:1 or 4:1 for certified seed production.

**Border rows**

- Sow four rows of male parents in around the field for the availability of adequate pollen.

**Season**

- Sow the female line during first fortnight of September for production of more pistillate inflorescence and male line one week later.

**Fertilizer requirement**

- Apply NPK @ 90:70:70 kg / ha as basal application.

**Spacing**

- 90 X 30 cm.

**Harvesting**

- Harvest the racemes as once over harvest when 80 % of the capsules turn to brown colour.
- The seeds from secondary raceme are better than primary and others.

**Threshing**

- Shell the seeds either using power operated thresher or manually by beating with pliable bamboo stick.
- Avoid hand operated thresher to reduce the mechanical damage.

**Seed grading**

- Grade the seeds using 18 / 64" round perforated sieve.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed.
- Treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1@ 3 g / kg of seed as eco-friendly treatment.
- Mix the seeds with dry sweet flag (or) vasambu (*Achorus calamus)* rhizome powder at the ratio of 1:100 for grain cum seed storage.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 7 - 8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than15 months) with a seed moisture content less than 5 %.
- The seeds of female parent are poor storer than male and hybrid.

# (iv) SUNFLOWER ( *Helianthus annuus* )

## CLIMATE REQUIREMENT

| T_Max$^oC$ | T_Min$^oC$ | Optimum $^oC$ | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 38 - 40 | 10 - 15 | 20 - 30 | 350 - 600 | up to2500 |

Tropical and subtropical climate. During vegetative phase, crop requires cold temperature. Higher temperature (> 38°C) during reproductive stage reduces the oil content. Day neutral plant. Crop gives highest yield of oil per hectare when grown below 1,500m MSL.Cannot tolerate drought and water logging.

## CROP IMPROVEMENT

## I. SEASON AND VARIETIES

| DISTRICT/SEASON | VARIETIES |
|---|---|
| **A. Rainfed** | |
| **1. Adipattam (Jun-July)** | |
| Coimbatore, Erode, Salem, Namakkal, | Variety : COSFV 5 |
| Tirunelveli, Dindigul, Dharmapuri, Tiruchirapalli, Perambalur, Karur | Hybrid : COH 3. |
| **2. Karthigaipattam(Oct- Nov)** Cuddalore, Villupuram, Virudhunagar, Sivagangai , Ramanathapuram, Madurai, Dindigul, Theni, Tiruchirapalli, Perambalur, Karur, Tirunelveli | Variety : COSFV 5<br>Hybrid : COH 3 |
| **B. Irrigated** | |
| **1. Adipattam (July-August)** Coimbatore, Erode, Salem, Namakkal,Tirunelveli, Dindigul, Dharmapuri, Tiruchirapalli, Perambalur, Karur | Variety : COSFV 5<br>Hybrid : COH 3 |
| **2. Karthigaipattam (Nov-Dec)** Cuddalore, Villupuram, Virudhunagar, Sivagangai , Ramanathapuram, Madurai, Dindigul,Theni, Tiruchirapalli, Perambalur, Karur, Tirunelveli | Variety : COSFV 5<br>Hybrid : COH 3 |
| **3. Margazhipattam (Dec-Jan)** Salem, Namakkal, Dharmapuri, Erode, Coimbatore, Madurai, Dindigul, Theni, Tirunelveli, Thoothukudi | Variety : COSFV 5<br>Hybrid : COH 3 |
| **4. Chithiraipattam (April - May)** Coimbatore, Erode, Dharmapuri, Salem, Namakkal, Tiruchirapalli, Perambalur, Karur | Variety : COSFV 5<br>Hybrid : COH 3 |

## I. DESCRIPTION OF SUNFLOWER VARIETIES

| Particulars | COSFV 5 | COH 3 |
|---|---|---|
| Year of Release | 2006 | 2017 |
| Year of Notification | SO.1178(E)/20.07.2007 | S.O. 6318(E) / 26.12.2018 |
| Parentage | Cross derivative of *Helianthus annus X H. preacox* | COSF 6A X IR 6 |
| Duration (days) | 85-90 | 90-95 |
| Yield (kg/ha) | | |
| Rainfed | 1500 | 2150 |
| Irrigated | 1700 | 2410 |
| Oil content (%) | 40-42 | 40- 42 |
| Ray floret | Yellow | Yellow |
| Plant height (cm) | 145-165 | 160-170 |
| Seed size & colour | Dark brown | Black |
| 1000 seed weight (g) | 48-50 | 52 |
| Volume weight (g/100ml) | 45-48 | 47 |

**CROP MANAGEMENT**

**1. FIELD PREPARATION**

Plough once with tractor or twice with iron-plough or three to four times with country-plough till all the clods are broken and a fine tilth is obtained.

**2. APPLICATION OF FERTILIZERS**

i) Spread 12.5 t/ha of FYM or compost or composted coir pith evenly on the field before the last ploughing and incorporate in the soil by working a country plough.
If soil test recommendations are not available, follow the blanket NPK/ha for both irrigated and rainfed crops.

| | Season | Blanket recommendation of Nutrients (kg/ha) | | |
|---|---|---|---|---|
| | | N | $P_2O_5$ | $K_2O$ |
| **Hybrids** | **IRRI** | 60 | 90 | 60 |
| | **RF** | *40* | *50* | *40* |
| **Varieties** | **IRRI** | 60 | 30 | 30 |
| | **RF** | *40* | *50* | *40* |

Soil test crop response based integrated plant nutrition system (STCR- IPNS recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (read reckoners are furnished for irrigated sunflower)

**Sunflower - Hybrid**

Soil : Mixed black calcareous (Perianaickenpalayam series)

Target : 2.0- 2.5 t $ha^{-1}$

FN =9.60T- 0.49SN-0.68 ON

$FP_2O_5$=4.20T -1.87SP-0.80 OP

$FK_2O$=9.24T-0.45SK-0.64 OK

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 2.0 t $ha^{-1}$ | | | Yield target – 2.5 t $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
| SN | SP | SK | FN | $FP_2O_5$ | $FK_2O$ | FN | $FP_2O_5$ | $FK_2O$ |
| 160 | 12 | 300 | 59 | 45* | 30* | 90** | 53 | 56 |
| 180 | 14 | 325 | 49 | 45* | 30* | 90** | 49 | 45 |
| 200 | 16 | 350 | 39 | 45* | 30* | 87 | 45* | 34 |
| 220 | 18 | 375 | 30* | 45* | 30* | 77 | 45* | 30* |
| 240 | 20 | 400 | 30* | 45* | 30* | 67 | 45* | 30* |

* Maintenance dose;** Maximum dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

iii) Biofertilizer : Soil application - Mix 10 packets (2000 g/ha) of Azospirillum and 10 packets(2000 g/ha) of Phosphobacteria or 20 packets of Azophos(4000 g/ha) with 25 kg FYM and 25 kg soil and apply before sowing.

### 3. APPLICATION OF MICRONUTRIENTS

a) Mix 12.5 kg/ha of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu with enough sand to make total quantity of 50 kg/ha. For **rainfed sunflower** apply TNAU MN mixture @ 7.5 kg ha $^{-1}$ as enriched FYM

b) variety and 10 kg $ha^{-1}$ as enriched FYM for hybrid and for ***Irrigated sunflower*** apply TNAU MN mixture @ 12.5 kg $ha^{-1}$ as enriched FYM for variety and 15 kg $ha^{-1}$ as enriched FYM for hybrid (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mixat friable moisture &incubate for one month in shade).

c) Apply the mixture over the furrows and top two thirds of the ridges before sowing.

d) Do not incorporate the mixture in the soil.

(i) To overcome manganese deficiency foliar spray of 0.5% $MnSO_4$ on 30,40 & $50^{th}$ day after sowing and

(ii) For zinc deficiency apply 25 kg $ZnSO_4$/ha as basal or 0.5% $ZnSO_4$. Spray on 30,40 & $50^{th}$ day after sowing.

(iii) For B and S deficient soils, apply 10 kg Borax or 0.2% boric acid twic and 40 kg S as Gypsum/ha.

### 4. FORMING RIDGES AND FURROWS

i. Form ridges and furrows with 60 cm spacing.

ii. Use bund-former or ridge plough to economise and

iii. Form irrigation channels across and ridges according to the topography of the field.

**5. SEED RATE**

| | Rainfed | Irrigated |
|---|---|---|
| Varieties | 7 kg/ha | 6 kg/ha |
| Hybrids | 5 kg/ha | 5 kg/ha |

**6. SEED TREATMENT**

Soaking seeds in 2% for 12 hrs and shade drying is recommended for rainfed $ZnSO_4$ sowing.

**7. SEED TREATMENT**

i) Treat the seed with *Trichoderma* @4g/kg. This can be done just before sowing. It is compatible with biofertilizers. Such seeds should not be treated with fungicides.
ii) Treat the seeds with Carbendazim or Thiram at 2 g/kg of seed.
iii) Treat the seeds 24 hours prior to sowing.
iv) Treat the seeds required for sowing 1 ha with 600 g of *Azospirillum* and 600g of phosphobacteria (or) 600g of Azophos using rice gruel as binder, shade dry the treated seeds for 30 min and sow immediately.
**Liquid formulation** Treat one hectare of seeds with 125 ml of *Azospirillum* and 125 ml of Phosphobacteria, shade dry it for 30 minutes before sowing
v) Moist hydration for 24 hours in moist gunny bags followed by drying and seed dressing with Thiram @ 2g/kg to enhance field emergence.
vi) Seeds dried to 8 - 9% moisture content, treated with Thiram @ 2g/kg and packed in polylined (300 guage) cloth bag can store upto 9 months with 70% germination.

**8. SOWING**

Spacing : Hybrids : 60 cm x 30cm
Varieties : 45 cm x 30cm

i) Place the seeds at a depth of 3 cm along the furrows in which the fertilizer mixture is placed. Put two seeds per hole

**9. THINNING**

Thin out seedlings leaving only one healthy and vigorous seedling in each hole on the $10^{th}$ day of sowing.

**10. WEED MANAGEMENT**

i) Apply Fluchloralin @ 1.0 lit/ha before sowing and incorporate or apply as pre-emergence spray on $3^{rd}$ day after sowing followed by irrigation or apply Pendimethalin @ 1.0 litre/ha as pre- emergence spray 3 days after sowing. The spray of these herbicides has to be accomplished with Knapsack sprayer fitted with flat fan nozzle using 500 lit water/ha as spray fluid.
All the herbicide application is to be followed by one late hand weeding 30 - 35 days after sowing.
After application of pre emergence herbicide, instead of hand weeding, power weeder can be used if sowing was done with the spacing of 75 x 25 cm.
ii) If pre emergence herbicide was not applied, hand weeding to be done on on $15^{th}$ and $30^{th}$ day after sowing and remove the weeds.

**11. WATER MANAGEMENT**

Irrigate immediately after sowing followed by an irrigation on 4 – 5$^{th}$ day and later at interval of 7 to 8 days according to soil and climatic conditions at seeding, flowering and seed development stage.

**12. FOLIAR SPRAY OF NAPHTHALENE ACETIC ACID (NAA)**

i) Foliar spray of Napthalene Acetic Acid (NAA) at 20 ppm concentration (280 g NAA in 625 litres of water per ha) on the 30th and 60th day of sowing.

ii) Use a high volume sprayer and give a thorough coverage of the entire plant.

iii) Do not use brackish water.

**13. SULPHUR FERTILIZATION**

Apply sulphur @ 20 kg/ha through ammonium sulphate or single super phosphate. Or apply gypsum@ 200kg/ha as basal

**14. BORIC ACID**

Foliar spray of boric acid @ 0.2 % (2g/l of water) to capitulum at ray floret opening stage to improve seed set and seed filling.

**15. IMPROVING SEED SET BY MECHANICAL MEANS**

a. During the mid flowering phase, improve pollination by :
   i. Mild rubbing of the capitulum with the hand covered with soft cloth or
   ii. Rubbing two flowers face to face gently.
   iii. The mid-flowering phase are: 58 to 60 days of planting for long duration varieties, 45 to 48 days of planting for short duration varieties
   iv. .Do this operation in the morning hours between 9.0 and 11.00 am when pollen shedding is high.

b. Keeping bee hives at the rate of 5/ha improves seed setting.

**16. JUDGE WHEN TO HARVEST**

Observe the bracts on the backside of the capitula. When they turn lemon yellow, the heads harden and the crop is ready for harvest.

Bird damage: Use of reflective ribbons scares the birds effectively and thus prevents loss of grain.

**17. HARVESTING**

i. Cut the capitula (flower heads) only

ii. Thresh and clean
   a. Immediately after harvest, dry the heads in the sun for 3 days.
   b. Spread the heads in thin layer and give turning once in 3 hours.

*NOTE: Do not heap or store the heads before drying properly as mould fungi will develop and spoil the grain quality.*

   c. Thresh using a mechanical thresher, or beat with a stick and separate the grains.
   d. Winnow and clean the seeds
   e. Dry the seeds again in the sun for another two days
   f. Store in gunny bags

## CROP PROTECTION

### A. Pest management

| | |
|---|---|
| **Weevil**<br>*Myllocerus* spp.<br>**Tobacco cutworm**<br>*Spodoptera litura*<br>**Gram podborer**<br>*Helicoverpa armigera* | ▪ Hand pick the *Helicoverpa* larvae and destroy.<br>▪ Spray Azadirachtin 5% W/W 0.5 ml/lit |
| **Leafhopper**<br>*Amrasca devastans* | ▪ Treat seed with imidacloprid 70 WS at 7 g/kg protection upto 7 weeks.<br>▪ Spray Imidacloprid 70 WS 490 ml/ha (or) Imidacloprid 17.8 SL 100 ml/ha |
| **Whitefly,** *B.tabaci, A.dispersus* | ▪ Spray Imidacloprid 70 WS 490 ml/ha (or) Imidacloprid 17.8 SL 100 ml/ha |
| **Thrips** | ▪ Spray Imidacloprid 17.8 SL 100 ml/ha |

### B. Disease management

| | |
|---|---|
| **Alternaria leaf spot:** *Alternaria helianthi* | • Spray mancozeb @ 1000 g/ha or<br>• Treat the seeds with carbendazim + mancozeb @ 3g/kg + propiconazole 0.1 % sprays at 30 and 45 days after sowing or<br>• Treat the seeds with *Pseudomonas fluorescens* @ 10 g/kg seeds along with foliar spray of hexaconazole or propiconazole @ 0.1% at 45 days after sowing and foliar spray of *P. fluorescens* at 60 days after sowing |
| **Rust:** *Puccinia helianthi* | Spray mancozeb @ 1000 g/ha |
| **Charcoal rot:** *Macrophomina phaseolina*<br>*(Rhizoctonia bataticola)* | • Soil application of *P. fluorescens* or *T. asperellum* @ 2.5 kg / ha with 50 kg of well decomposed FYM or sand at 30 days after sowing.<br>• Spot drenching with carbendazim @ 1 g/ l |
| **Powdery mildew:**<br>*Golovinomyces cichoracearum* | Two sprays of difenoconazole @ 0.05% at 40 and 60 DAS |
| **Head rot:** *Rhizopus* sp | Spray mancozeb @ 1000 g/ha in case of intermittent rainfall at the head stage, directing the spray to cover the capitulum. Repeat fungicidal application after 10 days, if humid weather continues |
| **Necrosis virus disease:** *Tobacco streak virus* (Ilarvirus)<br>(Vector: Thrips) | • Raise sorghum as border crop (one month prior to sunflower sowing).<br>• Seed treatment with imidacloprid @ 2 g/kg of seeds<br>• Spray imidacloprid 17.8 SL @ 100 ml/ha |

## SUNFLOWER - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production, leave a distance of 200 m all around the field from the same and other varieties / hybrids of sunflower.

**Spacing**

- 45 x 30 cm.

**Pre-sowing seed treatment**

- Seed soaking in 2 % $KNO_3$ for 6 hrs to release dormancy.
- Seed hardening with 2 % $KH_2PO_4$ for 16 h and dry back to original moisture content.
- Seed coating with polymer @ 3 g / kg + imidachloprid @ 2 ml / kg + carbendazim @ 2 g / kg + *Pseudomonas fluorescens* @ 10 g / kg.

**Fertilizer**

- Apply NPK @ 60:45:45 kg / ha as basal application.

**Foliar application**

- At the stage of capitulum opening, spray 0.2 % boric acid for increased seed set.

**Supplementary pollination**

- During flowering, rub the heads with muslin cloth or palm during 8 - 11 am on alternate days till the completion of flowering (7 - 10 days).
- Keep bee hives @ 5 nos. / ha to increase insect activity.

**Harvesting**

- Harvest the heads when the thalamus drooped and turned to lemon yellow in colour with black coloured seeds.
- Harvest the heads and dry immediately until the seed moisture content reduced to 15 - 16 %.
- Separate the seeds either with mechanical thresher or manually.

**Seed grading**

- Grade the seeds using 9 / 64" round perforated sieve.
- Upgrade the size graded seed using specific gravity separator.
- Remove the broken and dehulled seeds from the lot.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed along with carbaryl @

200 mg / kg of seed.

- Treat the seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 7 - 8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 7 %.

## SUNFLOWER - HYBRID SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified quality seed production, leave a distance of 400 m all around the field from the same and other varieties / hybrids of sunflower.

**Border rows**

- Sow four rows of male parent around the field for the availability of adequate pollen.

**Planting Ratio**

- Sow female and male plants in a ratio of 4:1 or 6:1

**Foliar spray**

- Spray 0.2 % boric acid at button opening stage to increase seed set.

**Supplementary pollination**

- During flowering, collect pollens from male flowers and smear the pollen over the female heads with muslin cloth or palm at the time between 8 - 11 am on alternate days till the completion of flowering.
- Keep bee hives @ 5 nos. / hectare.

**Harvesting**

- Harvest 'R' lines first and remove from the field before harvesting the hybrid.
- Harvest the earheads of female plants as once over harvest.

# (v) SAFFLOWER (*Carthamus tinctorius*)

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 38 - 40 | 5 | 22 - 30 | 350 - 450 | up to 1000 |

Tropical and subtropical semi arid climate. Grown during rabi, primarily as a rainfed crop. Yields are lower under humid or rainy conditions due to reduced seed set and increased disease incidence. Not recommended for areas with >450 mm of annual precipitation. Tolerated very low temperature during the rosette stage, but very sensitive to frost injury after stem elongation until crop maturity. This crop does best in areas with warm temperatures and sunny, dry conditions during the flowering and seed-filling periods. Temperature for seed germination is 15°C.

## CROP IMPROVEMENT

| DISTRICT/SEASON | VARIETIES |
|---|---|
| **A. Rainfed** | |
| **1. Karthigaipattam (Nov-Dec)** | |
| All districts | K 1, CO 1 |

## I. DESCRIPTION OF SAFFLOWER VARIETIES

| Particulars | K 1 | CO 1 |
|---|---|---|
| Parentage | Pureline selection from American spiny variety | Pureline selection from CTS 7403 (Non spiny) |
| Duration (days) | 120 | 125 |
| Yield (kg/ha) | | |
| Rainfed | 700 | 800 |
| Oil content (%) | 32 | 33 |
| Special features | spiny florets, suitable for Southern districts | Non-spiny, tolerant Alternaria, moderately Resistant to wilt |

## CROP MANAGEMENT

## III. PREPARATION OF THE FIELD

### 1. FIELD PREPARATION

a) Plough with tractor 2-3 times with a mould board plough or 5 times with a country plough.

b) Break the clods in between the ploughings and bring the soil to a fine tilth.

### 2. APPLICATION OF FYM

a) Spread 12.5 t of FYM or compost or composted coir pith per ha evenly and incorporate in the soil. b) If the manure is not applied before commencement of ploughing, spread the manure evenly before the last ploughing and incorporate in the soil.

*NOTE: Do not leave the organic manure exposed to sunlight as nutrients will be lost.*

**3. APPLICATION OF FERTILIZERS**

Apply N at 20 kg/ha basally.

**4. SEED RATE**

Adopt a seed rate of 10 kg/ha.

**5. SPACING**

Adopt a spacing of 45 cm between rows and 15 cm between plants.

**6. SELECTION OF GOOD QUALITY SEEDS**

Select mature good quality seeds, free from pest damage and fungal attack.

**7. PRE-TREATMENT OF SEEDS WITH FUNGICIDES**

a) Treat with Carbendazim or Thiram at 4 g/kg of seed in a polythene bag and ensure a uniform coating of the fungicide over the seed. b) Treat the seeds 24 hours prior to sowing.

*NOTE: Seed treatment will protect the young seedlings from root rot disease in the early stage.*

**8. SOWING**

a. Sow the seeds in line at a depth of 2 to 3 cm and cover with soil. b. Sow using gorru or country plough.

*NOTE: First week of November is the best sowing time.*

**9. THINNING OUT SEEDLINGS**

Thin out the seedlings to a spacing of 15 cm between plants on the 15$^{th}$ day of sowing.

**10. WEED MANAGEMENT**

Weeding with have hoe on 25 and 40 days after of sowing (DAS)

**11. HARVESTING**

i. Observe the crop considering the average duration of the crop.
ii. The leaves and entire plant loose their colour and turn brown at maturity.
iii. Cut the plants at the bottom.
iv. Keep the plants in the threshing floor and beat the plants (heads) with sticks till the mature seeds are separated.
v. Winnow the seed and dry in the sun.
vi. Collect and store the seeds in gunnies.

**CROP PROTECTION**

Treat with Carbendazim or Thiram at 4 g/kg of seed in a polythene bag and ensure a uniform coating of the fungicide over the seed. Treat the seeds 24 hours prior to sowing.

*NOTE: Seed treatment will protect the young seedlings from root rot disease in the early stage.*

## SAFFLOWER - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production, leave a distance of 200 m all around the field from the same and other varieties of the crop.

**Spacing**

- 60 x 20 m.

**Fertilizer**

- Apply NPK @ 60:60:20 kg / ha as basal application.

**Harvest**

- Harvest the pods as once over harvest.

**Seed grading**

- Grade the seeds using BSS 6 x 6 wire mesh sieve.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2g / kgof seed.
- Treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1@ 3 g / kg of seed as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 7 - 8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 7 %.

## (vi) Coconut (*Cocos nucifera*); Palmae

**Climate**

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 38 - 40 | 10 - 15 | 25 - 30 | 800 - 2500 | up to 600 |

Tropical and subtropical climate. Withstand water logging. Minimum sunshine shou hours per year.

**VARIETIES AND HYBRIDS**

**Varieties**

i. East Coast Tall
ii. West Coast Tall
iii. VPM-3 (Selection from Andaman Ordinary Tall)
iv. ALR (CN -1) (Selection from Arasampatty Tall)
v. ALR (CN-2) (Selection from Tiptur Tall)
vi. COD (Dwarf for tender coconut purpose only)
vii. VPM 4 (Selection from WCT)
viii. ALR 3 (Dwarf for tender nut purpose only and Selection from Kenthali Dwarf)

**Hybrids**

**Tall x Dwarf**

(To be grown under well managed conditions)

ix. VHC 2 - ECT X MYD
x. VHC 3 - ECT X MOD
xi. VPM 5 – LCT x CCNT

(Besides, the hybrids of ECT x COD, WCT x COD and WCT x MYD are also produced by the State Department of Agriculture. The dwarf x tall type (COD x WCT) which has to be grown under well-managed conditions with assured irrigation is also produced by State Department of Agriculture).

### CROP MANAGEMENT

**Soil**

Red sandy loam, laterite and alluvial soils are suitable. Heavy, imperfectly drained soil is unsuitable.

**Seasons**

June-July, December - January. The planting can also be taken up in other seasons wherever irrigation and drainage facilities are available.

**Spacing**

Adopt a spacing of 25' x 25' (7.5 x 7.5 m) with 175 plants/ha. For planting in field border as a single row, adopt 20' spacing between plants.

**Planting**

Dig pit size of 3’ x 3' x 3'. In the pits, sprinkle Lindane 1.3 % D to prevent white ant damage. Fill the pit to a height of two feet (60 cm) with FYM, red earth and sand mixed in equal proportions. At the center of the pit, remove the soil mixture and plant the seedling after removing all the roots. Press the soil well around the seedling and provide the seedling with shade by using plaited coconut leaves or palmyrah leaves. Keep the pits free from weeds. Remove soil covering the collar region. As the seedlings grow and form stem, fill up the pits gradually by cutting the sides.

**Water management**

From 5th year onwards, adopt the following irrigation schedule based on pan evaporation for drip irrigation and basin irrigation.

**Western region**

| Months | Normal condition (for best yield) | Moderate water scarcity condition | Severe water scarcity condition |
|---|---|---|---|
| **A. Drip irrigation** | | | |
| February to May | 65 lit / day | 45 lit/ day | 22 lit / day |
| January, August and September | 55 lit / day | 35 lit / day | 18 lit/day |
| June and July, October to December | 45 lit / day | 30 lit/ day | 15 lit / day |
| **B. Basin irrigation** | | | |
| February to May | 410 lit / 6 days* | | |
| January, August and September | 410 lit /7 days* | | |
| June and July, October to December | 410 lit /9 days* | | |

**Eastern region**

| Months | Normal condition (for best yield) | Moderate water scarcity condition | Severe water scarcity condition |
|---|---|---|---|
| **A. Drip irrigation** | | | |
| March - September | 80 lit / day | 55 lit / day | 27 lit/day |
| October – February | 50 lit / day | 35 lit/ day | 18 lit /day |
| **B. Basin irrigation** | | | |
| March – September | 410 lit / 5 days* | | |
| October – February | 410 lit /8 days* | | |

* Quantity of water to be applied in the basin. Add 30-40 % of the above quantity of water (135 -165 litres/palm) to meet the conveyance loss.

For drip irrigation, open four pits size of 30 x 30 x 30 cm opposite to each other at one meter distance from the trunk. Place 40 cm long PVC conduit pipe (16 mm) in a slanting position in each pit and place the drippers inside the conduit tube and allow the water to drip 30 cm below the soil surface. Fill the pits with coir pith to prevent evaporation.In the first year, irrigate on alternate days and from the second year to the time of maturity irrigate twice in a week based on the water requirement.

**Drought management and soil moisture conservation**

**Mulching with coconut husks/leaves/coir pith**

Apply coconut husks with convex surface facing upwards (100 Nos.) or dried coconut leaves (15 Nos) or coir pith up to a height of 10 cm in the basin of 1.8 m radius around the palms as mulch for soil moisture conservation particularly during summer season.

**Burial of coconut husk or coir pith**

Husk burial can be done in coconut basins or in the interspaces to overcome drought and button shedding. Bury husks @ 100 Nos. with concave surface facing upwards or 25 kg of coir pith/palm in circular trenches, dug 30 cm width and 60 cm depth at 1.5 metres radius. The husk can be also buried in the trenches at a distance of 3 m from the palm with a size of 45 cm deep and 150 cm width in between two rows of coconut. The soaking of the coconut husk or coir pith as the case may be preserves the monsoon rains.

**Manuring**

From 5$^{th}$ year onwards, apply 50 kg of FYM or compost or green manure.1.3 kg Urea (560 g N), 2.0 kg Superphosphate (320 g $P_2O_5$) and 2.0 kg Muriate of potash (1200 g $K_2O$) in two equal splits during June – July and December – January. Apply manures and fertilizers in circular basins of 1.8 m from the base of the palm, incorporate and irrigate. During 2nd, 3rd and 4th year ¼, ½ and ¾ doses of the above fertilizer schedule should be adopted respectively. Sufficient moisture should be present at the time of manuring. Fertigation may be done at monthly intervals with 75% of the recommended dose of the above fertilizers. Phosphorous may be applied as super phosphate in the basins and incorporated or as DAP through drip when good quality of water is available. TNAU micronutrient mixture is recommended @ 1.0kg/tree/year.

**TNAU coconut tonic nutrition**

For nut bearing coconut Palm, root feed TNAU coconut tonic @200ml/palm once in six months.

**Bio-fertilizer recommendation**

At the time of planting, apply 50g of *Azospirillum,* 50 g of Phosphobacteria (or) 50 g of Azophos and 50 g of AM fungi. Mix all the contents with sufficient quantity of FYM or any compost. After planting apply the above biofertilizers once in 6 months/palm near to the feeding roots as that of fertilizer application

**Organic recycling**

Any one of the green manure crops like sunnhemp, wild indigo, calapagonium or daincha may be sown and ploughed *in situ* at the time of flowering as a substitute of compost to be applied. Sow sunnhemp @ 50 g/palm in the basin and incorporate before flowering. Coir pith compost/vermicompost made from coir pith/ coconut leaves/ other wastes from coconut grove can be applied.

**Intercultural operation weed management**

The interspace in the coconut garden has to be ploughed twice in a year in June-July and December - January. Intercultural operation is essential to keep weed population under check, to enhance the utilisation of the applied plant nutrients by the coconut trees, to facilitate proper aeration to the roots of coconut, to induce fresh root growth.

**Weed management**

For the broad-leaved weeds, pre-emergence spraying of atrazine @1.0 kg / ha for the control of grasses and sedges, post emergence spraying of glyphosate @ 10 -15 ml and 20 g Ammonium sulphate + 2 ml soap solution /litre of water.

**Inter cropping**

Inter/mixed crops may be selected based on the climatic requirement of the inter/mixed crop, irrigation facilities and soil type. The canopy size, age and spacing of the coconut are also to be considered. Market suitability should be taken into consideration before selecting an intercrop.

**Below 7 years of age**: Any suitable annual crop for particular soil type and climatic condition may be raised as intercrops upto 5 years after planting depending upon the canopy coverage. Groundnut, sesamum, sunflower, tapioca, turmeric and banana can be grown. Avoid crops like paddy and sugarcane etc.

**7 – 20 years of age**: Green manure crops and fodder crops (Napier grass and guinea grass) alone can be grown.

**Above 20 years of age** (20 years of age has to be adjusted based on the sunlight transmission of above 50% inside the canopy).

The following crops can be grown depending on the soil and climatic suitability.

| | | |
|---|---|---|
| (i) **Annuals** | : | Groundnut, bhendi, turmeric, tapioca, sweetpotato, sirukizhangu, elephant foot yam, ginger, pineapple |
| (ii) **Biennials** | : | Banana varieties, poovan and monthan are suitable. |
| (iii)**Perennials** | : | Cocoa*, pepper* (Panniyur 1 or Panniyur 2 or Panniyur 5 or Karimunda), nutmeg* and vanilla* |

*Suitable areas are Pollachi tract of western region and Kanyakumari district. For vanilla,
use disease free planting material and maintain high vigilance to maintain a disease free crop.

**Multiple cropping system**

Coconut + banana + sirukizhangu + bhendi is suitable system for the eastern region. Crops like banana, pepper, cocoa, nutmeg, vanilla can be tried under multiple cropping system in suitable areas in the western region. In all the systems, apply recommended quantity of water and manures and fertilizers to the intercrops separately.

**Crop physiology**

Root feeding of TNAU coconut tonic @ 200 ml / palm twice a year at six months interval decreases button shedding and increases the number and size of nuts.

## Crop protection

### Pest management

| Pests | Management strategies |
|---|---|
| **Rhinoceros beetle**<br>*Oryctes rhinoceros* | ▪ Remove and burn all dead coconut trees in the garden (which are likely to serve as breeding ground) to maintain good sanitation.<br>▪ Collect and destroy the various bio-stages of the beetle from the manure pits (breeding ground of the pest) whenever manure is lifted from the pits.<br>▪ Incorporate the entomopathogen i.e, fungus (*Metarrhizium anisopliae*) in manure pits to check the perpetuation of the pest.<br>▪ Soak castor cake at 1 kg in 5 l of water in small mud pots and keep them in the coconut gardens to attract and kill the adults.<br>▪ Treat the longitudinally split tender coconut stem and green petiole of fronds with fresh toddy and keep them in the garden to attract and trap the beetles.<br>▪ Examine the crowns of tree at every harvest and hook out and kill the adults.<br>▪ For seedlings, apply 3 naphthalene balls/palm weighing 3.5 g each at the base of inter space in leaf sheath in the 3 inner most leaves of the crown once in 45 days.<br>Set up light traps following the first rains in summer and monsoon period to attract and kill the adult beetles.<br>▪ Field release of Baculovirus inoculated adult rhinoceros beetle @ 15/ha reduces the leaf and crown damage caused by this beetle.<br>▪ Apply mixture of either neem seed powder + sand (1:2) @150 g per palm or neem seed kernel powder + sand (1:2) @150 g per palm in the base of the 3 inner most leaves in the crown<br>▪ Place phorate 10 G 5 g in perforated sachets in two inner most leaf axils for 2 times at 6 months intervals.<br>▪ Set up rhinolure pheromone trap @ 1/ 2 ha to trap and kill the beetles. |
| **Black headed caterpillar**<br>*Opisina arenosella* | ▪ The incidence of the pest is noticed from the month of November to May and from August to November after rainfall. The coconut trees of all ages are attacked.<br>• Release the larval (*Bethylid, Braconid* and *Ichneumonid*) and pupal (*Eulophid*) on (chalcid) parasitoids and predators periodically from January, to check the build up of the pest during summer.<br>▪ Among the larval parasitoids, the bethylid *Goniozus nephantidis* is the most effective in controlling the pest. The optimum level of release is 1:8 of host-parasitoid ratio. The parasitoi should be released @3000/ha under the coconut trees when the pest is in the 2nd or 3rd instar larval stage. Parasitoid release trap may be used to release the parasitoid at the site of feeding. Parasitoids should not be released in the crown region since they will be killed by predators like spiders and reduviid bugs.<br>▪ Remove and burn all affected leaves/leaflets.<br>▪ Spray Malathion 50 EC 0.05% (1mi/lit) to cover the undersurface of the leaves thoroughly in case of severe epidemic outbreak of the pest |

| | |
|---|---|
| | in young palms.<br>▪ **Root feeding for the control of coconut Black headed caterpillar:** Select a fresh and live root, cut sharply at an angle and insert the root in the insecticidal solution containing monocrotophos 36 WSC 10 ml + water 10 ml in a 7 x 10 cm polythene bag. Secure the bag tightly to the root with a cotton thread. Twenty four hours later, check whether there is absorption. If there is no absorption select another root. These methods should not be resorted to as a routine practice and it is suggested only for cases of severe epidemic outbreak of the pest and when the survival of the tree is threatened. |
| **Red palm weevil**<br>*Rhynchophorus ferrugineus* | ▪ Remove and burn all wilting or damaged palms in coconut gardens to prevent further perpetuation of the pest.<br>▪ Avoid injuries on stems of palms as the wounds may serve as oviposition sites for the weevil. Fill all holes in the stem with cement.<br>▪ Avoid the cutting of green leaves. If needed, they should be cut about 120 cm away from the stem.<br>▪ Fill the crown and the axils of top most three leaves with a mixture of fine sand and neem seed powder or neem seed kernel powder (2:1) once in three months to prevent the attack of rhinoceros beetle damage in which the red palm weevil lays eggs.<br>▪ Setting up of attractant traps (mud pots) containing sugarcane molasses 2½ kg or toddy 2½ litres + acetic acid 5 ml + yeast 5 g + longitudinally split tender coconut stem/logs of green petiole of leaves of 30 numbers in one acre to trap adult red palm weevils in large numbers.<br>▪ Install pheromone trap @1/2 ha<br>**Root feeding**: As under black headed caterpillar |
| **Termites**<br>*Odontotermes obesus* | ▪ Locate termite mounds in or near the coconut nursery or garden and destroy.<br>▪ Swabbing with neem oil 5% once on the base and upto 2 m height of the trunk for effective control.<br>▪ Spray copper sulphate 1% or cashew nut shell oil 80% or spray chlorphyriphos @ 3ml/lit of water, neem oil 5% or NSKE 20% to preserve plaited coconut leaves from the termite attack. |
| **Scale insect**<br>*Aspidiotus destructor* | ▪ Pluck mature nuts and spray monocrotophos 36 WSC 1 ml/ha.<br>▪ Do not harvest nuts for 45 days after spraying. |
| **Mealy bugs**<br>*Pseudococcus longispinus* | ▪ Remove leaflets harbouring these insects and destroy them<br>▪ **Spray any one of the following :**<br>Malathion 50 EC 2 ml/lit<br>Dimethoate 30 EC 1 ml/lit<br>Methyl demeton 25 EC 1 ml/lit<br>Phosphamidon 40 SL 1.25 ml/lit<br>▪ Monocrotophos 36 WSC 1 ml/lit Neem oil 30ml/lit. |

<table>
<tr>
<td>Leaf caterpillars<br>Turnaca acuta<br>Nut caterpillar<br>Nut coreid bug</td>
<td>▪ Collect and destroy the immature stages of the insects by conducting study (or neem compaign) wherever possible and spray carbary 50 WP 2 gm/lit .<br>▪ Root feeding with monocrotophos 36 WSC @ 10 ml + 10 ml water at 45 days interval for 3 times for control of leaf caterpillar.<br>▪ Set up light trape to trap and collect adult moths<br>▪ Spray Dichlorvas 76 WSC 2 ml / lit.</td>
</tr>
<tr>
<td>Slug caterpillar<br>Contheyla rotunda</td>
<td>Spray any one of the following:<br>▪ Dichorvos 76 WSC 2 ml/lit<br>▪ Bacillus thuringiensis 2 g/lit,<br>▪ Triazophos 40 EC 5 ml<br>▪ Methyl demeton 25 EC 4 ml/lit<br>▪ Root feeding with monocrotophos 15 ml + 15 ml of water</td>
</tr>
<tr>
<td>Scolytid bark borer beetles<br>Xyleborus parvulus</td>
<td>▪ Stem injection through a stove wick soaked in 0.2% dichlorvos and plugging the hole and repeating the treatment using the same wick and<br>hole a month after.</td>
</tr>
<tr>
<td>Eriophyid mite<br>Aceria guerreronis</td>
<td>Manurial and fertilizer recommendation (Soil application/tree/year)<br>Urea 1.3 kg<br>Superphosphate 2.0 kg<br>Muriate of potash* 3.5kg<br>* Increased quantity is recommended to increase the plant resistance to the mite. Neem cake application @ 5 kg Organic manure (well rotten FYM) @ 50 kg<br>1. Micronutrients (Soil application / tree / year)<br>Borax 50 g<br>Gypsum 1.0 kg Magnesim sulphate 500g<br>Grow sunnhemp as intercrop twice a year (Seed rate 30 kg/ha)<br><br>Spot application of ecofriendly botanicals
<table>
<tr><th>Round</th><th>Eco-friendly Botanical</th><th>Quantity / tree</th></tr>
<tr><td>1</td><td>Azadirachtin 1%</td><td>5 ml in one lit. of water</td></tr>
<tr><td>2</td><td>Neem oil + Teepol</td><td>30 ml in one lit. of water</td></tr>
<tr><td>3</td><td>Azadirachtin 1%</td><td>5 ml in one lit. of water</td></tr>
</table>
Method of application<br>✓ The botanicals should be applied in the sequence indicated above at 45 days interval using a one litre hand sprayer. Rocker or Pedal sprayer can be used for spraying small trees.<br>✓ The spray should be applied at the crown region by a climber covering only the top six bunches during non rainy season<br>✓ The bunches must be covered well by the spray fluid and approximately one litre of spray fluid may be required per tree<br>Precautions and safety measures<br>❖ Spraying should be avoided during windy season to prevent contamination<br>❖ At the time of spraying, protective mask and clothing should be used<br>❖ Wash face and hands cleanly with soap after spraying.</td>
</tr>
</table>

| | |
|---|---|
| **Coconut Rugose spiraling whitefly** | The coconut rugose spiraling whitefly was noticed in serious proportion in various district coconut gardens of Tamil Nadu. The insects suck the sap and cause damage in the leaf fronts with copious honey dew secretions on the leaves. It induce development of sooty mould fungus there by leaves become completely black and reduces the photosynthesis rate.<br>The following TNAU technologies can be adopted to manage the spiraling whitefly,<br>➢ Release of Encarsia guadeloupae @ 100 parasitoids /ac (10 leafbits/ac)<br>➢ Installation of yellow sticky traps (5 ft. x 1.5 ft.) smeared with castor oil @ 5/ ac<br>➢ Release of Chrysoperla zastrowi sillemi eggs @ 500/ac in young palms<br>➢ Pesticide holiday' must be declared to conserve the natural enemies fauna |

| **New invasive pest** | |
|---|---|
| **Palm civet**<br>*Vivera zibatha* | ▪ Poison baiting with ripe banana fruit sandwiched with 0.5 g carbofuran 3 G granules. |
| **Rat**<br>*Rattus rattus wroughtoni* | ▪ Tree banding with inverted iron cones or Prosophis thorns. Baiting with bromodialone 0.005% at 10 g/tree at crown region twice at an interval of 12 days. |

## Diseases management

### Basal stem rot (*Ganoderma lucidum*)

- Aureofungin-sol @ 2g + copper sulphate @ 1g dissolved in 100 ml water or hexaconazole @ 2 ml with 100 ml of water, applied as root feeding for 3 times at 3 months interval. (The active absorbing root of pencil thickness be selected and a slanting cut is made. The solution is taken in a polythene bag or bottle and the cut end of the root is dipped in the solution)
- Forty liters of 1% Bordeaux mixture should be applied as soil drench around the trunks in a radius of 1.5 meter
- Neem cake @ 5 kg/tree can be applied along with fertilizers and azotobactor @ 200 g/tree

### Bud rot (*Phytophthora palmivora*)

- The infected tissues from the crown region should be removed and protected with Bordeaux paste
- Spray 1% bordeaux mixture or copper oxychloride @ 0.25 % on crown region as pre-monsoon spray
- Spray copper oxychloride @ 0.25 % after the onset of monsoon

### Stem bleeding (*Ceratocystis paradoxa*)

The bark of the trunk should be removed in the bleeding area and Bordeaux paste should be applied in this area

**Preparation of 1% bordeaux mixture**

Copper sulphate @ 400g should be dissolved in 20 litres of water and 400 g of lime in another 20 litres of water separately. The copper sulphate solution should be added to the lime solution constantly stirring the mixture. Earthen or wooden vessels alone should be used and metallic containers should not be used. To find out whether the mixture is in correct proportion, a polished knife should be dipped in the mixture for one minute and taken out. If there is reddish brown deposit of copper, additional quantity of lime should be added till there is no deposit in the knife.

**Preparation of bordeaux paste:**

Take 200 g of copper sulphate and dissolve it in one litre of water and 200 g of lime in one litre of water separately, both are mixed simultaneously in a third vessel and the resultant mixture can be used as a paste.

## SPECIAL PROBLEMS IN COCONUT

**Rejuvenation of existing garden**

The low yield in vast majority of gardens is due to thick population, lack of manuring and irrigation. These gardens could be improved if the following measures are taken.

i. **Thinning of thickly populated gardens**

In the farmer's holdings where thick planting is adopted, many trees give an yield of less than 20 nuts/palm/year. By cutting and removal of these trees, the yield could be increased. Besides, there is saving in the cost of cultivation and increase in net profit. After removal of low yielding trees, the populations should be maintained at 175 palms/ha.

ii. **Ensuring adequate manuring and irrigation**:

The yield can be increased in the existing gardens when manuring + irrigation + cultural practice is adopted as per recommendation.

**Pencil point disorder (Micronutrient deficiency)**

Because of micronutrient deficiency, the stem will taper towards its tip with lesser number of leaves. The leaf size will be greatly reduced and the leaves will be pale and yellow in colour. Along with the recommended fertilizer dose, 225 g each of Borax, Zinc sulphate, Manganese sulphate, Ferrous sulphate, Copper sulphate and 10 g of Ammonium molybdate may be dissolved in 10 litres of water and poured in the basin of 1.8 m radius. This disorder can be corrected if noticed early. Severely affected palms may be removed and replanted with new seedlings.

**Button shedding**

Shedding of buttons and premature nuts may be due to any one of the following reasons:

i) Excess acidity or alkalinity
ii) Lack of drainage
iii) Severe drought
iv) Genetic causes
v) Lack of nutrients
vi) Lack of pollination

vii) Hormone deficiency
viii) Pests
ix) Diseases

The following remedial measures are suggested.

**Rectification of soil pH**

Excess acidity or alkalinity of soil may cause button shedding. If the soil pH is less than 5.5, it is an indication of excess acidity. This could be rectified by adding lime. Increase in alkalinity is indicated by soil pH higher than 8.0. This situation could be rectified by adding gypsum.

**Providing adequate drainage facilities**

Lack of drainage results in the roots of coconut trees getting suffocated for want of aeration. Shedding of buttons occur under such condition. Drainage channels have to be dug along the contours to drain the excess water during rainy season.

**Management of young coconut gardens under waterlogged conditions**

(i) A trench between two rows of young coconut palms should be dug during onset of the monsoon rains. The size of the trench is 3 m width, 30 – 45 cm depth to entire length of field. The soil excavated from the trench should be placed along the rows of palms to make a raised bed.
(ii) Form mound around the young palms to a radius of 1.2 m width with height of 30 –45 cm.

**Genetic causes**

In some trees button shedding may persist even after ensuring adequate manuring, irrigation and crop pest and disease management. This is an indication of inherent defect of the mother palm from which the seed material was obtained. This underlines the need for proper choice of superior mother palm for harvesting seed coconut to ensure uniformly good yielding trees.

**Lack of nutrition**

Button shedding occurs due to inadequate or lack of manuring. The recommended dose of manurial schedules and proper time of application are important to minimise the button shedding. Apply extra 2 kg of muriate of potash with 200 g of Borax/palm over and above the usual dosage of fertilizer to correct the barren nuts in coconut for period of 3 years.

**Boron deficiency or crown choke disorder**

Apply 200 g of borax/palm/year in two splits.

**Lack of pollination**

Button shedding also occurs due to lack of pollination. Setting up of beehives @ 15 units/ha may increase the cross pollination in the garden. Further the additional income obtained through honey, increases the net profit per unit area.

**Hormone deficiency**

The fertilised female flowers i.e., buttons shed in some cases. By spraying 2, 4- D at 30 ppm or NAA 20 ppm (30 mg per litre of water) on the inflorescence one month after opening of the spathe, the setting percentage could be increased.

**Pests**

Button shedding may happen due to the attack of bug. Spraying of systemic insecticides like Methyldematon 0.025% (1ml/lit) or Dimethoate 0.03% (1ml/lit) may reduce the occurrence.

**Diseases**

Button shedding also occurs due to disease incidence such as basal stem rot. Adoption of control measures suggested for the disease reduces not only spread of the disease but also prevents shedding of buttons.

**Coconut mother palm selection and nursery management**

The need for collecting seed materials from high yielding coconut palms is highly essential in a perennial crop like coconut.
The following points may be remembered.

**Mother palm selection**

1. Select seed gardens, which contain large proportion of high yielding trees with uniformity in yielding ability. Trees growing closer to households, cattle shed, compost pits and other favorable conditions should be avoided.
2. High yielding mother palms giving not less than 100nuts/palm/annum should be chosen for collecting seednuts. Alternate bearers should be avoided. The age of the palm chosen be middle age i.e., from 25 to 40 years. Even trees with 15 years age can be selected, if it is high yielding and has stabilized yield.
3. The mother palm should have straight trunk, spherical or semi spherical crown, high rate of leaf and spathe production, short and stout petiole, more number of female flowers regular bearing habit, non – buckling bunches, high setting parentage, medium in nut size, high copra outturn and free from pest and diseases. A good regular bearing mother palm produces on an average one leaf and an inflorescence in its axil every month. So, there will be twelve bunches of varying stages of maturity at any one time. Avoid trees producing habitually barren nuts.
4. Harvest seednuts during the months of February - August to get maximum germination and good quality seedlings. Harvest the bunches intended for seednut by lowering them to the ground using a rope to avoid injury to seednuts
5. The seednuts should be round in shape and when tapped by finger should produce metallic sound. Fully ripe nuts develop twelve months after fertilisation.
6. To get more quality seedlings, the seednuts of tall and hybrid are to be air cured for one month followed by sand curing for two months. For dwarf varieties, the air curing should be lesser than one month followed by sand curing for two months.

**Nursery management**

1. Select nursery area in a well drained plot with coarse texture soil near water source for irrigation. Nursery can be raised in the open space with artificial shade or in the adult coconut garden.
2. Plant seednuts in long and narrow beds at a spacing of 30 x 30 cm either horizontally or vertically in deep trenches with 20-25 cm depth. Five rows of nuts may be planted in each bed accommodating 50 nuts per row.
3. Irrigate the nursery beds once in three days.
4. Keep the nursery free of weeds. To manage the weed problem in coconut nursery, growing sunnhemp 2 times (each harvested at flowering stage) followed by one hand weeding at $6^{th}$ month was found to be very effective besides yielding green manure for manuring the adult coconut palms.
5. Provide shade to the nursery by raising Sesbania or Leucaena on the sides of beds.
6. The seednuts start germination 6 – 8 weeks after planting and germination continues upto six months. Select seedlings that germinate before 5 months after planting. Remove those nuts which do not germinate 5 months after sowing.
7. Regularly survey for pest and diseases
8. Select seedlings 9 to 12 months after planting. Seedlings, which have germinated earlier, having good girth at collar and early splitting of leaflets, should be selected for planting. Do not select the so called Kakkamukku Pillai i.e., seednuts which have just germinated. Eliminate the seedlings which are deformed or having stunted growth.
9. Remove the seedlings from the nursery by lifting with spade. Do not pull out the seedlings by pulling leaves or stem.
10. Select quality seedlings with a minimum of 6 leaves and girth of 10 cm at collar.

# (vii) OILPALM

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 33 - 38 | 10 - 15 | 24 - 29 | 2000 – 4000 | up to 900 |

Tropical and subtropical climate. Cannot tolerate drought and need 80% RH.

**INTRODUCTION**

Oil palm requires evenly distributed annual rainfall of 2000 mm without a defined dry season. In areas with dry spell, a deep soil with high water holding capacity and a shallow water table augmented with copious irrigation will satisfy the water requirement of the palm. Temperature can be a limiting factor for oil palm production Best oil palm yields are obtained in places where a maximum average temperature of 29-33 C and minimum average temperature of 2-24 C are available. Higher diurnal temperature variation causes floral abortion in regions with a dry season.

The crop requires 1800-2000 sunlight hours annually, more than 300 cal/$cm^2$ / per day, constant sunlight of atleast 5 hours per day for better oil palm yield.

Moist, deep and well drained medium textured soils rich in humus content are considered ideal. Gravelly and sandy soils, particularly the coastal sands are not ideal for oil palm cultivation. Heavy clay soils with poor drainage properties may pose problems of aeration during rainy seasons.

**NURSERY AND ITS MANAGEMENT**

Nursery is raised by planting germinated sprouts initially in a pre-nursery bed or in polybags in a primary nursery and transplanting them at five leaf stage to a secondary nursery of large sized polybags. Raising seedlings in large polybags without a pre-nursery stage is also being practiced.

The potting mixture is made by mixing top soil, sand and well decomposed cattle manure in equal proportions. Smaller polybags of 250 guage and 23 x 13 cm size, preferably black are used for raising primary nurseries. These bags are filled with the potting mixture leaving one cm at the top of the bag. A healthy germinated sprout is placed at the centre at 2.5 cm depth. While placing the sprout, care must be taken to keep the plumule of the sprout facing upwards and the radicle downwards in the soil. It is better to plant sprouts soon after the differentiation of radicle and plumule. The seedlings are to be watered daily. Application of a fertilizer mixture containing one part of ammonium sulphate, one part of super phosphate, one part of muriate of potash and two parts of magnesium sulphate is recommended at 15 g at one month stage, 45 g at three months stage and 60 g at six months stage per seedling. This has to be applied 6 - 8 cm away from seedlings during the first application, 10-12 cm away during second and 15-20 cm away during the third application in primary nursery. Surface soil is slightly scratched at the time of fertilizer application.

## SINGLE STAGE POLY BAG NURSERY AND SECONDARY NURSERY

The germinated seeds can be directly planted into large black polybags with the advantage of avoiding the pre-nursery stage. At present the single stage polybag nursery is recommended in India. Since the plants are to remain in these polybags for more than one year, good quality polybags of 500 gauge and 40 x 45 cm size are to be used. On the lower half of the bag, perforations are made at an interval of 7.5 cm for drainage. A bag can carry 15 - 18 kg of nursery soil depending on the type of soil mixture used.

The water requirement for different stages of growth of seedlings are as follows: 0 - 2 months at 4 mm/day, 2 - 4 months at 5 mm/day, 4 - 6 months at 7 mm/day and 6 - 8 months at 10 mm/day. It is better to supply if feasible the daily requirement in two halves to prevent overflow and wastage caused by one time application. Application of 9 - 18 lit. of water per seedling per week according to the stage of growth and soil type.

## FIELD PLANTING

Prepare the land for oil palm plantings at least 3 months before transplanting the seedlings to the main field. In soils with low permeability, drainage channels are to be constructed to prevent water stagnation in upper layer of soil

## AGE OF SEEDLINGS AT TRANSPLANTING

It is advisable to plant well grown seedlings of 12 - 14 months old. At this stage, a well developed tenera seedling will have a height of 1-1.3 m from base and will have more than 13 functional leaves. These seedlings were found to maintain higher leaf production, bear earlier, produce heavy bunches, give higher fruit/bunch ratio and a higher oil to mesocarp in the first year of harvest.

## SELECTION OF SEEDLINGS

All deformed, diseased and elongated seedlings are to be discarded. Differences in the height of healthy seedlings ranging from 90 to 159 cm tend to even up after 14 months of transplanting to maintain.

## TIME OF TRANSPLANTING

Transplanting to the main field has to be done during the onset of rainy season. In very impermeable soils and where there is chance for the seedlings to suffer severely during rainy season, proper drainage has to be ensured.

## SPACING AND METHOD OF PLANTING

The optimum planting density for oil palm is the density of population that gives maximum production from unit area. Triangular system of planting with 9 x 9 x 9 m spacing accommodates 143 palms/ha. is being recommended. For efficient utilization of solar energy the rows are to be oriented in the North-South direction. Equilateral triangular system of planting with 9 m spacing between palms will allow each plant to occupy the centre of a hexagon thus allowing better use of the area.

## TRANSPORTING SEEDLINGS AND PREPARING PITS

While transporting seedlings to the planting site one hand is placed at the bottom of the bag while holding the plant collar with the other one. Leather gloves can be used to avoid injury with spines of the leaves.

Pits of 60 $cm^3$ are taken prior to planting and filled with surrounding top soil and allowed to settle. Rock phosphate is applied at 200 g per planting pit. Nitrogen is not usually applied in the planting pits as the application of fertilizers may damage the root system and affect survival of the plants if there is a dry period soon after planting. Nitrogen and potassium are usually applied 4 – 6 weeks after planting. In Mg deficient soils, magnesium is applied at 100 g as anhydrous $MgSO_4$ or 200 g epsum salt per seedling.

## REPLACEMENT AND GAP FILLING

Field inspection is carried out one to two months after planting to gap fill dead plants. Replanting is carried out during the onset of next monsoon. These palms are to be given special care so that they can catch up with the rest of the plantations. Early production of more female inflorescences in the initial 30 months, is an indication of high yielders and all those that fail to produce female bunches will remain as poor yielders. However, replacements are found to be affected to some extent by the vigorous growth of the neighbouring palms which will shade the replanted palms.

## FERTILIZER REQUIREMENT

Based on the fertilizer experiments conducted under rainfed conditions in India, the following fertilizer schedule is recommended for oil palm until specific results are derived from multilocational fertilizer trials.

Fertilizer recommendation for oilpalm

| **Age** | **Nutrients (gram/palm/year)** | | |
|---|---|---|---|
| | **N** | **P** | **K** |
| First year | 400 | 200 | 400 |
| Second year | 800 | 400 | 800 |
| Third year | 1200 | 600 | 270 |
| onwards | | | 0 |

## METHOD OF FERTILIZER APPLICATION

The fertilizers are preferably applied in two equal split doses during May - June and September -October by uniformly spreading them within a 2 metre circle around the base of the palm and forking to incorporate them into the soil. Supply of sufficient quantity of green leaves or compost is advantageous especially where the soil is poor in organic matter content. Mg deficiency can be corrected through the application of 500 g of MgSO4 palm/year. Borax @ 100 g per palm also recommended.

Urea is found to be the most economic nitrogen source if losses by volatilization and leaching are minimised. Rock phosphate and muriate of potash are the best source for phosphorus and potassium respectively. During the initial years fertilizers may be applied within the area covered by the crown canopy. In the case of older palms, fertilizers are applied depending on the concentration of roots and are usually applied in the weeded circle. Appropriate soil conservation methods such as growing cover crops and platform cutting (on sloppy lands) enhance the efficiency of fertilizers by preventing losses through run off.

**NUTRIENTS - FUNCTIONS AND DEFICIENCY SYMPTOMS**

The effect of major nutrients on growth and yield of oil palm has been studied in most of the oil palm growing countries in Asia and Africa.

a) Nitrogen: In oil palm, characteristic yellowing symptoms are developed under N deficiency conditions. Nitrogen is found to be essential for rapid growth and fruiting of the palm. It increases the leaf production rate, leaf area, net assimilation rate, number of bunches and bunch weight. Excessive application of nitrogen increases the production of male inflorescence and decreases female inflorescence thereby reducing the sex ratio.

b) Phosphorus: In oil palm seedlings, P deficiency causes the older leaves to become dull and assume a pale olive green colour while in adult palms high incidence of premature desiccation of older leaves occurs. Phosphorus application increases the bunch production rate, bunch weight, number of female inflorescences and thereby the sex ratio. However, lack of response to P due to P fixation in soils is very common in the tropics. Eventhough the main effect of phosphorus on the productivity of the palm has not been significant in most studies, it gives a positive interaction with nitrogen and potassium.

c) Potassium: When potassium is deficient, growth as well as yield is retarded and it is translocated from mature leaves to growing points. Under severe deficiency, the mature leaves become chlorotic and necrotic. Confluent orange spotting is the main K deficiency condition in oil palm in which chlorotic spots, changing from pale green through yellow to orange, develop and enlarge both between and across the leaflet, veins and fuse to form compound lesions of a bright orange colour. Necrosis within spots is common, but irregular. Mid crown yellowing is another prominent K deficiency condition of the palm in which leaves around the 10th position on the phyllotaxy become pale in colour followed by terminal and marginal necrosis. A narrow band along the midrib usually remains green. There is a tendency for later formed leaves to become short and the palm has an unthrifty appearance with much premature withering.

Potassium removal is large compared to the normal exchangeable K content in most top soils. It is mostly required for the production of more number of bunches, maximum number of female inflorescences, increased bunch weight and also for increasing the total dry matter production and yield.

d) Magnesium: In adult oil palm and in seedlings in the field, severe Mg deficiency symptoms are most striking and have been named as ‘orange frond’. While the lower most leaves are dead, those above them show a gradation of colouring from bright orange on the lower leaves to faint yellow on leaves of young and intermediate age. The youngest leaves do not show any discolouration. The most typical Mg-deficiency symptom is the shading effect in which the shaded portion of the leaflet will be dark green while the exposed portion of the same leaflet is chlorotic. Heavy rates of K applications induce Mg-deficiency, particularly on poor acid soils.

Among the secondary nutrients, calcium and sulphur, and probably chlorine, may not pose much problems to oilpalm cultivation in the country.

e) Micronutrients: Micronutrient elements, iron, manganese, copper and zinc are not generally found limiting in the nutrition of oil palm on acid soil conditions. Boron deficiency is occasionally found on young palms in the field showing a reduction of leaf area in certain leaves producing incipient 'little leaf', advanced 'little leaf' with extreme reduction of leaf area and bunching and reduction in the number of leaflets and 'fish-bone' leaf. The 'fish-bone' leaves are abnormally stiff with leaflets reduced to projections. Leaf malformations including 'hook leaf' and corrugated leaflets are some other associated symptoms. Soil application of 50 - 200 g borax, per palm, depending on age, and severity of symptoms is practiced for correcting the malady.

**WATER REQUIREMENT**

Continuous soil moisture availability encourages vigorous growth and increased yield of oil palm. Adequate supply of water, good soil depth and water holding capacity contribute to water availability. In oil palm as water deficiency increases, stomata will remain closed and the development and opening of spear will be inhibited. Water deficiency adversely affects flower initiation, sex differentiation and therefore, results in low sex ratio due to production of more male inflorescences. It is established that oil palm needs 120 - 150 mm of water to meet its monthly evapo-transpiration needs. In areas where perennial water source is available, basin irrigation is possible. But where the terrain is undulating and water is scarce during summer months, drip irrigation is recommended to keep four drippers per palm in the weeded palm circle to supply atleast 90 litres of water per palm per day during summer months which will vary according to the ETP values in a locality.

**FERTIGATION**

Drip fertigation with the recommended dose of fertilsers at bimonthly interval was found to increase the yield.

**WEED CONTROL**

The basin area of oil palm is kept free of weed growth through ring weeding. It is more important for young palms, roots of which are to be kept free from competition from weed. Depending on the extent of weed growth and rainfall, hand weeding is carried out even upto four times in a year during early years of the plantation which is progressively reduced to two rounds a year.

Herbicide application has become common in recent years. Care must be taken in the choice of herbicide and its application to prevent the damage of young palms. It is recommended to preferably apply contact herbicides rather than translocated herbicides. Translocated herbicides like Paraquat which is inactivated when contacted with soil are also used. Herbicides such as 2, 4-D, 2, 4- 5-T, halogenated aliphatic acids Dalapon and TCA are found to produce abnormalities in oil palm seedlings and are to be avoided. Pre-emrergence Atrazine @ 1.0 kg/ha for the control of grasses and sedges and POE Paraquat 10 ml / litre of water.

**MAINTENANCE OF PATHS**

In young plantation, the maintenance of paths is important for inspection and in later years for harvesting. This is carried out by timely weed control as done in the case of ring weeding.

**ABLATION**

The bunches produced initially will be very small and have low oil content. Removal of such inflorescences is called ablation or castration. Removal of all inflorescences during the initial three years is found to improve vegetative growth of young palms so that regular harvesting can commence after three and half years of planting. Ablation is done at monthly interval by pulling out the young inflorescence using gloves or with the help of devices such as narrow bladed chisels. Ablation improves drought resistance capacity of young palms by improving shoot and root growth especially in low production areas where dry condition exists.

**PRUNING OF LEAVES**

In oil palm two leaves are produced per month. Therefore, it becomes necessary to prune excess leaves so as to gain access to bunches for harvest. Severe pruning will adversely affect both growth and yield of palm, cause abortion of female flowers and also reduce the size of the leaves. It was suggested that palms aged 4 - 7 years should retain 6 - 7 leaves per spiral (48 - 56), those aged 8 - 14 years 5 - 6 leaves per spiral (40 - 49) and those above 15 years should have 4 - 5 leaves per spiral (32 - 40). Leaf pruning is carried out in India using chisels so that leaf base that is retained on the palm is as short as possible or otherwise it may catch loose fruits, allow growth of epiphytes and the leaf axils form a potential site for pathogens. The leaf petioles are removed by giving a clear cut at a sufficient distance from the base of the petiole using a sharp chisel for young palms and with the long sickle in taller palms.

Pruning is preferably carried out at the end of the rainy season. It is also better to carry it out during the low crop season when labourers are also available. Pruning is confined to only lower senile leaves during initial harvests but when canopy closes in later years, leaves are cut so as to retain two whorls of fronds below the ripe bunch.

**Insect pollination in oil palm**

The oil palm, hitherto though to be wind pollinated, has been now proved to be an a insect pollinated species. From West Africa, the original home of oil palm, eight species of pollinating weevils were reported. Occurence of ***Eldeidobius kamerunicus*** in the oil palm plantations of Kerala was introduced during 1985 from where it was introduced and got established in little Andamans during 1986.

The weevils are dark brown in colour. Adult weevils feed on the anther filament. Eggs are deposited inside the male flowers and larva feeds on the spent flowers. Life-cycle is completed within 11 to 13 days. Males live longer than females. The activity of the insects is in accordance with the receptivity of the male and female inflorescences.

It was roughly estimated that 40 palms in a grove might be the minimum to sustain a sufficiently high continuous population of pollinators to pollinate. All are receptive female inflorescences. The weevils carry maximum pollen during the third day of antheses. Antennae, rostrum, thorax, legs etc. are the main sites of pollen land. E.kamerunicushas a fairly good searching ability. It can survive in dry as well as in wet seasons.

Introduction of weevil in India increased the fruit let from 36.8 percent to 56.1 percent resulting in 40 per cent increase in F/B ratio. The maximum attainable pollination potential was as much as to cent percent with 57 percent increase in FFB weight.

For introduction, male flowers cut from palms which have the weevils are transferred to a plantation where one wishes to introduce. In order to make sure that they are not carrying any plant pathogens to other area/countries, we have to breed them under laboratory conditions for seven or eight generations before introduction.

**Pest Management**

In India, since the import of germplasm is in the form of seeds/sprouts, possibilities for introduction of the pest species from other countries are limited. But many of the pest species of related palm species such as coconut and areca palm, have got adapted to oil palm. Among the 49 species of insects infesting adult oilpalms, 14 species are known pests of coconut and 19 species are known pests of areca palms. Insect pests of oilpalm in India are more or less same as those reported from Malaysia and other South-East Asian countries.

## PEST OF ADULT PALMS

**The rhinoceros beetle**

The rhinoceros beetle is primarily a serious pest of coconut palm, and in recent years has attained the pest status in oilpalm also. The adult beetle which bores through into the spear leaves, resulting in snapping of the fronds at the feeding sites. In oil palm plantations failed female inflorescences, dead palm trunks, persistent leaf axils and empty bunch heaps, act as breeding sites for the pest.

**The red palm weevil**

Infestation by the red palm weevil Chynchophorus ferrungineus was noticed in majority of oil palm plantations resulting in the death of the palms. Damage is due to the feeding activity of the grubs, usually 12-87 per palm, which bore through and feed on the softer tissues of stem and meristem. Palms infested by R.ferrugineus show gradual wilting and drying of outer whorl of fronds. In some cases roofing of spear was also noticed.

**Biological control**

In nature, the rhinoceros beetle is suppressed by entomophogens like *Baculovirus oryctusvirus* and *Metarhizium anisopliae*. Release of *Baculovirusoryctes minimise* the pest incidence.

**Cultural control**

i) Field sanitation and elimination of breeding sites like dead palm trunks, empty bunch heaps etc., within the plantations are essential for the management of both red palm weevil and rhinoceros beetle.
ii) When the infestation by rhinoceros beetle is very high, especially in young plantations, Hand picking of the adult beetles using hooks is very effective.
iii) For red palm weevils, use of attractants incorporating fermented sugarcane juice, acetic acid, yeast etc., to collect and kill the adult weevils is recommended.

**Chemical control**

i) For rhinoceros beetles, placing 3-4 napthalene balls in the youngest spear axils at weekly intervals is recommended.
ii) For palms with advanced stage of infestation by red palm weevil, stem injection of 5-8 ml of monocrotophos is advised.

**Fruit bunch covering against avian pests**

Covering the bunches with different materials such as noirenets, reed baskets, plaited coconut leaf baskets and senile oil palm leaf are effective in preventing the fruit damage. But senile oil palm leaf covering is more practical and economical as the material is readily available and involves only the labour charges and cost of rope bits.

**Rodent control**

Among rats, the burrowing type is more serious which tunnel into the bole of the seedlings. Different baits such as acute poison baits (Zinc phosphide, Aluminium phosphide etc.) anticoagulants (warfarin, fumarin, bromadiolone) and traps such as iron like traps, snap traps, deathfall trap, boro trap etc. may be used as an integrated approach to minimise the rodent damage to the crop.

**Disease**

Oil palm, a new crop to the country is reported to be affected by a number of diseases and disorders. Among these, bud rot causes considerable economic losses.

**Bud rot**

- Higher disease incidence is noticed in young plantations. Rotting initiates at the basal portion of the spear closure to the meristem and extends to the whole spear. The spear could be easily pulled off.
- Cleaning the affected tissues and drenching the crown with carbendazim 0.1 percent cures the disease.
- The leaves emerging immediately after the application of fungicides are shorter and successively emerging ones are normal.

**Leaf spots**

- Leaf spots caused by *Curvularia* noticed on the inner whirl and young leaves. The fungal spots enlarge with a yellow ring around spots. As these spots enlarge the leaf will be scorched.
- *Pestalotiopsis* fungal spots are irregular with grey to brown centre. Numerous black dots, the acervuli of the fungus, are seen on the lesions.

**Management**

Affected leaves must be cut and burnt Spray Mancozeb @ 0.2%.

**HARVESTING**

Proper and timely harvesting of fruit bunches is an important operation which determines the quality of oil to a great extent. The yield is expressed as fresh fruit bunches (FFB) in kg per hectare per year or as oil per hectare per year. The bunches usually ripen in six months after anthesis. Unripe fruits contain high water and carbohydrate and very little oil. As the fruit ripens oil content increase to 80 - 85% in mesocarp. Over ripe fruit contains more free fatty acids (FFA) due to decomposition and thus increases the acidity. Usually the ripe fruits, attached to the bunches contain 0.2 to 0.9% FFA and when it comes out of extraction plant the FFA content is above 3%.Ripeness of the fruit is determined by the degree of detachment of the fruit from bunches, change in colour and change in texture of the fruit. Ripening of fruits start from top downwards, nigrescens fruits turning reddish orange and the virescens (green) to reddish brown. Fruits also get detached from tip downward in 11 - 20 days time. Ripeness is faster in young palms than in older palms for the bunches of equal weight. The criteria used in determining the degree of ripeness based on the fruit detachment are as follows:

a) fallen fruits: 10 detached or easily removable fruits for young palms and 5 for adult palms,
b) number of fruits detached after the bunch is cut; 5 or more fruits/kg of bunch weight,
c) quantity of detachment per bunch; fruit detachment on 25% of visible surface of bunch.

These criteria could be applied with flexibility.

**FREQUENCY OF HARVESTING**

Harvesting rounds should be made as frequent as possible to avoid over ripening of bunches. A bunch which is almost ripe but not ready for harvest for a particular harvesting round should not be over-ripe by next round. In lean period of production, harvesting can be made less frequent and it should be more frequent in peak periods. Harvesting rounds of 7 - 14 days are generally practiced. Other factors determining frequency are, extraction capacity of the mill, transportation facilities, labour availability and skill of the workers. In India, harvesting is usually carried out with a chisel of 6 - 9 cm wide attached to a wooden pole or light hollow aluminium pipe, Bunches are cut without damaging the petiole the leaf that supports it. Use of narrow chisel is usually carried out till the palm reaches two meters above the ground. For taller palms upto 4 meters, a wider chisel of 14 cm is used. The curved knife is attached to a long bamboo or aluminium pole with screws or steel wires to harvest from taller palms. In uneven stands, an adjustable, telescopic type of pole is in use.

**Yield of Oilpalm**

In well maintained garden the yield of oilpalm will be as furnished below :

| Age of oilpalm | Yield Ton/ha/year |
|---|---|
| 3-4 years | 5 |
| 4-5 years | 12 |
| 5-6 years | 25 |
| 6-25 years | 30 |

**ECONOMICS**

A detailed account of the economics of oilpalm cultivation in India has been furnished. The data furnished therein is modified using current labour charges and oil price and the details on various investments and returns from one hectare adult plantation. This excludes the cost of land as we expect government owned land, leased land, or already owned property will be used for oilpalm cultivation. From the fourth year, the yield of bunches increases upto tenth year, and a stabilized bearing is attained thereafter. The investment during first year under irrigation will be almost three times of that under rainfed conditions mainly on account of the initial expenditure required to install the drip irrigation system. With irrigation the annual returns will exceed the annual expenses from the first harvest itself, i.e, during the fourth year after planting. By the end of sixth year the total returns will be more than total investments including all the expenditure for installing pumpset and the drip irrigation system. A minimum of 22 FFB per hectare can be expected from the tenth year onwards.

**TABLE 1 - COST OF PRODUCTION AND (Rs.) PER HECTARE**

| S. No. | Particulars | Cost of production |
|---|---|---|
| 1 | Labour cost for 200 Nos. @ Rs.120/- per day as casual labour | 24,000 |
| 2 | Fertilizer cost | 5000 |
| 3 | Plant Protection cost | 500 |
| | **Total cost of production** | **29,500** |

**TABILE 2 : INCOME FROM OILPALM GARDEN DEPENDING UPON THE BUNCH PRODUCTION**

| S.No. | No. of Bunches/ tree/year | FFB yield t/ha/year | Gross Income Rs./ha/year | Net income (Gross income cost) Rs./ha/year |
|---|---|---|---|---|
| 1 | 10 bunches @ 10kg/tree/year | 14.3 | 1,02,960 | 73,460 |
| 2 | 12 bunches @ 15kg/tree/year | 25.7 | 1,85,040 | 1,55,540 |
| 3 | 12 bunches @ 20kg/tree/year | 34.3 | 2,46,960 | 2,17,460 |

# (viii) NIGER (Guizotia abyssinica)

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 35 | 10 - 15 | 15 - 28 | 650 - 1000 | 1000 - 1250 |

Tropical and subtropical dry climate. It can grow in semi-shade or full sun. Flowering was very delayed at day lengths of more than 12 hours.

## CROP IMPROVEMENT

## I. SEASON AND VARIETIES

| DISTRICT/SEASON | VARIETIES |
|---|---|

**A. Rainfed**

**1. Adippattam (June- July)**
Dharmapuri, Krishnagiri, Hilly regions of Shevroy, Kolli hills, Jawad hills and Thalavadi hills

**2. Purattasipattam (Sep-Oct)** Dharmapuri, Krishnagiri, Hilly regions of Shevroy, Kolli hills, Jawad hills and Thalavadi hills, Dharmapuri, Krishnagiri, Hilly regions of Shevroy, Kolli hills, Jawad hills and Thalavadi hills

**3. Purattasipattam (Sep-Oct)** Dharmapuri, Krishnagiri, Hilly regions of Shevroy, Kolli hills, Jawad hills and Thalavadi hills

## I. DESCRIPTION OF NIGER VARIETIES

| Particulars | Paiyur 1 |
|---|---|
| Parentage | Mass selection from Composite II |
| Duration (days) | 80 |
| Yield (kg/ha) | |
| Rainfed | 260 |
| Oil content (%) | 44.6 |
| Plant height (cm) | 80-85 |
| Branches | Profuse |
| Days to 50 % flowering | 50 |
| Seed size | Bold |
| Seed colour | Brown |

# CROP MANAGEMENT
## I. PREPARATION OF THE FIELD

**1. FIELD PREPARATION**

a) Plough with tractor 2-3 times with a mould board plough or 5 times with a country plough.

b) Break the clods in between the ploughings and bring the soil to a fine tilth.

**2. APPLICATION OF FYM**

a) Spread 12.5 t of FYM or compost or composted coir pith per ha evenly and incorporate in the soil. b) If the manure is not applied before commencement of ploughing, spread the manure evenly before the last ploughing and incorporate in the soil.

*NOTE: Do not leave the organic manure exposed to sunlight as nutrients will be lost.*

**3. APPLICATION OF FERTILIZERS**

Apply N at 20 kg/ha basally.

**4. SEED RATE**

Adopt a seed rate of 5 kg/ha.

**5. SPACING**

Adopt a spacing of 30 cm between rows and 10 cm between plants.

**6. SELECTION OF GOOD QUALITY SEEDS**

Select mature good quality seeds, free from pest damage and fungal attack.

**7. PRE-TREATMENT OF SEEDS WITH FUNGICIDES**

a) Treat with Carbendazim or Thiram at 4 g/kg of seed in a polythene bag and ensure a uniform coating of the fungicide over the seed. b) Treat the seeds 24 hours prior to sowing.

*NOTE: Seed treatment will protect the young seedlings from root rot disease in the early stage.*

**8. SOWING**

a. Sow the seeds in line at a depth of 2 to 3 cm and cover with soil. b. Sow using gorru or country plough.

**9. THINNING OUT SEEDLINGS**

Thin out the seedlings to a spacing of 10 cm between plants on the 15th day of sowing.

**10. WEED MANAGEMENT**

Hoe and weed on $20^{th}$ and $35^{th}$ day of sowing.

## 11. HARVESTING

i) Observe the crop considering the average duration of the crop.
ii) The leaves and entire plant loose their colour and turn brown at maturity.
iii) Cut the plants at the bottom.
iv) Keep the plants in the threshing floor and beat the plants (heads) with sticks till the mature seeds are separated.
v) Winnow the seed and dry in the sun.
vi) Collect and store the seeds in gunnies.

**CROP PROTECTION**

**Pre-Treatment of Seeds with fungicides**

Treat with Carbendazim or Thiram at 4 g/kg of seed in a polythene bag and ensure a uniform coating of the fungicide over the seed. Treat the seeds 24 hours prior to sowing.

*NOTE: Seed treatment will protect the young seedlings from root rot disease in the early stage.* Varietal production seed

## VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production leave a distance of 200 m all around the field from the same and other varieties of niger.

**Spacing**

- 30 x 30 cm

**Fertilizer**

- Apply NPK @ 40 : 40 : 20 kg $ha^{-1}$ as basal application.

**Harvesting**

- Harvest the crop as whole plants at 85 days after sowing, when the seeds attained physiological maturation.

**Seed grading**

- Grade the seeds using BSS 16 x 16 wire mesh sieve.

**Seed treatment**

- Slurry treat the seeds with carbendazim @ 2g $kg^{-1}$ of seed (or)
- Slurry treat seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1) @ 3g $kg^{-1}$ of seed as eco – friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8-9 months) with seed moisture content of 8 - 9%.
- Store the seeds in polylined gunny bag for medium term storage (12- 15 months) with seed moisture content of 7 – 8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than15 months) with seed moisture content of less than 5%.

**Other management practices**

- As in crop management techniques.

# 6. FIBRE CROPS

## (i) CLIMATE REQUIREMENT OF COTTON

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 12 | 27 - 32 | 500 - 700 | Up to 1500 |

Tropical warm season crop. A daily mean temperature of 16°C for seed germination, 21 - 27°C for proper vegetative growth and 27 - 32°C for fruiting phase. Abundant sunshine during boll maturation and harvesting is essential to obtain a good quality crop produce. Heavy showers of rain or heavy irrigation during fruiting period cause shedding of flowers and young bolls.

## I. SEASON AND VARIETIES

| District/Season | Varieties/Hybrids |
|---|---|
| **Irrigated (Main)** | |
| **Winter Irrigated (Aug – Sep)** | |
| Coimbatore, Erode, Madurai, Dindigul, Theni, Salem, Namakkal | MCU 5, MCU 5VT, Suraj, MCU 13, Surabhi, Suvin, CO 14 |
| Dharmapuri | MCU 5, MCU 5VT, Suraj, MCU 13, Surabhi, CO 14 |
| Cuddalore, Villupuram | LRA 5166, SVPR 2, SVPR 4, Surabhi, CO 14 |
| Madurai, Virudhunagar, Tirunelveli, Trichy, Salem, Erode, Dindigul | SVPR 5 |
| **Summer – Irrigated (Feb – Mar)** | |
| Erode | MCU 5, MCU 12, MCU 13, Surabhi |
| Madurai, Virudhunagar, Dindigul, Tirunelveli, Thoothukudi, Theni, Ramanathapuram, Sivagangai, | MCU 5, SVPR 2, SVPR 4, Surabhi, SVPR 5, SVPR 6 |
| **Rainfed (Sep – Oct)** | |
| Madurai, Dindigul, Theni, Ramanathapuram, Virudhunagar, Sivagangai, Tirunelveli, Thoothukudi, Dharmapuri, Perambalur, Trichy | LRA 5166, K11, KC 2, SVPR 2,KC 3, SVPR4, K12 |
| **Rice Fallow** | |
| Thanjavur, Tiruvarur, Nagapattinam, Karur, Cuddalore and Villupuram | MCU 7, SVPR 3 |

## II. PARTICULARS OF COTTON VARIETIES/HYBRIDS

| Varieties/ Hybrids | Year of Release | Year of Notification | Parentage | Season | Irrigated/ Rainfed | Mean yield of seed (kg/ha) | Special features |
|---|---|---|---|---|---|---|---|
| MCU 5 | 1968 | | Multiple cross | Aug-Oct Feb-Mar | Irrigated | 1850 | Extra long staple (29 mm MHL), Can spun upto 70s, ginning 34% |
| MCU 7 | 1972 | SO.596(E)/ 13.08.1984 | X ray irradiation of X L 1143 EE | Jan-Feb | Rice fallows | 1330 | Medium staple (23.7 mm MHL), Can spun upto 30s, early maturing with 33.2% ginning outturn. Tolerant to Black arm |
| MCU 12 | 1999 | SO.821(E)/ 13.09.2000 | Derivative from the cross LRA 5166 x MCU 11 | Aug-Oct | Irrigated | 2000 | Shorter in duration than MCU 5, GOT 34.8% Can spun upto 50s |
| MCU 13 | 2004 | SO.1177(E)/ 25.08.2005 | It is a multiple cross derivative involving the parents of [(TCH 665 x LS 149) x (TCH 665 x TCH 21)] x (TCH 21 x EECH) x (TCH 92-7 x EECH) | Aug-Oct Jan-Feb | Irrigated | 2200 | Early duration Can spun upto 50s |
| CO 14 | 2016 | SO.2238(E)/ 29.06.2016 | (MCU5/TCH92-7) x MCU 5-1 | Aug-Oct | Irrigated | 1768 | Extra long stable cotton (2.5% span length - >35.0mm), Ginning outturn: 34.8%, capable for spinning upto 70s count. |
| SVPR 2 | 1996 | SO.360(E)/ 01.05.1997 | TSDT 22 x JR 36 | Feb - Mar Sep-Oct | Irrigated Rainfed | 2000 | High ginning out turn of 36.4%, medium staple (24.3 mm), can spin 30's, suited to summer irrigated, winter rainfed and tankfed rice fallow tracts of Tamil Nadu. |
| SVPR 3 | 2000 | SO.821(E)/ 13.09.2000 | Selection from L.H 900 x 1301 D.D | Jan-Feb | Rice fallows | 1800 | Suitable for rice fallow tract, early duration (135-140 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | days), Tolerant to drought, leafhopper, alternaria spot, black arm disease. |
| SVPR 4 | 2009 | SO.2137(E)/ 31.08.2010 | Hybrid derivative of MCU 5x S4727 | Feb-Mar Sep- Oct | Irrigated Rainfed | 1800 | Superior medium staple cotton with good fibre strength. suitable for spinning 40's yarn. |
| SVPR 5 | 2014 | SO.3540(E)/ 22.11.2016 | Cross derivative of NDLH 1658 x Surabhi | Aug - Sep Feb- March | Irrigated | 1845 | Long staple - 29.0mm (UHML), Bundle strength 27.8g/tex(HVI mode), can spin 40 - 50's counts, moderately resistant to Jassid. |
| SVPR6 | 2017 | SO.1379(E)/ 27.03.2018 | Cross derivative of SVPR 2 x BJA 592 | Feb- March | Irrigated | 2312 | Long staple 29.1mm (UHML), Bundle strength 27.3 g/tex(HVI mode), Can spin 40's count, Moderately resistant to Jassid. |
| KC 2 | 1997 | SO.647(E)/ 09.09.1997 | MCU 10 x KC 1 | Sep - Oct | Rainfed | 1000 | High ginning out turn of 37.5%, medium staple cotton - 24.4 mm, Suited for rainfed black cotton soil of Tirunelveli, Thoothukudi and Virudhunagar Districts. |
| KC 3 | 2006 | SO.1178(E)/ 20.07.2007 | Hybrid derivative of TKH 97x KC1 | Sep- Oct | Rainfed | 1080 | Resistant to leaf hopper, medium staple cotton – 26.4 mim, suited to southern districts of Tuticorin, Tirunelveli and Virudhunagar District. |
| MCU 5 VT | | | Selection from MCU 5 | Aug-Oct | Irrigated | 2500 kg/ha | Long staple variety capable of spinning |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | | | | | upto 60 ‘s count yarn |
| Suraj | | | LRA 5166 (CCH 326612 x HLS 329) | Aug-Oct | Irrigated | 2500 kg/ha | Long staple and suitable for high density planting system |

| **Varieties/ Hybrids** | **Year of Release** | **Year of Notification** | **Parentage** | **Season** | **Irrigated/ Rainfed** | **Mean yield of seed (kg/ha)** | **Special features** |
|---|---|---|---|---|---|---|---|
| K 11 | 1993 | SO.360(E)/ 01.05.1997 | (0794-1-DX H 876) x (0794-1-DX H 450) Multiple Hybrid derivative | Sept – Oct | Rainfed | 1100 | Better fibre properties with lesser pest incidence than K10 |
| K12 | 2017 | SO.399(E)/ 24.01.2018 | K11 x K9 | Oct-Nov | Winter rainfed | 1193 | Early duration: 135-140 days, 2.5% span length 27.7mm, can spun upto 30’s counts. Resistance to drought, leaf hopper |
| LRA 5166 | | | Laxmi x Reba B.50 x AC 122 | Aug-Oct Jan – Feb | Irrigated Rainfed | 1800 725 | Medium staple (29 mm), can spun upto 40s, ginning 36.2% |
| Surabhi | | | MCU 5 VT (MCU 5 x *G.mexicanum*) | Aug-Oct | Irrigated | 2200 | Extra long staple, *Verticillium* wilt resistant |
| Suvin | | | Hybrid derivative from the cross Sujatha x St. Vincent | Aug-Oct | Irrigated | 1020 | Extra long staple cotton with 28% ginning outturn and 32 mm MHL, spins 100s |

Extra long staple : CO 14 and Suvin
Long staple : SPVR 5, SVPR 6, MCU 5, MCU 5 VT, MCU 12 , MCU 13,Surabhi and Suraj
Superior medium staple : LRA 5166, SVPR4, KC 3 and K 12
Medium staple: SVPR 2, SVPR 3, MCU 7 and KC 2
Short staple: K 11
***Gossypium hirsutum* :**CO 14, Surabhi, SPVR 5, SPVR 6, MCU 5, MCU 5 VT, MCU 12 , MCU 13, LRA 5166, SVPR 2, SVPR 3, SVPR 4 , MCU 7, KC 3, KC 2, Suraj
***Gossypium barbadense***: Suvin
***Gossypium arboreum*** : K 11 and K12
Variety suitable for high density planting : Suraj , CO 15,KC 3, Karunganni Cotton K 12

**Definition/terminologies**

**Staple length**

Graders estimate the fibre length by hand stapling and is called staple length and expressed in millimeter.

**Microniare**

It is the measure of the index of the fibre diameter and is assessed by determining weight per unit length of the fibre. It is expressed in micronaire value (µg/inch).

**Fibre strength**

Fibre strength is generally considered to be next to fibre length and fineness. It is referred as bundle or tensile strength, essential for high speed spinning. It determines yarn strength. Unit of this parameter was expressed in gms/tex.

**Uniformity ratio**

It is the ratio of 50% span length to 2.5% span length expressed as percentage.

$$\text{Uniformity ratio} = \frac{\text{50\% span length x 100}}{\text{2.5\% span length}}$$

**Maturity - Coefficient:**

The maturity of cotton fibres is expressed by the maturity ratio parameter, which is calculated on the basis of the fibre circularity coefficient , defined as the ratio of the cell wall area and that of a circle of the same perimeter as the fibre cross-section.

## CROP MANAGEMENT
## I. PREPARATION OF FIELD FOR IRRIGATED COTTON
## CROP FIELD PREPARATION

### 1.1.1 PREPARATION OF THE FIELD

i) Prepare the field to get a fine tilth.

ii) Chiselling for soils with hard pan: Chisel the soils having hard pan formation at shallow depths with chisel plough at 0.5 M interval, first in one direction and then in the direction perpendicular to the previous one, once in three years. Apply 12.5 t farm yard manure or composted coir pith/ha besides chiselling to get increased yield

iii) If intercropping of Greengram/Soyabean is proposed, prepare the main field, so as to provide ridges and furrows to take up sowing 20 days prior to cotton sowing.

### 1.1.2. APPLICATION OF FYM/COMPOST AND BIOFERTILIZERS

Spread 12.5 t of FYM or compost or 2.5 t of vermicompost per ha if available, uniformly on the unploughed soil.

Apply 2 kg of *Azospirillum +* 2 kg Phosphobacteria (or) 2 kg of Azophos + 2 kg Pink Pigmented Facultative Methylotroph (PPFM) with 25 kg of FYM and 25 kg of sand, mix uniformly before sowing as soil application.

### 1.1.3. PRE-TREATMENT OF ACID DELINTED SEEDS WITH BIOFERTILIZER

Treat one hectare of seeds with 600g of *Azospirillum,* 600g of Phosphobacteria (or) 600 g of Azophos + 600 g of Silicate Solubilizing Bacteria.

**Liquid formulation** Treat one hectare of seeds with 125 ml of *Azospirillum,* 125 ml of Phosphobacteria and Silicate solubilizing bacteria (SSB) shade dry for 30 minutes before sowing.

### 1.1.4. FORMATION OF RIDGES AND FURROWS

i) Form ridges and furrows 10 m long with appropriate spacing depending upon the variety.
ii) Use ridge plough or bund former to form ridges so as to economise on cost of cultivation.
iii) In fields with ragi stubbles, just dibble cotton seeds at the specified spacings.
iv) Adopt the following spacing between ridges for different varieties/hybrids.

| **Varieties/Hybrids** | **Spacing between ridges (cm)** |
|---|---|
| MCU 5, SVPR 2, LRA 5166, MCU 12, MCU 13 | 75 |
| Suvin | 90 |
| MCU 7 | 60 |

*NOTE: Adopt higher spacing rows in fertile soils by 15 to 30 cm.*

### 1.1.5. APPLICATION OF INORGANIC FERTILIZERS

v) If soil test recommendations are not available, follow the blanket recommendation for the different varieties.

| **Varieties / Hybrids** | **Quantity of fertilizers (Kg/ha)** | | |
|---|---|---|---|
| | **N** | **$P_2O_5$** | **$K_20$** |
| MCU 7, SVPR 3 | 60 | 30 | 30 |
| MCU 5, MCU 12, MCU 13,Suvin, SVPR 2 | 80 | 40 | 40 |

ii) If basal application could not be done, apply on the 25$^{th}$ day after sowing.
iii) Apply 50 per cent of N and K full dose of $P_2 O_5$ as basal and remaining ½ N and K at 40 – 45 DAS for varieties. For hybrids apply N in three splits *viz*., basal, 45 and 65 DAS.

Soil test crop response based integrated plant nutrition system (STCR- IPNS recommendation may be adopted for prescribing fertilizer doses for specified yield targets (ready reckoners are furnished )

**Cotton -Variety (1)**

Soil : Mixed blackcalcareous (Perianaickenpalayam series)
Target : 2.5 - 3.0 t ha$^{-1}$

FN = 8.81 T-0.62 SN
$FP_2O$= 2.53T-1.36SP
$FK_2O$=4.92T-0.25SK

| **Initial soil test values (kg ha$^{-1}$)** | | | **Yield target – 2.5 t ha$^{-1}$** | | | **Yield target – 3.0 t ha$^{-1}$** | | |
|---|---|---|---|---|---|---|---|---|
| | | | **NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$** | | | **NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$** | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 180 | 10 | 300 | 54 | 20* | 20* | 98 | 30 | 33 |
| 200 | 12 | 340 | 41 | 20* | 20* | 85 | 28 | 23 |
| 220 | 14 | 380 | 40* | 20* | 20* | 73 | 25 | 20* |
| 240 | 16 | 420 | 40* | 20* | 20* | 61 | 22 | 20* |
| 260 | 18 | 460 | 40* | 20* | 20* | 48 | 20* | 20* |

* Maintenance dose

**Cotton - Variety (2)**

Soil : Red sandy loam (Irugur series)

Target : 2.5 and 3.0 t ha$^{-1}$

FN = 7.66T-0.43 SN-0.71 ON

$FP_2O_5$ = 3.22T-3.27 SP-0.87 OP

$FK_2O$ = 5.97T-0.50SK-0.66 OK

| Initial soil test values (kg ha$^{-1}$) | | | Yield target – 2.5 t ha$^{-1}$ NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | Yield target – 3.0 t ha$^{-1}$ NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 180 | 10 | 200 | 59 | 20* | 20* | 97 | 32 | 39 |
| 200 | 12 | 220 | 51 | 20* | 20* | 89 | 25 | 29 |
| 220 | 14 | 240 | 42 | 20* | 20* | 80 | 20* | 20* |
| 240 | 16 | 260 | 40* | 20* | 20* | 72 | 20* | 20* |
| 260 | 18 | 280 | 40* | 20* | 20* | 63 | 20* | 20* |

*Maintenance dose

**Cotton under Drip fertigation –Bt Hybrid (3)**

Soil : Mixed black calcareous (Perianaickenpalayam series)

Target : 3.5 - 4.0 t ha$^{-1}$

FN = 8.51 T-0.40 SN-0.73 ON

$FP_2O_5$ = 4.41T-2.25 SP - 0.75 OP

$FK_2O$ = 6.59T-0.18SK-0.66 OK

| Initial soil test values (kg ha$^{-1}$) | | | Yield target – 3.5 t ha$^{-1}$ NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | | Yield target – 4.0 t ha$^{-1}$ NPK (kg ha$^{-1}$) + FYM @ 12.5 t ha$^{-1}$ + *Azospirillum* @ 2 kg ha$^{-1}$ + PSB @ 2 kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 14 | 400 | 163 | 91 | 124 | 205 | 113 | 157 |
| 220 | 16 | 450 | 155 | 86 | 115 | 197 | 108 | 148 |
| 240 | 18 | 500 | 147 | 82 | 106 | 189 | 104 | 139 |
| 260 | 20 | 550 | 139 | 77 | 97 | 181 | 99 | 130 |
| 280 | 22 | 600 | 131 | 73 | 88 | 173 | 95 | 121 |

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg ha$^{-1}$, respectively; T is the yield target in q ha$^{-1}$; SN, SP and SK respectively are available N,P and K in kg ha$^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg ha$^{-1}$.
Apply 55 kg S as Gysum basally for a sulphur deficient soil.

iv) Foliar application of 2% DAP + 1% KCl or polyfeed and Multi k may be sprayed to improve kapas yield

v) Apply the fertilizers in a band, two-thirds of the distance from the top of the ridge, and incorporate.

**1.1.6.APPLICATION OF MICRONUTRIENT MIXTURE**

TNAU MN mixture 12.5 kg/ha for variety and 15 kg/ha for hybrid apply as enriched FYM. Enriched FYM is prepared at 1.10 ratio of MN mixture and FYM, mixed at friable moisture and for one month in shade. Need based foliar spray of 2% $Mgso_4$ + 1% urea during boll formation stage.

Mix 12.5 kg of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu with enough sand to make a total quantity of 50 kg for one ha.

**Yield Maximization and reducing reddening in Bt cotton**
**Irrigated**

Application of TNAU MN mixture (12.5 kg $ha^{-1}$ as EFYM for variety and 15 kg $ha^{-1}$ as EFYM for Bt cotton) along with the recommended NPK to obtain the maximum seed cotton yield with reduced extent of leaf reddening..

**1.1.7. NUTRITIONAL DISORDERS**

a. In the case of Zinc deficient soils $ZnSO_4$ @ 50 kg/ha as basal or 0.5% $ZnSO_4$ spray thrice at 45, 60 and 75 DAS.
b. When reddening occurs in leaves apply 0.5% $MgSO_4$ + 1.0% urea + 0.1% $ZnSO_4$ foliar spray on $50^{th}$ and $80^{th}$ day to correct this malady.
c. Need based foliar spray of 2% $MgSO_4$ + 1.0% urea during boll formation stage to reduce magnesium deficiency.

**I. Main Field Operations**

**Seed Rate**

Adopt the following seed rates for different varieties/hybrids

| Varieties / Hybrids | Quantity of seed (Kg/ha) | | |
|---|---|---|---|
| | With fuzz | Delinted | Naked |
| MCU 5, MCU 7, MCU 12, MCU 13 | 15.00 | 7.50 | .. |
| SVPR 2 | 15.00 | .. | .. |
| KC 2 | 20.00 | 15.00 | .. |
| SUVIN | .. | .. | 6.00 |

**1.2.2. SPACING**

In a pure crop of cotton, adopt the spacing as below for the different varieties.

| Varieties / hybrids | Spacing ( cm) | |
|---|---|---|
| | Between rows | Between plants |
| MCU 5, MCU 12, MCU 13 | 75 | 30 |
| LRA 5166, SVPR 2 | | |
| KC 2 | 45 | 15 |
| SUVIN | 90 | 45 |
| MCU 7, SVPR 3 | 60 or 75 * | 30 |

* Fertile soils

a. If cotton intercropped with other crops, one paired row of cotton is alternated with three rows of intercrop and the total population of cotton crop is maintained at the same level as in the case of pure crop.
b. For intercropping with Greengram / Soyabean, complete the sowing and irrigation 20 days prior to cotton sowing on one side of the ridge.

| Varieties/hybrid | Spacing for cotton crop ( cm) | | |
|---|---|---|---|
| | Within Paired row | Between Paired rows | Between plants |
| MCU 5, MCU 12,MCU13 | 60 | 90 | 30 |
| SUVIN | 80 | 100 | 45 |

Plant two rows of intercrop between each paired row of cotton

| Intercrop | Seed rate(kg/ha) | Spacing (cm) | |
|---|---|---|---|
| | | Rows | Plants |
| Blackgram | 12.5 | 30 | 10 |
| Greengram | 12.5 | 30 | 10 |
| Cowpea | 7.5 | 30 | 20 |
| Soyabean | 20.0 | 30 | 10 |

For higher returns, advance sowing of either greengram or soyabean 20 days before sowing of cotton in winter season.

### 1.2.3.ACID-DELINTING OF COTTON SEEDS

i) Choose plastic bucket bucket for acid delinting of seeds.
ii) Do not use earthen wares, metal vessels, porcelain wares or wooden drum for acid delinting as concentrated sulphuric acid will corrode them.
iii) Put the required quantity of seeds in the container and add commercial concentrated sulphuric acid at the rate of 100 ml per kg of fuzzy seed.
iv) Stir vigorously and continuously with a wooden stick for 2 to 3 minutes till the fuzz sticking to the seeds is completely digested and the seed coat attains a dark brown colour of coffee powder.
v) Add water to fill the container. Drain the acid water and repeat the washing 4 or 5 times to remove any trace of acid.
vi) Remove the floating, ill-filled and damaged seeds while retaining the healthy and good seeds which remain at the bottom.
vii) Drain the water completely and dry the delinted seeds in shade.

**Advantages of Acid delinting**

i) Eliminates some externally seed borne pathogenic organisms.
ii) Kills eggs, larvae and pupae of pink boll worm.
iii) Helps to remove immature, ill-filled, cut and damaged seeds.
iv) Makes seed dressing more effective and easy
v) Facilitates easy sowing and good germination.

### 1.2.4.1.PRE-TREATMENT OF ACID DELINTED SEEDS WITH FUNGICIDES

i) Treat the delinted seeds with talc formulation of Trichoderma viride @ 4g/kg of seed or with Carbendazim (or) Thiram @ 2g/kg of seed.
Biocontrol agents are compatible with biofertilizers.
First treat the seeds with biocontrol agents and then with biofertilizers. Fungicides and biocontrol agents are incompatible.
ii) Treat the delinted fungicide treated seeds with 3 packets (600 g) of Azospirillum and 3 packets of phosphobacteria 600g (or) 6 packets of Azophos (1200 g) and sow immediately.

**1.2.4.2.SEED HARDENING**

Soak the seeds in equal volume of Pungam leaf extract (1%) for 8 hours and dry back to original moisture to increase germination and vigour. Dry the seeds in shade.

Seed pelleting: Seeds coated with arappu leaf powder (100 g/kg) along with DAP (40 g/kg), micronutrient mixture (15 g/kg) and Azospirillum (200 g/kg) phosphobacteria (200 g/ha) or Azophos (400 g/ha) using 5% maida solution or gruel as adhesive (300 ml/kg) to increase the germination and vigour.

**1.2.5.SOWING**

i) Dibble the seeds at a depth of 3-5 cm on the side of the ridge 2/3 height from the top and above the band where fertilisers and insecticides are applied, maintaining the correct spacing and then cover seeds with soil.
ii) In the case of intercropping, sow the seeds of the intercrop in between the paired rows of cotton in a row of 5 cm apart and cover the seeds.
iii) Sow the required number of seeds in each hole.

| Varieties / hybrids | No. of seeds / hole | |
|---|---|---|
| | Fuzzy seeds | Delinted seeds |
| Hybrids | 2 | 1 |
| Varieties | 3 | 2 |

**1.2.6. WEED MANAGEMENT**

i) Apply Pendimethalin @ 1.0 litre/ha three days after sowing or Fluchloralin 1.0 kg a.i /ha on 3DAS + power weeding on 45 DAS followed by earthing up or Trifloxy salfuron @ 10 g/ha on 15 DAS for broad leave weeds and sedges. Or Pre emergence application of Pendimathalin (38.7% CS) 650 ml/ha. Sufficient moisture should be present in the soil at the time of herbicide application. This will ensure weed free condition upto 40 days.
ii) One hand weeding on 45 DAS will keep weed free environment upto 60 DAS.
iii) Hoe and hand weed between 18th to 20th day of sowing, if herbicide is not applied at the time of sowing.

**1.2.7.GAP FILLING**

a. Take up gap filling on the 10th day of sowing.
   i) In the case of TCHB 213, raise seedlings in polythene bags of size 15 x 10 cm.
   ii) Fill the polythene bags with a mixture of FYM and soil in the ratio of 1:3.
   iii) Dibble one seed per bag on the same day when sowing is taken up in the field.
   iv) Pot water and maintain.
   v) On the 10th day of sowing, plant seedlings maintained in the polythene bags, one in each of the gaps in the field by cutting open the polythene bag and planting the seedling along with the soil intact and then pot water.

b. In the case of all other varieties, dibble 3 to 4 seeds in each gap and pot water.

**1.2.8.THINNING**

Thin out the seedlings on the 15th day of sowing. In the case of fertile soils, allow only one seedling per hole, whereas in poor soil allow two seedlings per hole.

### 1.2.9.TOP DRESSING

iv) Top dress 50% of the recommended dose of N and K on 40 – 45 DAS for varieties.

v) Top dress 1/3rd of recommended dose of N on 40-45 DAS and the remaining 1/3rd on 60- 65$^{th}$ DAS for hybrids.

### 1.2.10.RECTIFICATION OF RIDGES AND FURROWS

Reform the ridges and furrows after first top dressing in such a way that the plants are on the top of the ridges and well supported by soil.

### 1.2.11.SPRAYING OF NAPTHALENE ACETIC ACID (NAA)

Spray 40 ppm NAA at 60 and 90 days after sowing on the crop to prevent early shedding of buds and squares and to increase the yield.

*NOTE: 40 mg of NAA dissolved in one litre of water will give 40 ppm.*

### 1.2.12.MANAGEMENT STRATEGIES FOR DELAYED SUMMER IRRIGATED COTTON SOWING

KCl 1% spray, twice on 50 and 70 DAS for delayed sowing (first fortnight of March) of summer irrigated cotton in rice-cotton cropping system for Srivilliputhur region.

### 1.2.13.ARRESTING TERMINAL GROWTH

Nip the terminal portion of the main stem as indicated below:

For varieties having less than 160 days duration nip the terminal portion of the main stem beyond the 15th node (75 to 80 DAS) and for varieties and hybrids having more than 160 days duration beyond the 20th node (85 - 90 DAS).

## II. WATER MANAGEMENT

Regulate irrigation according to the following growth phases of the crop.

| Stages | No. of Irrigations | Days after dibbling seeds | |
|---|---|---|---|
| | | **Light soil** | **Heavy soil** |
| **Germination Phase(1-15 days)** | | | |
| Irrigate for germination | 1 | Immediately after sowing | Immediately after sowing |
| and establishment | 2 | Give a life irrigation on | Give a life irrigation on |
| | | 5th day of sowing to | 5th day of sowing to |
| | | facilitate the seedlings | facilitate the seedlings |
| | | to emerge out | to emerge out |
| **Vegetative phase (16-44 days)** | | | |
| Regulate | 1 | Irrigate on the 20th or | Irrigate on the 20th or 21st day |
| | | 21st day of sowing, three | of sowing, three days after |
| | | days after hoeing and | hoeing and weeding |
| | | Weeding | |
| | 2 | Irrigate again on | Irrigate again on |

| | | | |
|---|---|---|---|
| | | the 35th or 36th | the 40th day of |
| | | day of sowing | Sowing |
| **Flowering phase (45-100daysfor hybrids and 87 days for varieties)** | | | |
| Irrigate copiously | 1 | 48th day | 55th day |
| | 2 | 60th day | 70th day |
| | 3 | 72nd day | 85th day |
| | 4 | 84th day | 100th day |
| | 5 | 96th day | ** |
| **Maturity phase (beyond 100 days for hybrids and 88 days for varieties)** | | For all varieties other than Suvin | |
| Control irriga | 1 | 108th day | 115th day |
| tion during | 2 | 120th day | 130th day |
| maturity phase | 3 | 130th day | |
| | 4 | 144th day | |
| | Stop Irrigation after 150th day | | |
| | For Suvin | | |
| | 1 | 108th day | 115th day |
| | 2 | 120th day | 130th day |
| | 3 | 132nd day | 145th day |
| | 4 | 144th day | 160th day |
| | 5 | 158th day | ... |
| Stop irrigation after 160th day | | | |
| *NOTE: i.* | *If irrigation is given on climatological approach, Schedule the irrigation at 0.40 and 0.60 IW/CPE ratio during vegetative and reproductive phases respectively.* | | |
| *ii)* | *The irrigation schedule given above is only a guideline and regulate the irrigation* | | |
| | *depending upon the prevailing weather condition and receipt of rains.* | | |
| *iii)* | *Adopt alternate furrow or skip furrow irrigation to save irrigation water.* | | |

The features of the methods are furnished below:

**Skip furrow irrigation**

a) Suited to heavy soils like clay and loam
b) Alternate furrows should be skipped and may be converted to ridges having a wide bed formation.
c) Short term crops like pulses may be raised in wider bed without exclusive irrigation.
d) Water saving is 50% when compared to control.

**Alternate furrow irrigation**

a) During any one run of irrigation a particular set of alternate furrows is irrigated.
b) The interval of irrigation should be shortened when compared to the conventional furrows.
c) During the next run, the left over furrows be irrigated.
d) Suited to heavy soils like clay and loam.

## III. HARVESTING

a) Harvest at frequent intervals, at less than 7 days interval.
b) Harvest in the morning hours upto 10 to 11 a.m only when there is moisture so that dry leaves and bracts do not stick to the kapas and lower the market value.
c) Pick kapas from well burst bolls only.
d) Remove only the kapas from the bolls and leave the bracts on the plants.
e) After kapas is picked, sort out good puffy ones and keep separately.
f) Keep stained, discoloured and insect attacked kapas separately.

*NOTE: Do not mix stained, discoloured and insect damaged kapas with good kapas, as they will spoil the good kapas also and lower the market value of the produce.*

## IV.POST HARVEST OPERATIONS

1) Immediately after picking, dry the kapas in shade. If it is not dried immediately the colour will change which will lower the market value.
2) Do not dry the kapas under direct sun as the fibre strength and luster will be lost.
3) Grade the kapas into good and second quality ones, if it is not sorted out at the time of picking.
4) Spread a thin layer of dry sand on the ground and keep the kapas over it.

## RICE FALLOW COTTON

### 2.1.PREPARATION OF THE FIELD

i) If the soil is in waxy condition, instead of Zero tillage, the seed rows may be tilled and the seed dibbled in Virudhunagar district.
ii) If the soil is dry and not in condition to take up sowing, let in water and then allow the soil to dry till soil comes to waxy condition.
iii) At the lower level of the field dig a trench 15 cm wide and connect this trench to the outside channel to drain off the excess water.

### 2.2.PRE-TREATMENT OF ACID DELINTED SEEDS WITH FUNGICIDES

iv) Same as for the irrigated crop.
v) Treat the acid delinted and fungicide treated seeds with 3 packets (600g) of Azospirillum and sow immediately.

2.3.SOWING THE SEEDS

| Particulars | | | MCU 7 | SVPR 3 |
|---|---|---|---|---|
| a) Seed rate (kg/ha) | | | | |
| | i) | Fuzzy seed | 15.0 | 15 |
| | ii) | Acid delinted | 7.5 | 7.5 |
| b) Spacing (cm) | | | | |
| | i) | Between rows | 60 | 60 or 75* |
| | ii) | Between plants | 30 | 30 |
| c) Number of seeds / hole | | | | |
| | i) | Fuzzy seeds | 4 | 4 |
| | ii) | Acid delinted | 2 | 2 |
| d) Depth of sowing (cm) | | | 3 | 3 |

* In fertile soils

**2.4.FILLING UP GAPS**

vi) Fill up gaps on the 10th day of sowing.

vii) Dibble 2 to 3 acid delinted seeds or 4 to 5 fuzzy seeds in the gaps in the case of MCU 7 and SVPR 3

**2.5.THINNING SEEDLINGS**

viii) Thin out seedlings on the 20th day of sowing

ix) Leave only one healthy and vigorous seedling per hill.

**2.6. WEED MANAGEMENT**

i) Pre-emergence application of Pendimethalin 1.0 litre/ha ensures weed free condition for 40 - 45 days. This should be followed by one hand weeding and earthing up during 40 - 45 days.

ii) Take up hoeing and weeding 20 days after sowing.

iii) Take up this operation when the top soil dries up and comes to proper condition.

**2.7.APPLICATION OF FERTILIZERS**

a) Apply NPK fertilisers as per soil test recommendations. If soil test is not done follow the blanket recommendation of 60:30:30 kg NPK/ha.

b) Apply half the dose of N and K full dose of $P_5O_5$ at 35th day in old delta and balance in 55 days the rows of cotton plants. In the case New delta apply full P and 1/3 of N and K at 20 DAS and 2/3 N and K at 40 DAS.

**2.8.APPLICATION OF MICRONUTRIENTS**

Apply basally12.5 kg/ha micronutrient mixture prepared by Department of Agriculture. Apply $MgSo_4$ basally @ 30 kg/ha to prevent reddening.

**2.9.FORMATION OF RIDGES Old delta**

a) If soil is in condition, give a hoeing with mammutti and form ridges and incorporate the fertilizer in the soil around the plants between 30th to 35th day of sowing.

b) If soil is not in condition, give one hoeing and weeding and cover the fertilizers.

c) Form long ridges and furrows from one end of the field to the other without forming any separate channels for carrying water to prevent excessive soaking of water.

d) Form ridges and furrows on alternate rows of plants. Skip furrow method of irrigation to prevent excessive irrigation

**New delta**

a) Give a hoeing with mummutti and form ridges and incorporate the fertiliser in the soil around the plants on the 40th day of sowing.

b) If soil is not in condition give one hoeing and weeding and cover the fertilizers.

c) Form long ridges & furrows on alternate rows of plants to adopt skip furrow irrigation.

*Note: In case of zinc deficient soils, apply 50 kg ZnSo4 /ha*

**2.10. APPLYING OF NAA**

Spray 40 ppm of NAA (40 mg of NAA dissolved in one litre of water) at 40/45th day using high volume spray. Repeat the same dose after 15 days of first spraying.

**2.11. TOPPING**

Arrest terminal growth by nipping the terminal 15$^{th}$ node for controlling excessive vegetative growth. (70-75 DAS

**2.12.WATER MANAGEMENT**

Regulate irrigation according to the growth phases of the crops.

| Stages | No. of | Days after dibbling seeds | |
|---|---|---|---|
| | Irriga | | |
| | tions | Old delta | New delta |
| 1. Vegetative Phase | | | |
| Regulate irrigation | 1 | One wetting on the 30th | One irrigation on the 20th day |
| during the germination | | to 35th day of sowing after | after the application of fertilisers |
| phase | | the application of fertilisers | |
| | 2 | ... | One irrigation on the 40th day after the application of N |
| 2. Flowering Phase | | | |
| Irrigate more frequently | 1 | 45th day of sowing after the | 45th day |
| | | application of 2nd dose of N | |
| | 2 | 55th day | 51st day |
| | 3 | 65th day | 56th day |
| | 4 | 75th day | 61st day |
| | 5 | 85th day | 66th day |
| | 6 | ... | 71st day |
| | 7 | ... | 76th day |
| | 8 | ... | 81st day |
| | 9 | ... | 86th day |
| | 10 | ... | 91st day |
| 3. Control | 1 | 99th day | 98th day |
| Irrigation during | 2 | 113th day | 105th day |
| maturity phase | 3 | ... | 112th day |

Stop irrigation from the 113th day onwards.

*Note: 1) The irrigation schedule given above is only a guideline and regulate irrigation depending upon the prevailing weather conditions and receipt of rains.*

*2) Observe the crop and if the plants show wilting symptoms in the afternoon and in the evening hours, give an additional irrigation.*

Harvesting

Post harvest operation

As that of the irrigated cotton.

Pest and disease management

## RAINFED COTTON

Follow water harvesting techniques and raise a successful crop of cotton.

### 3.1. SEASON AND VARIETIES

For Thirumangalam in Madurai district, Sattur in Virudhunagar district and parts of Kovilpatti in Thoothukudi district, where the seasonal rainfall is 375 mm and most of it is received during September or first week of October. Select LRA 5166 (or) SVPR 2 (or) KC 2, KC 3.

In places, where rains are received during October or November, Select K 11 for Ramanathapuram, Virudhunagar, Tirunelveli and Thoothukudi districts.

### 3.2.PREPARATION OF LAND

#### 3.2.1.PREPARATION OF THE FIELD

i) Start preparation of the land immediately after harvest of the previous crop.
ii) Adopt permanent broad ridges system.

#### 3.2.2.APPLICATION OF FYM OR COMPOST

iii) Spread 12.5 t of FYM or compost or composted coir pith or 2.5 t of vermicompost per ha uniformly on the unploughed soil.
iv) Incorporate the manure in the soil by working the multipurpose implement or country plough.
v) Apply TNAU MN mixture @ 7.5 by as enriched FYM.

#### 1.2.3. APPLICATION OF INORGANIC FERTILIZERS

i) Apply NPK fertilizers as per soil test recommendation as far as possible.
ii) If soil tests are not done, follow the blanket recommendations for the different varieties.

| Varieties | Quantity of fertilizers (Kg/ha) | | |
|---|---|---|---|
| | N | $P_2O_5$ | $K_20$ |
| K 11 | 20 | 0 | 0 |
| SVPR 2 | 40 | 20 | 40 |
| KC 2 | 40 | 20 | 40 |

Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished )

**Rainfed Cotton -Bt Hybrid**

Soil : Black (Pilamedu series)

Target : 2.8 - 3.2 t $ha^{-1}$

FN = 5.35T-0.24 SN-0.53 ON

$FP_2O_5$ = 3.67T-1.99 SP-0.84 OP

$FK_2O$ = 3.83T-0.13SK-0.55 OK

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 2.8 t $ha^{-1}$<br>NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 3.2 t $ha^{-1}$<br>NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| SN | SP | SK | FN | $FP_2O_5$ | $FK_2O$ | FN | $FP_2O_5$ | $FK_2O$ |
| 175 | 14 | 200 | 83 | 45** | 45** | 90** | 45** | 45** |
| 200 | 16 | 250 | 77 | 45** | 45** | 90** | 45** | 45** |
| 225 | 18 | 300 | 71 | 45** | 42 | 90** | 45** | 45** |
| 250 | 20 | 350 | 65 | 43 | 36 | 86 | 45** | 45** |
| 275 | 22 | 400 | 59 | 39 | 29 | 80 | 45** | 45** |

** Maximum dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in q $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure in kg $ha^{-1}$.

### 3.2.4. APPLICATION OF MICRONUTRIENT MIXTURE

vi) Mix 12.5 kg of micronutrient mixture formulated by the Department of Agriculture, Tamil Nadu with enough sand to make a total quantity of 50 kg. (or)
Apply TNAU MN mixture @ 7.5 kg /ha as Enriched FYM (Prepare enriched FYM at 1:10 ratio of MN mixture & FYM ; mix at friable moisture &incubate for one month in shade).

vii) Apply uniformly over the furrows after sowing and cover the seeds. Do not incorporate in the soil.

### Yield Maximization and reducing reddening in Bt cotton Rainfed

Application of TNAU MN mixture (7.5 kg $ha^{-1}$ as EFYM for variety and 10 kg $ha^{-1}$ as EFYM for Bt cotton) along with the recommended NPK to obtain maximum seed cotton yield with reduced extent of leaf reddening

### SEEDS AND SOWING

viii) Adopt the following seed rates for different varieties/hybrids.

| Varieties | Quantity of seeds (kg/ha)<br>Fuzzy seeds | <br>Delinted seeds |
|---|---|---|
| K 11 | 20 | .. |
| LRA 5166, SVPR 2 | 20 | 15 |

*Note: Delint only LRA 5166 and SVPR 2 seeds. Do not delint seeds of K 11*

ix) In the case of mixed crop of cotton, maintaining the same seed rates as for a pure crop and
adopt the following seed rate for the pulses crop. Blackgram/greengram10 kg/ha
Cowpea 7.5 kg/ha

**3.2.6.SPACING**

x) In the case of pure crop of varieties/hybrids, a spacing of 45 cm between rows and 15 cm between plants may be adopted.

xi) In the case of cotton, intercropped with pulses, one paired row of cotton is alternated with two rows of pulses and the total population of cotton crop is maintained at the same line as that for a pure crop of cotton.

xii) Adopt a spacing of 30 x 10 cm for the pulse crop in between each paired row of cotton. APK 1 Blackgram is best suited for this situation.

**3.2.7.ACID DELINTING**

Adopt procedure for acid delinting as for an irrigated crop.

**3.2.8.PRETREATMENT OF ACID DELINTED SEEDS WITH FUNGICIDES**

Same as for the irrigated crop.

**3.2.9.SOWING**

xiii) Use the multipurpose farming implement to sow the seeds and to apply basal fertilizers simultaneously.

xiv) Fill the hopper in the implement with the fertilizer mixtures and work the implement.

xv) Engage 3 persons for dropping the seeds, 2 for cotton and one for pulses.

In one operation, placement of fertilizer, sowing of seeds and covering will be completed.

*NOTE: Cotton and pulses can be sown at a depth of 5 cm in black cotton soil even before the onset of monsoon rains in dry bed sowing. When light rains are received, the moisture will not penetrate deeper and the seeds will not germinate and die away. Only when good rains are received, the moisture level will be sufficient to penetrate to the level of the seed and facilitate germination and proper establishment.*

**3.2.10. WEED MANAGEMENT**

xvi) Pre-emergence application of Pendimethalin (38.7% CS) 650 ml/ha followed by one hand weeding on 40 days after crop emergence. At the time of herbicide application sufficient soil moisture must be there.

xvii) If sufficient soil moisture is not available for applying herbicides hand weeding may be given at 10 - 20 days after crop emergence.

xviii) Integrated weed management in cotton: Post emergence application of pyrithiobac sodium @ 62.5g a.i./ha + quizalofop ethyl @ 50 g a.i./ha at 2 to 4 leaf stage or 45 DAS.

### 3.2.11. GAP FILLING

Dibble 3 to 4 seeds in each gap if sufficient moisture is available.

### 3.2.12. THINNING SEEDLINGS

xix) Allow two seedlings per hole and thin out on 15th day of sowing, adopting proper spacing between plants.

xx) Thin the pulse crop on the 20th day of sowing, adopting a spacing of 15 cm between plants for cowpea and 10 cm for other pulse crop.

### 3.2.13. FOLIAR FERTILIZATION

Spray 0.5% urea and 1% KCl on the 45th and 65th day of sowing if sufficient moisture is available.

**In site water harvesting and crop resident addition for rainfed cotton in black soil.**

Brand Bed Furrow (BBF) system wth coirpith application @ 5 t/ha for higher soil moisture retension, seed cotton yield and enhanced the carbon storage under vermisols.

### 3.2.14. INTERCULTIVATION WITH DHANTHULU/BLADE HARROW

Work dhanthulu or blade harrow on the 30th and 45th day of sowing.

*NOTE: Other cultivation practices, plant protection measures, harvest etc., are the same as for the irrigated crop.*

### CROP PHYSIOLOGY

Foliar spray of TNAU Cotton Plus @ 2.5 kg/acre in 200 litres of water at flowering and at boll formation stages reduces flower and square shedding, improves boll bursting, increases seed cotton yield and imparts drought tolerance.

## CROP PROTECTION

### B. PEST MANAGEMENT

- Remove the cotton crop and dispose off the crop residues as soon as harvest is over.
- Avoid stacking of stalks in the field.
- Avoid ratoon and double cotton crop.
- Adopt proper crop rotation.
- Use optimum irrigation and fertilizers.
- Grow one variety throughout the village as far as possible.
- Treat the seeds with imidacloprid or use designer seed (Delinted seed + polykote @ 3g / kg + carbendazim @ 2 g / kg + imidacloprid @ 7 g / kg + *Pseudomonas fluorescens* 10 g / kg + Azophos 40 g / kg). When the treated seeds are used, it protects against sucking pests upto 45 days after sowing and promotes early vigour of the crop.
- Synchronize the sowing time in the villages and complete the sowing within 10 to 15 days.
- Avoid other malvaceous crops in the vicinity of cotton crop.
- Timely earthing up and other agronomic practices should be done.
- Hand pick and burn periodically egg masses, visible larvae, affected and dropped squares, flowers and fruits and squash pink bollworm in the rosettes.

- Use locally fabricated light traps (modified Robinson type) with 125W mercury lamps to determine the prevalence and insect population fluctuations.
- The magnitude of the activity of the moths of the cotton pink bollworm, the cut worm (*Spodoptera litura*) and the American bollworm can be assessed by setting up the species-specific sex pheromone trap each at the rate of 12 per ha.
- Apply insecticides only where it is absolutely necessary when pest population or damage reaches ET level.
- Intercropping with pulses viz., cowpea, greengram, blackgram, soybean and maize reduces the bollworm incidence and population of sucking pests of cotton, *viz*., aphid and leafhopper with the highest activity of natural enemies *viz*., spiders and predatory lady bird beetles.

Economic threshold level for important pests

| Pest | ETL |
|---|---|
| Thrips | 50 nymphs or adults / 50 leaves |
| Aphids | 15% of infested plant |
| Leafhopper | 50 nymphs or adults / 50 leaves |
| Mite | 10 mites / $cm^2$ leaf area |
| **Boll-worms** | |
| Spotted | 10% infested shoots / squares / bolls |
| Spiny | 10% infested shoots / squares / bolls |
| Pink | 10% infested fruiting parts |
| *Helicoverpa* | One egg or one larva / plant |
| Whiteflies | 5-10 / leaf |
| Stem weevil | 10% infestation |
| Tobacco cutworm | 8 egg masses / 100 m row |

<table>
<tr>
<td>American bollworm<br>Helicoverpa armigera</td>
<td>Monitoring:<br>Pest monitoring through light traps, pheromone traps and in situ assessments by roving and fixed plot surveys has to be intensified at farm, village, block, regional and State levels. For management, an action threshold of one egg per plant or 1 larva per plant may be adopted.<br>Cultural practices:<br>• Synchronized sowing of cotton preferably with short duration varieties in each cotton ecosystem.<br>• Avoid continuous cropping of cotton both during winter and summer seasons in the same area as well as rationing.<br>• Avoid monocropping. Growing of less preferred crops like greengram, blackgram, soyabean, castor, sorghum etc., along with the cotton as intercrop or border crop or alternate crop to reduce the pest infestation.<br>• Removal and destruction of crop residues to avoid carry over of the pest to the next season, and avoiding extended period of crop growth by continuous irrigation.</td>
</tr>
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| | |
|---|---|
| | • Optimizing the use of nitrogenous fertilizers which will not favour the multiplication of the pest.<br>• Judicious water management for the crop to prevent excessive vegetative growth and larval harbourage.<br>**Biological control:**<br>• Application of Nuclear Polyhedrosis Virus (NPV) at 3 x $10^{12}$ POB / ha in evening hours at $7^{th}$ and $12^{th}$ week after sowing.<br>• Conservation and augmentation of natural predators and parasitoids for effective control of the pest.<br>• Inundative release of egg parasitoid, *Trichogramma* spp., at 6.25 cc / ha at 15 days interval 3 times from 45 days after sowing<br>• Egg- larval parasitoid, *Chelonus blackburnii* and predator, *Chrysoperla carnea* at 1,00,000 / ha at $6^{th}$, $13^{th}$ and $14^{th}$ week after sowing.<br>• ULV spray of NPV at 3 x $10^{12}$ POB / ha with 10% cotton seed kernel extract, 10% crude sugar, 0.1% each of Tinopal and Teepol for effective control of *Helicoverpa*.<br>**Note:** Dicofol, methyl demeton and monocrotophos are comparatively safer to *Chrysoperla* larva recording low egg mortality.<br>**Chemical control :**<br>• Discourage the indiscriminate use of insecticides, particularly synthetic pyrethroids.<br>• Use of proper insecticides which are comparatively safer to natural enemies at the correct dosage and alternating different groups of insecticides for each round of spray.<br>• Avoid combination of insecticides as tank mix.<br>• Adopt proper delivery system using spraying equipments like hand compression sprayer, knapsack sprayer and mist blower to ensure proper coverage with required quantity of spray fluid and avoid ULV applications or Akela spray applications.<br>• Proper mixing and preparation of spray fluid for each filling of spray fluid tank.<br>**At early stages of square formation apply one of the following insecticides**<br>Acephate 75% SP 780g/ha<br>Azadirachtin 0.03% EC 2500ml/ha<br>Chlorpyriphos 20% EC 1250ml/ha<br>Diflubenzuron 25% WP 300 - 350g/ha<br>Emamectin benzoate 5% SG 190-220g/ha<br>Fipronil 5% SC 2000ml/ha<br>Flubendiamide 20% WG 250g/ha<br>Flubendiamide 39.35% SC 100-125ml/ha<br>Indoxacarb 14.5% SC 500ml/ha<br>Novaluron 10%EC 1000ml/ha<br>NPV of *H. armigera* 0.43%AS 400-600ml/ha |

| | |
|---|---|
| | Profenofos 50% EC 1500-2000ml/ha<br>Pyridalyl 10% EC 750-1000ml/ha<br>Chlorantraniliprole 18.5% SC @150 ml/ha<br>Lufenuron 5.4% EC @600 ml/ha<br>Spinosad 45.0% SC 165-220ml/ha<br>Thiodicarb 75%WP 1000g/ha<br>Monocrotophos 36% SL @1125-2250 ml/ha<br><br>**Biological control:**<br>*Bacillus thuringiensis*-k750-1000g/ha<br>*Bacillus thuringiensis* var. kurstaki (3a,3b,3c) 5%WP 750-1000g/ha<br>*Beauveria bassiana* 1.15%WP 400g/ha |
| **Spotted bollworm**<br>*Erias vitella;*<br>*E. insulana* | **Spraying any one of the following insecticides**<br>Flubendiamide 39.35%SC100-125ml/ha<br>Chlorantraniliprole 18.5% SC @150 ml/ha<br>Indoxacarb 14.5%SC 500ml/ha<br>Diflubenzuron 25%WP 300-350g/ha<br>Profenophos 50%EC 1500-2000ml/ha<br>Fipronil 5% SC 2000ml/ha<br>Spinetoram 11.7 % SC @420-470 ml/ha<br>**Biological control:**<br>*Bacillus thuringiensis* var kurstaki (3a,3b,3c) 5%WP 750-1000g / ha |
| **Pink boll worm**<br>*Pectinophora gossypiella* | • Use pheromone traps to monitor the adult moth activity @ 12 / ha<br>• Inundative release of egg parasitoid *Trichogrammatoidea bactrae* @ 40,000 / ha at 15 days interval 3 times from 45 days after sowing with coinciding the incidence of the pest.<br>**Spraying any one of the following insecticides:**<br>Emamectin Benzoate 5% SG 190 – 220 g/ha<br>Chlorpyriphos 50% EC 1000 – 1200 ml / ha<br>Profenofos 50%EC 1500 – 2000ml/ha<br>Diflubenzuron 25%WP 300-350g/ha<br>Thiodicarb 75% WP 1000 g /ha |
| **Tobacco cutworm**<br>*Spodoptera litura* | ➢ Use of light trap to monitor and kill the attracted adult moths.<br>➢ Set up the sex pheromone trap at 12/ha to monitor the activity of the pest and to synchronize the pesticide application, if need be, at the maximum activity stage.<br>➢ Growing castor along border and irrigation bunds.<br>➢ Removal and destruction of egg masses in castor and cotton crops.<br>➢ Removal and destruction of early stage larvae found in clusters which can be located easily even from a distance.<br>➢ Collection and destruction of shed materials.<br>➢ Hand picking and destruction of grownup caterpillars.<br>**Spray any one of the following insecticides**<br>Chlorpyriphos 20 EC 3750 ml/ha<br>Diflubenzuron 25%WP 300-350g/ha |

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| | Chlorantraniliprole 18.5% SC @150 ml/ha<br>Spinetoram 11.7 % SC @420-470 ml/ha<br>➢ Spraying of insecticides should be done either in the early morning or in the evening and virus in the evening.<br>➢ Spraying nuclear polyhedrosis virus at 1.5 x $10^{12}$ POB per ha. |
| **Stem weevil**<br>*Pempherulus affinis* | • Basal application of FYM 25 t/ha and 250 kg/ha of neem cake.<br>• Seed treatment with chlorpyriphos 20EC @ 10ml/kg of seed + drenching collar region with chlorpyriphos 50 EC @ 1200 ml/ha on 15 and 30 days after sowing + Earthing up. |
| **Whitefly**<br>*Bemisia tabaci* | • Avoid alternate, cultivated host crops of the whitefly in the vicinity of cotton crop.<br>• Growing cotton only once a year either in winter or summer season in any cotton tract.<br>• Adopting crop rotation with non-preferred hosts such as sorghum, ragi, maize, etc., for the whitefly to check the buildup of the pest.<br>• Removal and destruction of alternate weed hosts like *Abutilon indicum*, *Chrozophore rottlari*, *Solanum nigrum* and *Hibiscus ficulensus* from the fields and neighbouring areas and maintaining field sanitation.<br>• Timely sowing with recommended spacing, preferably wider spacing and judicious application of recommended dose of fertilizers, particularly nitrogenous and irrigation management is essential to arrest the excessive vegetative growth and pest build up. Late sowing may be avoided and the crop growth should not be extended beyond its normal duration.<br>• Field sanitation may be given proper attention.<br>• Cultivation of most preferred alternate host crops like brinjal, bhendi, tomato, tobacco and sunflower may be avoided. In case their cultivation is unavoidable, plant protection measures should be extended to these crops also.<br>• Monitoring the activities of the adult white flies by setting up yellow pan traps and sticky traps at 1 foot height above the plant canopy and also in situ counts.<br>• Collection and removal of white fly infested leaves from the plants and those which were shed due to the attack of the pest and destroying them.<br>**Chemical control:**<br>Acetamiprid 20%SP 100g/ha<br>Azadirachtin 0.15% 2500-5000ml/ha<br>Buprofezin 25% SC 1000ml/ha<br>Chlorpyriphos 20%EC 1250ml/ha<br>Clothianidin 50%WDG 200-250 g/ha(Soil drenching)<br>Clothianidin 50%WDG 40-50 g/ha (Foliar spray)<br>Diafenthiuron 50%WP 600g/ha<br>Dinotefuran 20% SG 150 g/ha<br>Fipronil 5%SC 1500-2000 ml/ha<br>Flonicamid 50% WG @ 150 g/ha |

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| | Imidacloprid 17.8% SL 100-125 ml/ha<br>Profenophos 50%EC 1000 ml/ha<br>Thiacloprid 21.7%SC 500- 600ml/ha<br>Thiamethoxam 30% FS @10 g/Kg seed (Seed dresser)<br>Thiamethoxam 70% WS @430 gm/ha<br>Thiamethoxam 25%WG 200 g/ha<br>Pyriproxyfen 10% EC @ 500- 700 ml/ha<br>Spiromesifen 22.9% SC @600 ml/ha<br>Spray any one of the following plant products alone or in combination with the recommended dose of insecticide<br>Neem seed kernel extract 5% or Neem oil at 5 ml/l of water<br>Fish oil rosin soap 25g / lit of water<br>Notchi leaves 5% extract<br>*Catharanthus rosea* extract 5%<br>Spray any one of the following in early stage (500l) mid and late stages (1000l spray liquid/ha)<br>In the early stages with high volume sprayer, use a goose neck nozzle to cover the under surface of the foliage to get good control of the pest. If high volume sprayers are not available, 375 litres of spray fluid may be used per hectare for application in the low volume motorized knapsack mist blower.<br>• The use of synthetic pyrethroids should be discouraged in cotton to avoid the problem of white fly. Cypermethrin, fenvalerte and deltamethrin cause resurgence of whiteflies. So avoid repeated spraying of pyrethroids.<br>• The plant protection measures should be adopted on a community basis in specified cotton areas.<br><br>**Biological control:**<br>• *Verticillium lecanii* 1.15%WP 2500g/ha |
| **Thrips**<br>*Thrips tabaci* | • Seed treatment with imidacloprid 70WS at 7g / kg protect the crop from aphids, leafhoppers and thrips upto 8 weeks.<br>**Spray any one of the following insecticides** (500l spray fluid/ha)<br>Methyl demeton 25EC 500ml/ha<br>Dimethoate 30EC 500ml/ha<br>Buprofezin 25%SC 1000ml/ha<br>Diafenthiuron 50%WP 600g/ha<br>Clothianidin 50%WDG 200-250 g/ha (Soil drenching)<br>Dinotefuran 20% SG 150 g/ha<br>Fipronil5% SC 1500-2000ml/ha<br>Flonicamid 50% WG @ 150 g/ha<br>Imidacloprid 70%WG 30-35g/ha<br>Imidacloprid 48%FS/100 kg seed 500-900g/ha<br>Imidacloprid 17.8%SL 100-125ml/ha<br>Profenophos 50% EC 1000ml/ha<br>Thiacloprid 21.7% SC 100-125ml/ha<br>Thiamethoxam 70% FS 430 g/ha<br>Thiamethoxam 25%WG 100 g/ha<br>Spinetoram 11.7 % SC @420-470 ml/ha |

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| **Aphids**<br>*Aphis gossypii* | Seed treatment with imidacloprid 70WS at 7g / kg protect the crop from aphids, leafhoppers and thrips upto 8 weeks.<br>**Spray any one of the following insecticides**<br>Acetamiprid 20%SP 50g/ha<br>Azadirachtin 0.03%EC 2500ml/ha<br>Buprofezin 25%SC 1000ml/ha<br>Clothianidin 50%WDG 200-250 g/ha(Soil drenching)<br>Carbosulfan 25% DS 60g/kg seed<br>Chlorpyriphos 20% EC 1250ml/ha<br>Diafenthiuron 50%WP 600ml/ha<br>Dinotefuran 20% SG 150 g/ha<br>Fipronil 5% SC 1500-2000 ml/ha<br>Flonicamid 50% WG @ 150 g/ha<br>Imidacloprid 70% WG 30-35kg/ha<br>Imidacloprid 17.8% SL 100-125ml/ha<br>Malathion 50% EC 1000ml/ha<br>Profenophos 50% EC 1000ml/ha<br>Thiacloprid 21.7%SC 100-125ml/ha<br>Thiamethoxam 25%WG100 g/ha<br>Thiamethoxam 70% WS @430 gm/ha<br>Thiamethoxam 30% FS @10 g/Kg seed (Seed dresser) |
| **Leaf hopper**<br>*Amrasca devastans* | **Spray any one of the following insecticides**<br>Imidacloprid 200SL at 100ml/ha<br>Imidacloprid 70% WG @30-35 g/ha<br>Imidacloprid 17.8% SL @ 100 – 125 ml/ha<br>Acetamiprid 20%SP 50g/ha<br>Azadirachtin 0.03%WSP 2500- 5000g/ha<br>Buprofezin 25%SC 1000ml/ha<br>Clothianidin 50%WDG 30- 40 kg/ha (Foliar spray)<br>Clothianidin 50%WDG 200-250 g/ha(Soil drenching)<br>Diafenthiuron 50%WP 600g/ha<br>Dinotefuran 20% SG 150 g/ha<br>Fipronil 5%SC 1500-2000ml/ha<br>Profenophos 50%EC 1000ml/ha<br>Thiacloprid 21.7%SC 100-125ml/ha<br>Flonicamid 50% WG @ 150 g/ha<br>Thiamethoxam 25%WG 100g/ha<br>Thiamethoxam 30% FS @10 g/Kg seed (Seed dresser)<br>Thiamethoxam 70% WS @430 gm/ha<br>NSKE 5% 25kg/ha<br>• Where the leaf hopper is a big menace apply Neem oil formulation 0.5% or neem oil 3% thrice at fortnightly intervals. |
| **Cotton mealy bug**<br>*Phenococcus solenopsis* | • Remove the alternate weeds hosts.<br>• Monitor the incidence regularly and look for crawler emergence.<br>• Take up the management at initial stage to get maximum control.<br>• Use of encyrtid parasitoids, *Acerophagus papayae* @ 100 per village against *Paracoccus marginatus* and *Aenasius* |

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| | *bambawaeli* against *Phenococcus solenopsis* are recommended. (Consult the specialists for effective chemicals for individual species).<br>• Wherever necessary use botanical insecticides like neem derivatives such as neem oil 2%, NSKE 5% and Fish oil rosin soap 25 g/lit. of water.<br>• Use of profenophos @ 2000 ml / ha may be adopted as an alternative |
| **Yellow mite** *Polyphagotarsonemus latus* | Spiromesifen 22.9% SC 600 ml/ha |
| **Red spider mite** *Tetranychus cinnabarinus* | Spray Spiromesifen 22.9% SC 600 ml/ha or Dicofol 18.5% EC @ 2700ml/500 lit. of water |

**Pest management strategies**

**Resurgence**

Repeated application of the following insecticides can cause resurgence of the insect pest of cotton

- *Amrasca devastans :* Deltamethrin
- *Aphis gossypii :* Cypermethrin, deltamethrin, fenvaerate, monocrotophos
- *Bemisia tabaci :* Cypermethrin, deltamethrin, fenvalerate, monocrotophos
- *Ferrisia virgata :* Cypermethrin, deltamethrin, fenvalerate, permethrin
- *Tetranychus urticae :* Acephate, fenvalerate

## Disease Management

| Name of the disease | Recommendations |
|---|---|
| **Bacterial leaf blight:** *Xanthomonas axonopodis* pv. *malvacearum* | •Avoid stacking of infected plants<br>•Spray *streptomycin sulphate* @ 300 ppm + copper oxychloride @ 2.0 kg/ha immediately after the symptom appearance and repeat at 10 days later. |
| ***Alternaria* leaf spot:** *Alternaria macrospora* | Spray any one of the following fungicides / biocontrol agent<br>•Copper oxychloride @ 2 kg or mancozeb @ 1 kg or chlorothalonil @ 500 g/ha or difenaconazole @ 0.05% or krexoxym methyl @ 0.1% or tebuconazole @ 1 ml/l or trifloxystrobin + tebuconazole @ 0.6 g/l or propiconazole @ 1 ml/l or metiram 55% + pyraclostrobin 5% WG @ 0.1% at 60, 90 and 120 days after sowing.<br>•*Bacillus subtilis* (BSC5) @ 0.04% on 60, 90 and 120 days after sowing can also be applied. |
| **Grey mildew:** *Ramularia areola* | Spray any one of the following fungicides<br>•Carbendazim @ 250 g/ha or mancozeb @ 1000g or chlorothalonil @ 500 g/ha or difenaconazole @ 0.05% or krexoxym methyl @ 0.1% or tebuconazole @ 1ml/l or propiconazole @ 1ml/l or metiram 55% + pyraclostrobin 5% WG @ 0.1% at 60, 90 and 120 days after sowing. |
| **Boll rot:** *Fusarium moniliforme, Colletotrichum capsici,* | Spray any one of the following fungicides<br>•Carbendazim @ 500 g or mancozeb @ 2000 g or copper oxychloride |

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| *Aspergillus flavus, A. niger, Rhizopus nigricans, Nematospora, Botryodiplodia* | @ 2500 g/ha along with an insecticide recommended for bollworm from 45th day at fortnightly interval. |
| ***Cercospora* leaf spot:** *Cercospora gossypii* | •Spray propiconazole @ 1 ml/l or metiram 55% + pyraclostrobin 5% WG @ 0.1% at 60, 90 and 120 days after sowing. |
| **Damping off and *Fusarium* wilt:** *Rhizoctonia solani* and *Fusarium oxysporum* f. sp. *vasinfectum* | •Seed treatment with *Pseudomonas fluorescens* + *Bacillus subtilis* + *Trichoderma asperellum* mixture @ 10 g/kg and soil application of *P. fluorescens* + *B. subtilis* + *T. asperellum* mixture @ 2.5 kg/ha during sowing and at 90 days after sowing. |
| **Root rot:** *Macrophomina phaseolina (Rhizoctonia bataticola)* | **Cultural method**<br>•Soil application of neem cake @ 150 kg/ha<br>**Biological control**<br>•Seed treatment with *T. asperellum* @ 10 g/kg followed by basal application of zinc sulphate @ 50 kg/ha.<br>•Seed treatment with *Bacillus* (BSC5) @ 10g/kg followed by soil application @ 2.5 kg/ha with 250 kg of compost at the time of sowing.<br>•Seed treatment with *P. fluorescens* @ 10 g/kg and soil application @ 2.5 kg/ha with 250 kg of compost at the time of sowing.<br>•Seed treatment with *P. fluorescens* + *B. subtilis* + *T.asperellum* mixture @ 10g/kg and soil application of *P. fluorescens* + *B. subtilis* + *T. asperellum* mixture @ 2.5 kg/ha during sowing and at 90 days after sowing.<br>**Chemical control**<br>• Spot drench with carbendazim @ 1 g/l at the base of affected plants as well as surrounding healthy plants<br>• Soil drenching with trifloxystrobin + tebuconazole @ 0.75g/l |

**Integrated pest and disease management (IPDM) technology for cotton**

- Seed treatment with imidacloprid 70 WS @ 10 g/kg seed
- Soil drenching with chlorpyriphos 20 EC @ 1.25 l/ha on 25 days after sowing
- Soil application with *Bacillus subtilis* (BSC5) on 30 days after sowing
- Foliar application of *B. subtilis* (BSC5) @ 10g/l on 60 days after sowing
- Monitoring with yellow sticky traps for whitefly @ 12 numbers / ha
- Monitoring with pheromone trap for *Spodoptera* @ 12 numbers / ha
- Need based application of imidacloprid 17.8SL @ 25 g.a.i./ha
- Need based application of 0.1 per cent trifloxystrobin (25%) + tebuconazole (50%) WG or mancozeb 75 WP @ 0.25 per cent
- Raising of trap crop (castor and maize) along the bunds

**Nematode Management**

❖ Seed treatment with *Pseudomonas fluorescens* @ 20 g/kg followed by soil application @ 2.5kg/ha reduces reniform nematode, *Rotylenchulus reniformis* in cotton.

## RAINFED COTTON

### CROP PROTECTION

### A. PEST MANAGEMENT

< The control measures recommended for irrigated cotton will hold good.

< **When water is not available, use any one of the following insecticides for the control of bollworms at 25 kg/ha :**

Carbaryl 5 D

Phosalone 4 D

### B. DISEASE MANAGEMENT

| Name of the disease | Recommendations |
|---|---|
| **Bacterial leaf blight:** *Xanthomonas axonopodis* pv. *malvacearum* | •Avoid stacking of infected plants<br>•Spray *streptomycin sulphate* @ 300 ppm + copper oxychloride @ 2.0 kg/ha immediately after the symptom appearance and repeat at 10 days later. |
| ***Alternaria* leaf spot:** *Alternaria macrospora* | Spray any one of the following fungicides / biocontrol agent<br>•Copper oxychloride @ 2 kg or mancozeb @ 1 kg or chlorothalonil @ 500 g/ha or difenaconazole @ 0.05% or krexoxym methyl @ 0.1% or tebuconazole @ 1 ml/l or trifloxystrobin + tebuconazole @ 0.6 g/l or propiconazole @ 1 ml/l or metiram 55% + pyraclostrobin 5% WG @ 0.1% at 60, 90 and 120 days after sowing.<br>•*Bacillus subtilis* (BSC5) @ 0.04% on 60, 90 and 120 days after sowing can also be applied. |
| **Grey mildew:** *Ramularia areola* | Spray any one of the following fungicides<br>•Carbendazim @ 250 g/ha or mancozeb @ 1000g or chlorothalonil @ 500 g/ha or difenaconazole @ 0.05% or krexoxym methyl @ 0.1% or tebuconazole @ 1ml/l or propiconazole @ 1ml/l or metiram 55% + pyraclostrobin 5% WG @ 0.1% at 60, 90 and 120 days after sowing. |
| **Boll rot:** *Fusarium moniliforme, Colletotrichum capsici, Aspergillus flavus, A. niger, Rhizopus nigricans, Nematospora, Botryodiplodia* | Spray any one of the following fungicides<br>•Carbendazim @ 500 g or mancozeb @ 2000 g or copper oxychloride @ 2500 g/ha along with an insecticide recommended for bollworm from 45th day at fortnightly interval. |
| ***Cercospora* leaf spot:** *Cercospora gossypii* | •Spray propiconazole @ 1 ml/l or metiram 55% + pyraclostrobin 5% WG @ 0.1% at 60, 90 and 120 days after sowing. |
| **Damping off and *Fusarium* wilt:** *Rhizoctonia solani* and *Fusarium oxysporum* f. sp. *vasinfectum* | •Seed treatment with *Pseudomonas fluorescens + Bacillus subtilis + Trichoderma asperellum* mixture @ 10 g/kg and soil application of *P. fluorescens + B. subtilis + T. asperellum* mixture @ 2.5 kg/ha during sowing and at 90 days after sowing. |
| **Root rot:** *Macrophomina phaseolina (Rhizoctonia bataticola)* | **Cultural method**<br>•Soil application of neem cake @ 150 kg/ha<br>**Biological control** |

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| | •Seed treatment with *T. asperellum* @ 10 g/kg followed by basal application of zinc sulphate @ 50 kg/ha.<br>•Seed treatment with *Bacillus* (BSC5) @ 10g/kg followed by soil application @ 2.5 kg/ha with 250 kg of compost at the time of sowing.<br>•Seed treatment with *P. fluorescens* @ 10 g/kg and soil application @ 2.5 kg/ha with 250 kg of compost at the time of sowing.<br>•Seed treatment with *P. fluorescens* + *B. subtilis* + *T.asperellum* mixture @ 10g/kg and soil application of *P. fluorescens* + *B. subtilis* + *T. asperellum* mixture @ 2.5 kg/ha during sowing and at 90 days after sowing.<br>**Chemical control**<br>• Spot drench with carbendazim @ 1 g/l at the base of affected plants as well as surrounding healthy plants<br>• Soil drenching with trifloxystrobin + tebuconazole @ 0.75g/l . |

**C.Nematode management**

Seed treatment with *P.flouresecens* @20g/Kg and soil application @ 2.5 kg/ha
Application of consortia formulation of Pfbv 22 + Bbv 57@ 2.5 Kg/h

## COTTON – VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants and designated diseases especially the wilt disease. The previous crop should not be of the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- Leave a distance of 50 m for foundation seeds and 30 m for certified seeds all around the field from the same and other varieties / hybrids of the crop.

**Season**

- Summer crop : February - March
- Winter crop : August - September

**Acid delinting of fuzzy seeds**

- Delint the fuzzy seeds with commercial sulphuric acid @ 100 ml / kg of seed for 2 - 5 minutes depending upon the variety (2 minutes for MCU 5 and 5 minutes for MCU 12).
- After acid delinting remove the floaters and insect damaged seeds and separate the brown colour and well filled sinkers.
- Wash the collected seeds thoroughly for 3 to 4 times with fresh water and neutralize with 0.5 % lime solution for removal of traces of acid.

**Pre-sowing seed treatment**

- Seed hardening with 2 % KCl for 10 hrs in the seed to solution ratio 1:1 and dry back to original moisture content.
- Seed coating with polymer @ 3 g / kg + imidachloprid @ 2 ml / kg + *Pseudomonas fluorescens* @ 10 g / kg + Azophos @ 120 g / kg of seed.
- The above two treatments can be integrated as designer seed treatment.

**Foliar application**

- Spray 1 % Diammonium phosphate on 70th, 80th and 90th days after sowing.

**Roguing**

- The crop should be rogued for off-types from vegetative stage to harvesting stage based on plant stature, leaf size, leaf colour, stem colour, flower colour, petal spot, pollen colour, number of sympodia, boll size and shape to maintain genetic purity.

**Harvesting**

- Pick the fully bursted kapas periodically in six pickings at weekly intervals.
- Consider first five pickings in winter crop and first four pickings in the summer crop for seed purpose, the seed from the subsequent pickings are inferior in quality.
- Do not retain the kapas unpicked in the field for more than a week as it reduces seed quality.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed.
- Treat the seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg of seed as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 8 - 10 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 7 - 8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 6 %.

## COTTON - HYBRID SEED PRODUCTION

**Land requirement**

- Land should be free from volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production, leave a distance of 30 m all around the field from the same and other varieties / hybrids of cotton.
- Between the parental lines leave an isolation distance of 5 m.

**Seeds and sowing**

- Male : 2 kg / ha
- Female : 4 kg / ha

**Fertilizer requirement**

- Compost : 12.5 t / ha, NPK : 20:60:50 kg / ha as basal application

**Top dressing**

- Top dress @ 12.5 kg N / ha at 60 and 90 days after sowing.
- Earthing up the crop adequately after first top dressing.
- Irrigate the crop immediately after every top dressing.

**Foliar application**

- Foliar spray of 100 ppm boric acid or 0.5 % zinc sulphate to the male parent at initiation flowering to improve the pollen viability and pollen production.
- Foliar spray of salicylic acid @ 250 ppm at 90 days after sowing for increased seed set.
- Foliar spray of 2 % DAP 4 times at 10 days interval during boll development period (60, 70, 80 and 90 days after sowing) for better development of crossed bolls.

**Emasculation and dusting for cross pollination**

- Emasculate and dust as far as possible all buds appearing during the first six weeks of reproductive phase to ensure good seed setting and development of bolls.
- Emasculate the female buds on the previous day evening.
- Smear pollen dust to the stigma of all the emasculated flowers for good number of boll formation.
- Restrict emasculation to each day evening to 3 pm to 6 pm and pollination to morning between 10 am to 1 pm to ensure highest purity of hybrid seeds.
- Choose optimum size of bud and avoid too young or too old buds for emasculation.
- Cover the male buds with paper cover during previous day evening for their use on next day.
- Cover emasculated buds with butter paper cover to avoid out crossing.
- Close the crossing programme after 9$^{th}$ week (from commencement of crossing) and remove all buds and flowers appearing subsequently to facilitate the development of crossed bolls.

**Topping**

- Top the plants either manually or spray Maleic Hydrazide @ 100 ppm at 90$^{th}$ and 105$^{th}$ days after sowing to enhance the sympodial branches formation.

**Harvesting**

- Harvest only fully bursted bolls.
- Harvest the crop as 4 - 6 pickings depending on the cultivar.
- Avoid later pickings (after 4 - 5 pickings) for seed purpose.

**Ginning**

- Gin the crossed kapas in separate gins erected in seed processing units or farm gins under the close supervision of the authorities concerned to ensure purity and avoid damage.
- Remove hard locks and stained kapas.
- After ginning, clean the seeds by hand picking to remove small, shrivelled and broken seeds.

**Pre-storage seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed.
- Treat the seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu (*Albizzia amara*) leaf powder mixed in the ratio of 5:4:1@ 3 g / kg of seed as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 9 - 10 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 7 - 8 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 6 %.

# (ii) JUTE (*Corchorus olitorius* & *Corchorus capsularis*)

## CROP MANAGEMENT

Jute can be successfully grown in Coimbatore, Cuddalore, Villupuram, Vellore, Tiruvannamalai, Chengleput and parts of Thanjavur, Tiruvarur, Nagapattinam, Tiruchirapalli, Perambalur, Karur, Pudukkottai and Tirunelveli, Thoothukudi districts where assured supply of irrigation water is available for its cultivation and retting for fibre extraction.

**Soil type**: Alluvial sandy loam, clay loamy soils are best suited for jute production. Capsularis jute can grow even in standing water especially towards the latter part of its growth, but Olitorius jute will not thrive in standing water. The latter is more drought resistant and is therefore grown on lighter soils.

**Season**: February
**Land Preparation**: Fine tilth is required since the seeds are very small
**Manures and fertilizer application**: Five tonnes of well decomposed farm yard manure is to be applied during last ploughing. Besides 20 kg per ha each of N, $P_2O_5$ and K O are to be applied. basally. Beds and channels are formed depending on water resources.

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| **Varieties:** | Capsularis JRC 212, JRC 321, JRC 7447 |
| | Olitorius j JRO 524, JRO 878, JRO 7835 |
| **Crop duration** | 120 to 140 Days |

**Seed rate and sowing**: Seeds can be sown either by broadcasting or by line sowing.

| Jute type | Seed rate (kg/ha) | | Spacing (cm) | No. of Plants/ Sq. Mtr. |
|---|---|---|---|---|
| | Line Sowing | Broad Casting | | |
| Olitorius | 5 | 7 | 25 x 5 | 80 |
| Capsularis | 7 | 10 | 30 x 5 | 67 |

**Weed management**: Hand weeding twice on 20 - 25 DAS and 35 - 40 DAS. Fluchloralin can be sprayed at 3 days after sowing at the rate of 1.5 kg per hectare and is followed by irrigation. Further one hand weeding can be taken up at 30 - 35 DAS.

**Top dressing of fertiliser**: Apply 10 kg of N at 20 - 25 days after first weeding and then again on 35 - 40 days after second weeding as top dressing. During periods of drought and fertilizer shortage, spray 8 kg of urea as 2 per cent urea solution (20 g urea in one litre of water) on jute foliage on 40 - 45 as well as 70 - 75 DAS.

**Water Management**: Jute crop requires 500 mm of water. First irrigation is to be given after sowing and life irrigation on fourth day after sowing. Afterwards irrigation can be given once in 15 days.

**Harvest**: Jute crop can be harvested from 100 to 110 DAS but can be extended from 120 - 135 DAS depending on local cropping systems. Jute plants are left in the field for 3 - 4 days for leaf shedding. Then thick and thin plants are sorted out and bundled in convenient size.
**Yield**: The green plant weight yield is 45 to 50 tonnes per hectare whereas the fibre yield is to 2.5 tonnes per hectare.

# 7. SUGARCANE (*Saccharum officinarum*)

## CLIMATE REQUIREMENT

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 42 | 15 | 32 - 35 | 2500 - 3000 | 1000 |

Tropical crop. Besides temperature and rainfall, light (day length) plays a very important role in proper growth and development i.e. tillering of cane. A long, warm growing season with a high incidence of solar radiation and adequate moisture is required.Short day length decreases number of tillers. Under long day length conditions, plant produces more dry matter.

## CROP IMPROVEMENT

### A. PLANTED (MAIN) CROP

### I. SEASON AND VARIETIES

Sugarcane is grown chiefly in the main season (December - May) in the entire State. In parts of Tiruchirapalli, Perambalur, Karur, Salem, Namakkal and Coimbatore districts, it is also raised during the special season (June - September). The particulars in respect of each season are given below:

### SEASON, PERIOD OF PLANTING

**1. Main season**

i) **Early** **:** Dec - Jan ii) **Mid :** Feb - March iii) **Late:** April – May

**2. Special season :** June - July

All early season varieties are suitable for special season.

### II. PARTICULARS OF VARIETIES

| Variety | Duration (Month) | Cane Yield (t/ha) | CCS % | CCS (t/ha) |
|---|---|---|---|---|
| CoG 94077 | 11 | 133.2 | 13.50 | 17.60 |
| Co 86032 | 10-12 | 110.0 | 13.00 | 14.30 |
| CoSi (SC) 6 | 10-11 | 142.0 | 13.10 | 18.60 |
| TNAU SC Si 7 | 10-11 | 156.0 | 13.40 | 20.90 |
| TNAU SC Si 8 | 11-12 | 146.0 | 12.90 | 18.00 |
| CoC 25 | 10-12 | 145.7 | 12.77 | 18.62 |
| CoG 6 | 10-12 | 140.6 | 13.34 | 18.39 |

## III. Morphological characters

| Characters | CoG 94077 | Co 86032 |
|---|---|---|
| Parentage | Co 740 x Co 775 | Co 62198 X CoC 671 |
| Leaf size | Medium | Medium |
| Leaf colour | Dark green | Dark green |
| Sheath colour | Greenish with Purple tinge | Green with purple |
| Sheath clasping | Loose | Loose |
| Spines | Absent | Few, hard, deciduous |
| Ligular process | Present on one side | Absent |
| Stem colour | Greenish yellow | Reddish pink (exposed) Greenish yellow (unexposed) |
| Girth | Medium | Medium |
| Joint | Slightly staggered | Cylindrical |
| Bud Groove | Short, shallow | Absent |
| Size | Medium | Medium |

| Character | TNAU SC Si 7 | TNAU SC Si 8 |
|---|---|---|
| Parentage | Co 99034 x CoG 93076 | CoC 90063 x Co 8213 |
| Leaf Size | Medium | Medium |
| Leaf colour | Dark green | Green |
| Sheath colour | Yellowish Green with purple tinge | Green with purple stripes |
| Sheath clasping | Slightly tight | Loose |
| Spines | Present (deciduous) | Very few, soft and deciduous |
| Splits | Absent | Absent |
| Ligular process | Present | Present (asymmetrical) |
| Stem colour | Yellowish green (exposed) pinkish yellow (unexposed) | Greenish yellow (exposed) Greenish Yellow (enexposed) |
| Girth | Medium | Medium |
| Joint | Straight | Straight |
| Bud groove | Absent | Present, Shallow |
| Size | Medium | Big |

| Characters | CoC 25 | CoG 6 |
|---|---|---|
| Parentage | Co 85002 x HR 83-144 | HR 83-144 x CoH 119 |
| Leaf size | Medium | Medium |
| Leaf colour | Green | Light Green |
| Sheath colour | Green with pinkish tinge with scarious border | Greenish purle |
| Sheath clasping | Loose | Loose |
| Spines | Absent | Decidous spines |
| Splits | Absent | Absent |
| Ligular process | Slightly indicated asymmetrical | Present (crescent shaped) |

| | | |
|---|---|---|
| Stem colour | Greenish yellow green (unexposed)<br>Pinkish (exposed) | yellow green (unexposed)<br>Green yellow (exposed) |
| Girth | Medium | Medium |
| Joint | Zig zag | Straight |
| Bud Groove | Deep and extent all over the length of the internode | Present |
| Size | Medium | Medium |

| Parameters | Co 0212 | Co 06022 |
|---|---|---|
| Parentage | Co 7201 X ISH 106 | GU 92-275 X Co 86249 |
| Maturity group | Mid-late | Early |
| Year of release | 2016 | 2018 |
| Institute name | ICAR-Sugarcane Breeding Institute, Coimbatore | ICAR-Sugarcane Breeding Institute, Coimbatore |
| Cane yield (t/ha) | 150.56 | 135.8 |
| CCS % | 12.80 | 13.10 |
| Sugar yield (t/ha) | 19.27 | 17.68 |
| Reaction to red rot | Moderately resistant | Moderately resistance |
| Special features | Tolerant to drought and salinity<br>A1 quality jaggery<br>Good ratooner<br>Erect and medium thick cane | A1 quality jaggery of golden yellow colour<br>Non lodging, erect, thick cane<br>Tolerant to water deficit stress |

| Parameters | Co 09004 (Amritha) | Co 11015 (Atulya) |
|---|---|---|
| Parentage | CoC 671 X CoT 8201 | CoC 671 X Co 86011 |
| Maturity group | Early | Early |
| Year of release | - | 2019 |
| Institute name | ICAR-Sugarcane Breeding Institute, Coimbatore | ICAR-Sugarcane Breeding Institute, Coimbatore |
| Cane yield (t/ha) | 109.85 | 142.72 |
| CCS % | 18.94 (Sucrose %) | 20.22 (Sucrose %) |
| Sugar yield (t/ha) | 14.56 | 20.16 |
| Reaction to red rot | Moderately resistance | Moderately susceptible |
| Special features | Resistant to smut<br>Less susceptible to borer<br>Tall cane, early fast growth, high tillering, medium thick cane, non-flowering, non lodging, good ratooner | Short duration (8 month)<br>High sugar content<br>Tall (>250 cm) and erect plant<br>Medium thick cane<br>A1 quality jaggery of golden yellow colour |

Varieties suitable for Jaggery: CoG 6, Co 0212, Co 06022 and Co 11015

**Varieties suitable for different seasons**

**Early (Dec-Jan) :**

CoC 25, CoG 6, TNAU Sugarcane Si 7, Co 09004, Co 06022, CO 91015(Atulya)

**Mid-late (Feb-Mar) :**

Co 86032, Co 06030, TNAU Sugarcane Si 8, Co 0212

**Special season (June-sept)**

CoC 25, CoG 6, TNAU Sugarcane Si 7, Co 09004, Co 06022, CO 91015(Atulya)

**Source of Seed**

For the varieties released from Tamil Nadu Agricultural University for supply of primary seed materials, the Sugarcane Research Stations at Cuddalore, Sirugamani and Melalathur may be contacted. For other varieties promoted by the factories, for seed materials the concerned factories may be contacted.

## CROP MANAGEMENT

### IV. MAIN FIELD PREPARATION FOR PLANTING SUGARCANE

**1. PREPARATION OF THE FIELD**

a) **Wetland (Heavy soils):** In wetlands, preparatory cultivation by ploughing the land and bringing the soil to fine tilth could not be done.

i. After harvest of the paddy crop, form irrigation and drainage channels of 40 cm depth and 30 cm width at intervals of 6 m across the field and along the field borders.

ii. Form ridges and furrows with a spacing of 80 cm between rows with spade.

iii. Stir the furrows with hand hoes and allow the soil to weather for 4 to 5 days.

b) **Problem soils with excessive soil moisture:**

In problem soils, with excessive moisture where it is difficult to drain water, form raised beds at 30 cm intervals with Length - 5 m, Width - 80 cm, and Height -15 cm.

c. **Garden lands with medium and light soils:**

In medium and light soil irrigated by flow or lift irrigation adopt the following:

i. The initial ploughing with two disc plough followed by eight disc plough and using cultivator for deep ploughing followed by one time operation of rotovator to pulverize the soil to get a fine tilth, free of weeds and stubbles.

ii. Level the field with laser leveler for effective and proper irrigation management.

iii. Open ridges and furrows with tractor operated victory plough with a depth of 30cm and spacing of 80 cm between the rows for normal planting with furrow irrigation.

iv. Open irrigation channels at 10 m intervals.

**2. BASAL APPLICATION OF ORGANIC MANURES:**

Apply FYM at 12.5 t/ha or compost 25 t/ha or filter press mud at 37.5 t/ha before the last ploughing under gardenland conditions. In wetlands this may be applied along the furrows and incorporated well.

**Preparation of reinforced compost from sugarcane trash and pressmud:**

Spread the sugarcane trash to a thickness of 15 cm over an area of 7 m x 3 m. Then apply pressmud over this trash to a thickness of 5 cm. Sprinkle the fertilizer mixture containing mussoorie rock phosphate, gypsum and urea in the ratio of 2:2:1 over these layers at the rate of 5 kg/100 kg of trash. Moist the trash and pressmud layers adequately with water. Repeat this process till the entire heap rises to a height of 1.5 m. Use cowdung slurry instead of water to moist the layer wherever it is available. Cover the heap with a layer of soil and pressmud at 1:1 ratio to a thickness of 15 cm. Leave the heap as such for three months for decomposition. Moist the heap once in 15 days. During rainy season, avoid moistening the heap. After three months, turn and mix the heap thoroughly and form a heap and leave it for one more month. Then turn and mix the heap thoroughly at the end of the fourth month. Moist the heap once in 15 days during 4th and 5th month also. This method increases the manurial value of trash compost by increasing, N, P and Ca content. It also brings down the C:N ratio by 10 times as compared to raw cane trash.

**Composition of cane trash, pressmud and cane trash compost**

| Major nutrients | Cane trash | Pressmud | Cane trash compost |
|---|---|---|---|
| Nitrogen (N) | 0.40 | Percent 1.90 | 1.60 |
| Phosphorus (P) | 0.13 | 1.50 | 1.10 |
| Potassium(K) | 0.40 | 0.50 | 0.40 |
| Calcium (Ca) | 0.56 | 3.00 | 1.00 |
| Magnesium (Mg) | 0.30 | 2.00 | 0.60 |
| Sulphur (S) | 0.12 | 0.50 | 0.48 |

| Micronutrients | Cane trash | Pressmud | Cane trash compost |
|---|---|---|---|
| | | PPM | |
| Iron (Fe) | 360 | 2240 | 2710 |
| Manganese (Mn) | 110 | 400 | 450 |
| Zinc (Zn) | 90 | 360 | 370 |
| Copper (Cu) | 30 | 130 | 80 |
| C:N ratio | 113:1 | 16:1 | 22:1 |

**2. BASAL APPLICATION OF PERTILIZER**

(i) If soil test is not done, follow blanket recommendation of NPK @ 300:100:200 kg/ha
Apply super phosphate (625 kg/ha) along the furrows and incorporate with hand hoe.

(ii) Soil test crop response based integrated plant nutrition system (STCR- IPNS) recommendation may be adopted for prescribing fertilizer doses for specified yield targets. (ready reckoners are furnished)

**Sugarcane (1)**

| | | | |
|---|---|---|---|
| Soil | : | Mixed black calcareous (Perianaickenpalayam series) | FN = 4.17 T - 1.09 SN - 1.11 ON<br>$FP_2O_5$= 1.01 T - 2.56 SP - 1.01 OP |
| Target | : | 125-150 t $ha^{-1}$ | $FK_2O$ = 3.44 T - 0.84 SK - 1.03 OK |

| **Initial soil test values (kg $ha^{-1}$)** | | | **Yield target – 125t $ha^{-1}$** | | | **Yield target – 150 t $ha^{-1}$** | | |
|---|---|---|---|---|---|---|---|---|
| | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | | **NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$** | | |
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 15 | 300 | 223 | 50* | 113 | 328 | 68 | 199 |
| 220 | 17 | 350 | 201 | 50* | 100* | 306 | 63 | 157 |
| 240 | 19 | 400 | 180 | 50* | 100* | 284 | 58 | 115 |
| 260 | 21 | 450 | 158 | 50* | 100* | 262 | 53 | 100* |
| 280 | 23 | 500 | 150* | 50* | 100* | 240 | 50* | 100* |

* Maintenance dose

**Sugarcane (2)**

Soil : Red coastal alluvium (Gadillum series)

Target : 125 t $ha^{-1}$ and 150 t $ha^{-1}$

FN =4.06 T-0.74SN-0.87 ON

$FP_2O_5$=0.71T-1.09 SP-0.72 OP

$FK_2O$=2.67T-0.57SK-1.33 OK

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 125 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 150 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 15 | 200 | 280 | 50* | 155 | 381 | 50* | 222 |
| 220 | 17 | 220 | 265 | 50* | 143 | 366 | 50* | 210 |
| 240 | 19 | 240 | 250 | 50* | 132 | 351 | 50* | 199 |
| 260 | 21 | 260 | 235 | 50* | 121 | 337 | 50* | 187 |
| 280 | 23 | 280 | 220 | 50* | 109 | 322 | 50* | 176 |

*Maintenance dose

**Sugarcane (3)**

Soil : Red sandy loam (Irugur series)

Target : 100 t $ha^{-1}$ -125 t $ha^{-1}$

FN =3.42 T-0.56 SN-0.93 ON

$FP_2O_5$=1.15T-1.94 SP-0.98 OP

$FK_2O$=3.16T-0.73SK-0.99 OK

| Initial soil test values (kg $ha^{-1}$) | | | Yield target – 100 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | | Yield target – 125 t $ha^{-1}$ NPK (kg $ha^{-1}$) + FYM @ 12.5 t $ha^{-1}$ + *Azospirillum* @ 2 kg $ha^{-1}$ + PSB @ 2 kg $ha^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|
| **SN** | **SP** | **SK** | **FN** | **$FP_2O_5$** | **$FK_2O$** | **FN** | **$FP_2O_5$** | **$FK_2O$** |
| 200 | 14 | 200 | 150 | 50* | 105 | 236 | 72 | 184 |
| 220 | 16 | 220 | 139 | 50* | 100* | 224 | 68 | 169 |
| 240 | 18 | 240 | 128 | 50* | 100* | 213 | 64 | 155 |
| 260 | 20 | 260 | 116 | 50* | 100* | 202 | 60 | 140 |
| 280 | 22 | 280 | 105 | 50* | 100* | 191 | 56 | 126 |

*Maintenance dose

Note: FN, $FP_2O_5$ and $K_2O$ are fertilizer N, $P_2O_5$ and $K_2O$ in kg $ha^{-1}$, respectively; T is the yield target in t $ha^{-1}$; SN, SP and SK respectively are available N,P and K in kg $ha^{-1}$ and ON, OP and OK are the quantities of N, P and K supplied through organic manure inkg $ha^{-1}$.

(i) Apply 37.5 kg Zinc sulphate/ha and 100 kg Ferrous sulphate + 12.5 t FYM/ha to zinc and iron deficient soils.

(ii) Application of sulphur in the form of Gypsum @ 500 kg /ha to sulphur deficient soils to increase the cane yield and juice quality.

(iii) Basal application of 5 kg $CuSO_4$ for copper deficient soil.

# V. MANAGEMENT OF MAIN FIELD OPERATIONS

## 1. PREPARATION OF SETTS FOR PLANTING

a. Take seed material from short crop (6 to 7 months age) free from pests and diseases incidence.
   i) Detrash the cane with hand before setts preparation.
   ii. Use sharp knife or sett cutting machine developed by TNAU to prepare setts without splits.
   iii. Discard setts with damaged buds, sprouted buds, splits etc.
   iv. **Sett treatment with biofertilizers:** Prepare slurry with 2 kg of *Azospirillum/ Gluconacetobacter,* 2kg of phosphobacteria , 2 kg of SSB and dip the setts required for one ha for 30 minutes and plant. (or) sett treatment with powder formulation of *Gluconacetobacter diazotrophicus* and AM fungi each @ 67.5 g/ha along with 75% of recommended dose of N & P.

## 2. SETT TREATMENT

- Select healthy setts for planting.
- The setts should be soaked in 100 litres of water dissolved with 50g Carbendazim, 200ml malathion and 1 kg urea for 15 minutes.
- Treat setts with Aerated steam at 50°C for one hour to control primary infection of grassy shoot disease.

## 3. SEED RATE

75000 two-budded setts/ha.

## 4. PLANTING

Different systems of planting is not found to influence the millable cane population, commercial cane sugar per cent, cane and sugar yield.

a) Irrigate the furrows to form a slurry in wet land condition (Heavy soil)
b) Place the setts along the centre of the furrows, accommodating 12 buds/metre length. Keep the buds in the lateral position and press gently beneath the soil in the furrow.
c) Next day cover the exposed setts with soil to avoid exposure of setts to sunlight.
d) Plant more setts near the channel or double row planting at every $10^{th}$ row for gap filling, at later stage.
e) In dry/ garden land dry method of planting may be followed. First arrange the setts along the furrows, cover the setts with soil and then irrigate.

**Improved technologies on cane planting systems**

**Mechanisation of planting**

- TNAU mechanical planter is useful for cost effective planting with saving of Rs.3750 / ha and it can cover an area of 1.5ha/day
- Reduces the human labour drudgery and seed rate up to 5 tones/ha.
- Paired row system of planting double side planting of sugarcane setts with 150 + 30 cm spacing for Astraf 8000 series (Mechanical harvester) operated areas and 150 + 30 cm spacing for New Holland 4000 series operated areas may be

adopted with single row of cane planting.

- Sugarcane cultivates under subsurface drip system the laterals may be placed 20cm depth in the furrows and setts are placed 5cm above the laterals.
- For sustainable sugarcane initiative system (SSI) transplanting young chip bud seedling raised in portray (25-35 days old) in wide spacing (5x2 feet) in the main field with drip fertigation system.
- Daincha / Sunhemp intercropping in the wider spaced cane cultivated area for improving soil health and reduce the weed infestation. It also reduces early shoot borer incidences and increases cane yield.
- Plant the setts on one side of the ridge for 80 cm spacing in heavy soil to avoid sett rot resulted better germination
- Sow rhizobium treated green manure seeds @ 10kg/ha on the opposite side of ridge with 10cm. Spacing on or before 3 days after planting.
- Incorporate the green manure crop 50-60 days after planting in between interow of wider spaced crop and give partial earthing up with recommended dose of N fertilizer on 90 – 100 day after planting.
- Introduction of power weeder with rotovator for weeding and earthing up with ridger to save the cost on labour and also to reduce human drudgery.

**5. FILLING UP GAPS**

ii. Fill the gaps, if any, within 30 days after planting with sprouted setts.
iii. Gap filling with two budded setts/ poly bag seedlings within 15 to 20 days after planting to maintain optimum plant stand.
iv. Maintain adequate moisture for 3 weeks for proper establishment of the sprouted setts.

**6. TRASH MULCHING**

Mulch the ridges uniformly with cane trash to a thickness of 10 cm within a week after planting. It helps to tide over drought, conserves moisture, reduce weed population and minimise shoot borer incidence. Mulch the field with trash after 21 days of planting in heavy soil and wetland conditions. Avoid trash mulching in areas where incidence of termites is noticed.

**7. RAISING INTER CROPS**

In areas of adequate irrigation, sow one row of soybean or blackgram or greengram along the centre of the ridge on the 3rd day of planting. Intercropping of daincha or sunhemp along ridges and incorporation of the same on the 45$^{th}$ day during partial earthing up helps to increase the soil fertility, and also the cane yield.

**8. WEED MANAGEMENT**

**WEED MANAGEMENT IN PURE CROP OF SUGARCANE**

i. Wherever weed menace is higher, one line weeding along the crop row and spade digging of ridges have to be done on 30, 60 and 90 DAP
ii. Spray Atrazine 1 kg or Oxyflurofen 750 ml/ha mixed in 500 liters of water as pre emergence herbicide on the 3rd day of planting, using deflector or fan type nozzle fitted with knapsack sprayer.
iii. Pre emergence application of atrazine @ 1.0 kg ha$^{-1}$ on 3 DAP followed by post emergence directed application of glyphosate @ 10 ml / litre of water on 45 DAP with hood+ one hand weeding on 90 DAP registered the maximum cane yield.

iv. If the parasitic weed striga is a problem, Pre-emergence application of Atrazine 1.0 kg/ha on 3 DAP + hand weeding on 45 DAP with an earthing up on 60 DAP combined with post-emergence sparaying of 2,4-D @ 6 g (0.6%) + Urea @ 20 g (2%) / litre of water on 90 DAP + Trash mulching 5 t/ha on 120 DAP.
v. Pre- plant application of glyphosate at 2.0 kg $h^{a-1}$ along with 2% ammonium sulphate at 21 days before planting of sugarcane followed by post emergence direct spraying of glyphosate at 2.0 kg $h^{a-1}$ along with 2% ammonium sulphate with a special hood on 30 DAP suppressed the nut sedges *(Cyperus rotandus*) and provided weed free environment.
vi. If herbicide is not applied work the junior-hoe along the ridges on 25, 55 and 85 days after planting for removal of weeds and proper stirring. Remove the weeds along the furrows with hand hoe. Otherwise operate power tiller fitted with tynes for intercultivation.
vii. Control of creeper weeds post emergence directed application of fernoxone (2, 4 –D sodium salt) @ 2 gm + 10 gm of urea per liter of water may be sprayed over the creeper weeds.

**Weed management in Sugarcane intercropping system**

Premergence application of Thiobencarb @ 1.25 kg ai/ha under intercropping system in Sugarcane with Soybean, blackgram or groundnut gives effective weed control. Raising intercrops is not found to affect the cane yield and quality.

## 9. EARTHING UP

After application of 3rd dose fertilizer (90 days), work victory plough along the ridges for efficient and economical earthing up. At 150 days after planting, earthing up may be done with spade.

## 10. DETRASHING

Remove the dry cane leaves on $150^{th}$ and $210^{th}$ day to avoid borer infestation.

## 11. PROPPING

Do double line propping with trash twist at the age of 210 days of the crop.

## 12. TOP DRESSING WITH FERTILIZERS

Apply 275 kg of nitrogen and 112.5 kg of K O/ha in three equal splits at 30, 60 and 90 days

**a. Soil application**

Coastal and flow irrigated belts (assured water supply areas). In the case of lift irrigation belt, apply 225 kg of nitrogen and 112.5 kg of K O/ha in three equal splits at 30, 60 and 90 days (water scarcity areas). For jaggery areas, apply 175 kg of nitrogen and 112.5 kg of $K_2O$/ha in three equal splits on 30, 60 and 90 days.

**NITROGEN SAVING**

a. **Neem Cake Blended Urea**: Apply 67.5 kg of N/ha + 27.5 kg of Neem Cake at 30 days and repeat on 60th and 90th days.

**Note**: Neem cake blending: Powder the required quantity of neem cake and mix it with urea thoroughly and keep it for 24 hours. Thus, 75 kg of nitrogen/ha can be saved by this method.

b. **Azospirillum**: Mix 12 packets (2400 g)/ha of Azospirillum inoculant or TNAU Biofert –1 with 25 kg of FYM and 25 kg soil and apply near the clumps on 30th day of planting. Repeat the same on 60th day with another 12 packets (2400 gm). Repeat the above on the other side of the crop row on the 90th day (for lift irrigated belt).
c. **Band placement:** Open deep furrows of 15 cm depth with hand hoes and place the fertilisers in the form of band and cover it properly.
d. **Subsurface application:** Application of 255 kg of Nitrogen in the form of urea along with potash at 10cm depth with 15cm intervals by the side of the cane clump will result in the saving of 20 kg N/ha without any yield reduction.

**Nutritional Disorders :**

**Nitrogen deficiency :** All leaves of sugarcane exhibit a yellow – green colour and retardation of growth. Cane stalks are smaller in diameter and premature drying of older leaves. Roots attain a greater length but are smaller in diameter.

**Phosphorus deficiency :** Reduction in length of sugarcane stalks, diameters of which taper rapidly at growing points. The colour of the leaves is greenish blue, narrow and some what reduce length. Reduced tillering, decreased shoot / root ratio with restricted root development.

**Potassium deficiency:** Depressed growth, yellowing and marginal drying of older leaves and development of slender stalks. An orange, yellow colour appears in the older lower leaves which develop numerous chlorotic spots that later become brown with dead centre. A reddish discoloration which is confined to the epidermal cells of the upper surfaces and midribs of the leaves. The young leaves appear to have developed from a common point giving a “Bunched top” appearance. Poor root growth with less member of root hairs.

**Zinc deficiency:** Mild zinc deficiency exhibit a tendency to develop anthrocyanin pigments in the leaves. Pronounced bleaching of the green colour along the major veins and also striped effect due to a loss of chlorophyll along the veins. In acute cases of zinc deficiency there is evidences of necrosis and growth ceases at the growing point (meristem).

**Iron deficiency:** Symptoms of Iron deficiency are generally seen in young leaves where pale stripes with scanty chlorophyll content occur between parallel lines. In advanced stages of deficiency the young leaves turn completely white, even in the veins. Root growth also becomes restricted.

**Boron deficiency :** Boron deficiency could be seen in the cane by depressed growth, development of distorted and chlorotic leaves and the presence of definite leaf and stalks lesions. In extreme cases of boron deficiency the plant will die.

**Importance of Balanced Nutrition**

The soil fertility has declined in many sugarcane growing areas of the state due to improper and some times, distorted fertilizer schedules adopted over the years under intensive cultivation of the crop. Hence balanced application of fertilizer based on soil test values and crop requirement is essential.

**How to Evaluate fertilizer requirement**

Through STCR fertilizer prescription equations

a. Perianaickenpalayam series (Inceptisols) of Coimbatore and Erode STL Jurisdiction
$FN = 4.17\ T – 1.09\ SN – 1.11\ ON$ $FP_2O_5 = 1.01\ T – 2.56\ SP – 1.01\ OP$ $FK_2O = 3.44\ T – 0.84\ SK – 1.03\ OK$

b. Gadillum series (Red laterite) of Cuddalore STL Jurisdiction
$FN = 4.06\ T – 0.74\ SN – 0.87\ ON$ $FP_2O_5 = 0.71\ T – 1.09\ SP – 0.72\ OP$ $FK_2O = 2.67\ T – 0.57\ SK – 1.30\ OK$

c. Irugur series (Inceptisols) of Coimbatore, Erode, Trichy and Salem STL Jurisdiction
$FN = 3.42\ T – 0.56\ SN – 0.93\ ON$ $FP_2O_5 = 1.15\ T – 1.94\ SP – 0.98\ OP$ $FK_2O = 3.16\ T – 0.73\ SK – 0.99\ OK$

**Micro nutrient fertilizers**

1. (a) Zinc deficient soils : Basal application of 37.5 kg/ha of zinc sulphate.
   (b) For zinc deficiency symptoms: foliar spray of 0.5% zinc sulphate with 1% urea at 15 days internal till deficiency symptoms disappear.
2. (a) Iron deficient soils: Basal application of 100 kg/ha of ferrous sulphate + 12.5t FYM.
   (b) For Iron deficiency symptoms: Foliar spray of 1% ferrous sulphate + 0.1% citric acid with 1% urea at 15 days interval till deficiency symptoms disappear.
3. Soil application of $CuSO_4$@ 5 kg/ha in copper deficient soils. Alternatively foliar spray of 0.2% $CuSO_4$ twice during early stage of crop growth.

**Common Micronutrient mixture :** To provide all micronutrients to sugarcane, 50 kg /ha of micronutrient mixture containing 20 kg Ferrous sulphate,10 kg Manganese sulphate, 10 kg Zinc sulphate, 5 kg of Copper sulphate, 5 kg of Borax mixed with 100 kg of well decomposed FYM, can be recommended as soil application prior to planting. (Or) Application of TNAU MN mixture @ 50 kg/ha as EFYM for higher cane yield.

**Recommended dosage of macro and micronutrients Macronutrients**

a. Sugarcane – plant crop (meant for sugar mills) 300:100:200 kg N, $P_2O_5$ and $K_2O$ per ha
b. Sugarcane – Ratoon crop (meant for sugar mills)
   300 + 25% extra N : 100 : 200 kg N, $P_2O_5$ and $K_2O$ per ha
c. Sugarcane for jaggery manufacture (plant as well as ratoon crop)
   225 : 62.5 : 112.5 kg N, $P_2O_5$ and $K_2O$ per ha

**13. BIOFERTILIZER FOR SUGARCANE**

*Azospirillum* is the common biofertilizer recommended for N nutrition which could colonize the roots of sugarcane and fix atmospheric nitrogen to the tune of about 50 to 75 kg nitrogen per ha per year. Recently, another endophytic nitrogen fixing bacterium, *Gluconacetobacter diazotrophicus* isolated from sugarcane can able to fix more nitrogen than *Azospirillum*. It colonizes throughout the sugarcane and increases the total N content. In soil, it can also colonize the roots and able to solubilize the phosphate, iron and Zn. It can also enhance the crop growth, yield of sugarcane and sugar content of the juice. Since it is more efficient than *Azospirillum*, this new organism was test-verified in various centres and released as new biofertilizer Gluconacetobacter diazotrophicus TNAU Biofert-I. Phosphobacteria as P solubiliser are recommended for sugarcane crop.

**Sett treatment with *Gluconacetobacter diazotrophicus***

Before planting the sugarcane setts can be treated with ten packets (2 kg) per ha of *Gluconacetobacter diazotrophicus* prepared as slurry with 250 L of water.

**Soil application *Gluconacetobacter diazotrophicus***

Twelve packets (2.4 kg) per ha is recommended for soil application each at 30th, 60th and 90th day after planting under irrigated condition.

**Same method of application can be followed for Phosphobacteria.**

- If basal application is not followed apply the same with 30th day, 60th day and 90th day after planting and copiously irrigate the field.
- Biofertilizer treatment should be done just before planting.
- Immediately plant/ Irrigate after biofertilizer application
- Do not mix biofertilizer along with chemical fertilizer.
- Reduces 25% of the recommended N to reap the benefits of biofertilizer application

## 14. WATER MANAGEMENT

Irrigate the crop depending upon the need during different phases of the crop.

**Germination phase (0 - 35 days)**:

Provide shallow wetting with 2 to 3 cm depth of water at shorter intervals especially for sandy soil for enhancing the germination. Sprinkler irrigation is the suitable method to satisfy the requirement, during initial stages.

Later, irrigation can be provided at 0.75, 0.75 and 0.50 IW/CPE ratio during tillering, grandgrowth and maturity phases respectively. The irrigation intervals in each phase are given below:

| **Stages** | **Days of irrigation interval** | |
|---|---|---|
| Tillering phase (36 to 100 days) | 8 | 10 |
| Grand growth phase (101 - 270 days) | 8 | 10 |
| Maturity phase (271 - harvest) | 10 | 14 |

**Drip Irrigation:**

- Planting setts obtained from 6-7 months old healthy nursery and planted in paired row planting system with the spacing of 30x30x30 / 150 cm. for manual harvest and 30/150 cm for machine harvest
- Eight setts per metre per row have to be planted on either sides of the ridge thus making it as four row planting system.
- 12 mm drip laterals have to be placed in the middle ridge of each furrow with the lateral spacing of 240 cm & 8 'Lph' clog free drippers should be placed with a spacing of 75 cm on the lateral lines. The lateral length should not exceed more than 30-40 m.
- Phosphorus @ 62.5 kg $ha^{-1}$ has to be applied as basal at the time of planting.
- Nitrogen and Potassium @ 275:112.5 kg $ha^{-1}$ have to be injected into the system as urea and muriate of potash by using "Ventury" assembly in 10-12

equal splits starting from 15 to 150- 180 days after planting.

- Low or medium in nutrient status soil to be given with 50 per cent additional dose of Nitrogen and Potassium.
- Irrigation is given once in three days based on the evapo-transpiration demand of the crop.
- The double side planting of sugarcane with lateral spacing of 120+40 cm under subsurface drip fertigation system improves the yield.
- Application of 125 % recommended NPK (Rec NPK-275 :63:112.5 kg /ha ) through fertigation under pit system of planting inprove the yield and yield attributes.

**Concept of fertigation**

- Fertigation is the judicious application of fertilizers by combining with irrigation water.
- Fertigation can be achieved through fertilizer tank, venturi System, Injector Pump, Non- Electric Proportional Liquid Dispenser (NEPLD) and Automated system.
- Recommended N & K @ of 275 and 112.5 kg. $ha^{-1}$ may be applied in 14 equal splits with 15 days interval from 15 DAP.
- 25 kg N and 8 kg $K_2O$ per ha per split.
- Urea and MOP (white potash) fertilisers can be used as N and K sources respectively
- Fertigation up to 210 DAP can also be recommended.

**Advantages of Fertigation**

- Ensures a regular flow of water as well as nutrients resulting in increased growth rates for higher yields
- Offers greater versatility in the timing of the nutrient application to meet specific crop demands
- Improves availability of nutrients and their uptake by the roots
- Safer application method which eliminates the danger of burning the plant root system
- Offers simpler and more convenient application than soil application of fertilizer thus saving time, labour, equipment and energy
- Improves fertilizer use efficiency
- Reduction of soil compaction and mechanical damage to the crops
- Potential reduction of environmental contamination
- Convenient use of compound and ready-mix nutrient solutions containing also small concentration of micronutrients.

**15. Contingent plan**

**Gradual widening of furrow:**

At the time of planting, form furrow at a width of 30 cm initially. After that, widen the furrow to 45 cm on 45th day during first light earthing up and subsequently deepen the furrow on 90th day to save 35% of water.

**Drought Management:**

i. Soak the setts in lime solution (80 kg Kiln lime in 400 lit) for one hour.
ii. Plant in deep furrows of 30 cm depth.
iii. Foliar spray of kel and urea each at 2.5 per cent during moisture stress period at 15 days interval.
iv. Foliar spray of Kaolin (60 g in 1 ltr. of water) to alleviate the water stress.
v. Under water scarcity condition, alternate furrow and skip furrow method is beneficial.
vi. Apply 125 kg of MOP additionally at 120 day of planting.
vii. Basal incorporation of coir waste @ 25 tonnes/ha at the time of last ploughing.
viii. Removal of dry trash at 5th month and leave it as mulch, in the field.

## 16. CROP PROTECTION

### A. Pest Management:

**SUGARCANE**

- Deep plough during summer
- Select scale insect free setts
- Treat the setts with imidacloprid 70% WS **@** 100 ml/ 100 kg to avoid termite
- Adopt early planting (Dec-Jan)
- Plant sugarcane in paired or wider rows for taking effective control measures
- Trash mulch on ridges at 3 DAP
- Intercrop with green gram, black gram and daincha
- Keep bunds free from weeds
- Avoid ratoons in infested fields
- Provide adequate rrigation & avoid excessive use of nitrogenous fertilizers
- Detrash on 150 and 210th DAP
- Drain excess water
- Avoid use of insecticide treated leaves as cattle feed.

| | |
|---|---|
| **Early Shoot borer,**<br>*Chilo infuscatellus* | • Release *Sturmiopsis inferens* gravid females @ 125/ha on 30 and 45 DAP<br>**Apply any one of the following insecticides/ha**<br>• Chlorantraniliprole 0.4% G @ 18.75 g<br>• Chlorantraniliprole 18.5 % SC @ 375 ml<br>• Chlorpyriphos 20%EC 1.0 lit<br>• Fipronil 0.3% GR @ 25 kg<br>• Fipronil 5% SC @1.5 lit<br>• Monocrotophos 36 %SL 1.5 lit<br>• NSKE 5 %<br>• Thiamethoxam 75% w/w SG @ 160 g |
| **Internode borer,**<br>*Chilo sacchariphagus indicus* | • Release egg parasitoid, *Trichogramma chilonis* at the rate of 2.5 cc / release/ha (Six releases at 15 days interval starting from fourth month). |
| **Top shoot borer,**<br>*Scirpophaga excerptalis* | • Collect and destroy egg masses<br>• Release prepupal parasitoid, *Isotima javensis* @ 125 females /ha |

| | |
|---|---|
| | **Apply any one of the following insecticides/ha**<br>• Carbofuran 3% CG @ 66 kg<br>• Chlorantraniliprole 0.4% G @ 18.75 kg<br>• Chlorantraniliprole 18.5% SC 375 ml |
| **Pyrilla,** *Pyrilla perpusilla* | • Release lepidopteran parasitoid, *Epiricrania melanoleuca* @ 8000 -10,000 cocoon /ha (or) 8 - 10 lakh eggs/ha<br>**Spray any one of the following on 150 and 210 DAP /ha after detrashing**<br>• Chlorpyriphos 20 % EC @ 1.50 lit<br>• Monocrotophos 36%SL @ 1.50 lit |
| **Aleurodids,**<br>*Aleurolobus barodensis*<br>**Aphid,**<br>*Melanaphis sacchari,*<br>*M. indosacchari*<br>**Scale insect,**<br>*Melanaspis glomerata*<br>**Mealybug,** *Saccharicoccus sacchari* | • Spray monocrotophos 36%SL @ 1.50 lit/ha |
| **Termite,**<br>*Odontotermes obesus* | • Flood irrigate the furrows at the time of planting<br>• Drench soil with chlorpyriphos 20% EC @ 6.25 lit/ha<br>Apply any one of the following insecticides/ha<br>• Chlorantraniliprole 18.5% SC @ 500 ml<br>• Clothianidin 50% WDG @ 250 g<br>• Imidacloprid 17.8% SL@ 350 ml<br>• Thiamethoxam 75% w/w SG @160 g |
| **Root grub**<br>*Holotrichia consanguinea H. serrata*<br>*Leucopholis lepidophora* | • Set up light trap to collect and destroy adults<br>• Collect and destroy adult beetles present on neem, *Ailanthus* and *Acacia* trees<br>• Imidacloprid 17.8% SL@ 350 ml / ha |
| **Woolly aphid,**<br>*Ceratovacuna lanigera* | • Avoid transportation of aphid infested leaves from one location to another<br>• Conserve and augment biocontrol agents like *Dipha aphidivora, Micromus* and coccinellids<br>Spray any one of the following insecticides /ha<br>• Chlorpyriphos 25%EC 1.0 lit<br>• Monocrotophos 36%SL 625 ml |
| **Root borer** | Spray any one of the following insecticides /ha<br>• Fipronil 5% SC @1.5 lit<br>• Fipronil 0.3% GR @ 25 kg |

## B) Disease management

| Disease | Recommendations |
|---|---|
| **Red rot:** *Colletotrichum fal catum* | • Selection of setts from healthy nursery programme.<br>• Growing of recommended resistant and moderately resistant varieties *viz*., Co 86249, CoC 22, CoC 25, CoG 6 and Co 0212<br>• Sett treatment with carbendazim before planting (carbendazim 50 WP @ 0.05% along with 1.0% urea for 15 minutes)<br>• The irrigation interval in red rot affected field must be lengthened. Once in 15 days during tillering, growth phases and once in 25 days during maturity phase which restricts the spread<br>• Removal of the affected clumps at an early stage and soil drenching with 0.1 % carbandazim 50 WP<br>• The trash of red rot affected field after harvest may be uniformly spread and burnt<br>• In the red rot affected field crop rotation with rice for one season and other crops for two seasons could be adopted |
| **Sett rot:** *Ceratocytis paradoxa* | • Sett treatment with carbendazim before planting (carbendazim 50 WP @ 0.05% along with 1.0% urea for 15 minutes)<br>• Proper drainage and planting of setts in 1-2 cm depth |
| **Smut:** *Sporisorium scitamineum* (*Ustilago scitaminea)* | • Sett treatment with carbendazim before planting (carbendazim 50 WP @ 0.05% along with 1.0% urea for 15 minutes)<br>• Treating the setts with Aerated Steam Therapy (AST) at 50 ºC for 1 hour or in hot water at 50 ºC for 30 minutes or at 52 ºC for 18 minutes<br>• Roguing of smut whips with gunny bags/polythene bag and burnt<br>• Discourage ratooning of the diseased crops having more than 10 per cent infection |
| **Grassy shoot disease (GSD):** Candidatus Phytoplasma | • Rogue out infected plants in the seed nursery<br>• Treat setts with aerated steam at 50°C for 1 hour to control primary infection<br>• Spray dimethoate @ 0.1 % to control insect vector<br>• Avoid ratooning if GSD incidence is more than 15 % in the plant crop |

| | |
|---|---|
| **Leaf spot:** *Cercospora longipes* | • pray mancozeb @ 2 kg or carbendazim @ 500 g/ha |
| **Rust:** *Puccinia melanocephala* | • pray mancozeb @ 2 kg/ha |
| **Yellow leaf disease:** Sugarcane yellow leaf virus (Vector: *Melanopsis sacchari*) | • se of disease free setts for planting<br>• election of tissue culture seedling from meristem tip culture<br>• roper nutritional management |

**General Recommendations**

- Select healthy setts for planting. In the seed crop, select plants which do not show symptoms of red rot, smut, grassy shoot and ratoon stunting. Setts showing red colour at the cut end and hollows should be rejected.
- In fields which had shown high level of red rot disease, follow crop rotation with rice.
- Sett treatment with carbendazim before planting (carbendazim 50 WP @ 0.05% along with 1.0% urea for 15 minutes.
- Treat setts with aerated steam at 50°C for one hour to control primary infection of smut and grassy shoot disease.
  Clumps infected by grassy shoot, smut and ratoon stunting diseases should be uprooted and destroyed.

**17. PRE-HARVEST PRACTICES**

**a. Apply cane ripeners**

i. Spray Sodium metasilicate 4 kg/ha in 750 litres of water on the foliage of crop at 6 months after planting.

ii. Repeat the same twice at 8th and 10th months to obtain higher cane yield and sugar percentage.

**b. Assessing maturity of crops**

i. Assess the maturity by hand refractometer brix survey and 18 to 20 per cent brix indicates optimum maturity for harvest.

ii. Top-bottom ratio of H.R.Brix reading should be 1:1.

**18. HARVESTING**

i. Early varieties have to be harvested at 10 to 11 months age and mid-season varieties at 11 to 12 months age.

ii. Harvest the cane at peak maturity. Cut the cane to the ground level for both plant and ratoon crops.

## B. RATOON CROP

**I. MANAGEMENT OF THE FIELD AFTER HARVEST OF THE PLANT CROP**

Complete the following operations within 10 days of harvest of plant crop to obtain better establishment and uniform sprouting of shoots.

1. Remove the trash from the field. Do not burn it. Irrigate the field copiously.
2. Follow stubble shaving with sharp spades to a depth of 4 - 6 cm along the ridges at proper moisture.

3. Work with cooper plough along with sides of the ridges to break the compaction.
4. The gappy areas in the ratoon sugarcane crop should be filled within 30 days of stubble shaving. The sprouted cane stubbles taken from the same field is the best material for full establishment. The next best method is gap filling with seedlings raised in polybags.
5. Apply basal dose of organic manure and super phosphate as recommended for plant crop.

**II. MANAGEMENT OF THE CROP**

1. 25% additional N application on 5-7 days after ratooning.
2. Foliar spray of Ferrous sulphate at 2.5 kg/ha on the 15th day. If chlorotic condition persists, repeat the spray twice further at 15 days interval. Add urea 2.5 kg/ha in the last spray.
3. Hoeing and weeding on 20th day and 40th to 50th day.
4. First top dressing on 25th day, 2nd on 45th to 50th day.
5. Final manuring on 70th to 75th day.
6. Partial earthing up on 50th day. If junior-hoe is worked two or three times upto 90th day, partial earthing up is not necessary.
7. Final earthing up on 90th day.
8. Detrashing on 120th and 180th day.
9. Trash twist propping on 180th day.
10. Harvest after 11 months.

## C. SHORT CROP (NURSERY CROP)

## SELECTION OF PROPER PLANTING MONTHS FOR RAISING NURSERY CROP IN RELATION TO MAIN FIELD PLANTING

Raise six to seven months old nursery crop prior to main field planting as follows:

| Raise nursery crop during | Main field planting |
|---|---|
| June | December - January (early season) |
| July | February - March (Mid season) |
| August | April - May (Late season) |
| Dec - Apr | June - September (Special season) |

**II. PRECAUTIONS IN MAINTAINING NURSERY CROP**

Adopt similar production techniques for raising short crop with the following modifications.

1. Do not detrash
2. Do not prop
3. Harvest at 6 to 7 months age
4. Remove trash by hand while preparing setts
5. Avoid bud damage
6. Transport the seed material to other places in the forms of full canes with trash intact.
7. Apply 50 kg of urea as top dressing additionally before one month of cutting the seed cane.

## CROP PHYSIOLOGY

Foliar spray of TNAU Sugarcane Booster @ 1.0, 1.5 and 2 kg/acre in 200 litres of water at 45,60 and 75 days after planting enhances cane growth and weight, internodal length, cane yield, sugar content and offers drought tolerance.

## CROP PROTECTION

### A. Pest Management: Economic threshold level for important pests Economic threshold level for important pests

| Pests | Management strategies |
|---|---|
| **Shoot borer**<br>*Chilo infuscatellus* | < Cultural: Early season planting (Dec-Jan) ;<br>< Trash mulching on ridges on 3DAP<br>< Intercropping with green gram, black gram, daincha effectively checks shoot borer.<br>< Spray Granulosis virus at 1.5 x $10^{12}$ PIB/ha twice on 35 and 50 days after planting (DAP) or release 125 gravid females of *Sturmiopsis inferens* /ha on 30 and 45 DAP<br>**Apply any one of the following insecticides: Soil application**<br>Lindane 10 G 12.5 kg Carbofuran 3CG 33 kg **Spraying**<br>Chlorantraniliprole 18.5%SC 375 ml/ha Fipronil 5%SC 1500-2000 ml/ha Fipronil 0.3%GR 25-33.3 Kg/ha Quinalphos 25%EC 2000 ml/ha Phosalone 35 EC 1000 ml<br>NSKE 5 % 25 Kg/ha<br>< Daincha intercropped sugarcane recorded the lowest early shoot borer incidence. |
| | Note: The virus should be applied with teepol (0.05%) during evening hours. The granular application should be immediately followed by irrigation. 'Granulosis' virus spraying on sugarcane at 750 Nos. of diseased larvae, crushed and filtered mixed in 500 l of water has been found harmless to parasitoids and predators. A sticker like 'teepol' (250 ml for 500 l) can also be added to make the solution stick on to the surface of the crop and it is preferable to use high volume<br>sprayer to be more effective. On cost benefit ratio basis NSKE 5% is recommended. |
| **Internode borer**<br>*Chilo sacchariphagus indicus* | < Release egg parasitoid, *Trichogramma chilonis* at the rate of 2.5 cc/release/ha. Six releases fifteen days interval starting from fourth month onwards will be necessary.<br>< During rainy weather and when ants are present, release the parasite through musquito net covered plastic disposable cups.<br>< Detrash the crop on the 150th and 210th day after planting. |
| **Top shoot borer**<br>*Scirpophaga excerptalis* | **Spraying any one of the following insecticides:**<br>Carbofuran 3%G 33.3 kg/ha Chlorantraniprole 18.5%SC 375 ml/ha<br>Phorate 10%G 30 kg/ha<br>**Biocontrol:**<br>Release *Isotima javensis* at 100 pairs/ha |

| | |
|---|---|
| **Pyrilla**<br>*Pyrilla perpusilla* | **Spray any one of the following on the 150th and 210th day (1000 l spray fluid):**<br>Chlorpyrifos 20% EC 1500 ml/ha<br>Dichlorvos 76% EC 376 ml/ha<br>< Detrash on the above days<br>< Avoid excess use of nitrogen. |
| **Aleurodids**<br>*Aleurolobus barodensis* | < **Spray any one of the following when the incidence is noticed (1000 l spray fluid):** Fenitrothion 50 EC 2000 ml<br>Monocrotophos 36 WSC 2000 ml<br>< The pest generally occurs in ill drained soil. |
| **White grub**<br>*Holotrichia consanguinea* | < Crop rotation,<br>< Deep ploughing during summer,<br>< Avoid ratoons in infested fields,<br>< Provide adequate irrigation, since under inadequate soil moisture conditions, the pest appears in the root zone. |
| **Termite**<br>*Odontotermes obesus* | Flood irrigate the furrows to avoid termite attack in the furrows at the time of planting<br>< **Sett treatment:**<br>Dip the setts in imidacloprid 70 WS 0.1% or Chlorpyriphos 20 EC 0.04 % for 5 min.<br>< **Soil application:**<br>Apply lindane 1.3 D 125 kg/ha<br>< **Spray:**<br>Chlorantraniliprole 18.5%SC 500-625 ml/ha Imidacloprid 17.8% SL 350 ml/ha Chlorpyriphos 20%EC 750 ml/ha |
| **Root borer** | **Spraying any one the following insecticides:**<br>Fipronil 5% SC 1500-2000 ml/ha<br>Fipronil 0.3% GR 25-33.3 kg/ha<br>Phorate 10% CG 25 kg/ha |
| **Black bug** | **Apply any one of the following insecticides**<br>Chlorpyriphos 20% EC 750 ml/ha<br>Quinalphos 25% EC 2000 ml/ha |
| **Mealy bug**<br>*Saccharicoccus sacchari* | < Detrash as per schedule<br>< Drain excess water<br>**Apply any one of the following insecticides when the incidence is noticed spray on the stem only:** Methyl parathion 50 EC 1000 ml/ha<br>Malathion 50 EC 1000 ml/ha |
| **Leaf hopper** | **Spraying any one the following insecticides:**<br>Quinalphos 25% EC 1200 ml/ha Carbofuran 3% CG 33.3kg/ha |

## IMPROVED TECHNIQUES IN BIOLOGICAL CONTROL

**Improved adult feeding techniques for *Trichogramma***

- *Trichogramma* adult feeding through cotton swabs will trap the adults which get entangled in the sticky cotton lint. To avoid this, a better adult feeding technique is developed.
- Make small dotted holes in a thick mylar film sheet or old film negatives by using a sewing machine, leaving a gap of 1 cm between the dotted holes horizontally. One side of the sheet (7 x 6 cm) will be smooth and the other will be eruptive. Streak 50% honey solution on the smooth side by using a camel hair brush. Then fold the sheet in such a way that the honey-smeared surface is on the inside and the eruptive surface outside and staple it. The gap between the dotted holes will provide free movement for the adults, which imbibe the honey through eruptive surface. In this method, the adults do not get trapped in the honey solution.

**Special problem: Woolly aphid** (*Ceratovacuna lanigera*)

**Attacked plants could be recognized from a distance by the following symptoms:**

- White appearance of the lower surface of colonized top leaves; sooty mould growth and the honeydew exudations deposited on the upper surface of lower or adjacent leaves; occasional white woolly deposition on the ground under severe colonization.
- Established colonies, characterized by the presence of members most of which showed white woolly filaments, can be generally observed from the second leaf downward in the grown-up crop. At low numbers, colonization on leaves is restricted to a short perpendicular distance on either side of the midrib for a considerable length of the leaf.
- Among the plants the attack is seen only in patches.
- Since the infestation has become a major cause for concern, major initiatives have been started by the Department of Agriculture and ICAR.

**Management strategies:**

- Enforcement of compulsory IPM measures against woolly aphid infestation in newly planted and ratoon sugarcane fields by invoking suitable provisions of the State Pest Act of the State.
- Harvesting of the entire matured sugarcane crop on priority for crushing as well burning of the trash.
- Application of granular systemic insecticides after two days of irrigation may reduce the infestation of aphids even up to 30 days.
- Promotion of paired or wider row cultivation of sugarcane for taking effective control measures.
- Conservation and augmentation of identified potential biocontrol agents like *Dipha aphidivora, Micromus and coccinellids* in woolly aphid infested fields.
- Release of *Dipha aphidivora* @ 1000/ha or *Micromus igorotus* @ 2500/ha wherever possible.
- Conservation of lepidopteran predator, *Dipha aphidivora* predator population in limited areas of sugarcane crop for further distribution and use thereof.
- Regular surveillance and monitoring of sugarcane woolly aphid for timely

forewarning and adoption of IPM measures including judicious use of recommended pesticides and bio-pesticides (*Metarhizium anisopliae*, *Beauveria bassiana*, *Verticillium lecanii*).

- Avoiding transportation of aphid infested leaves from one location to another.
- Avoiding use of infested cane for seed purpose.
- Ensuring that the insecticides treated leaves are not used as fodder.
- Insecticide application at low levels or at initial stages of infestation may be restricted to only attackednplants since the attack is seen only in patches

During acute incidence, spray any one of the following insecticides once or twice in affected patches: Acephate 75SP 2gm/lit Chlorpyrifos 25EC 2ml/lit Monocrotophos 36WSC 2ml/lit.

| **Disease** | **Recommendations** |
|---|---|
| **Red rot:** *Colletotrichum falcatum* | •Removal of the affected clumps at an early stage and soil drenching with 0.1 % carbandazim 50 WP<br>•The irrigation interval in red rot affected field must be lengthened. Once in 15 days during tillering, growth phases and once in 25 days during maturity phase which restricts the spread<br>•The trash of red rot affected field after harvest may be uniformly spread and burnt<br>•In the red rot affected field crop rotation with rice for one season and other crops for two seasons could be adopted |
| **Smut:** *Sporisorium scitamineum* (*Ustilago scitaminea)* | •Roguing of smut whips with gunny bags/polythene bag and burnt<br>•Discourage ratooning of the diseased crops having more than 10 per cent infection |
| **Grassy shoot disease (GSD):** Candidatus Phytoplasma | •Spray dimethoate @ 0.1 % to control insect vector<br>•Avoid ratooning if GSD incidence is more than 15 % in the plant crop |
| **Leaf spot:** *Cercospora longipes* | •Spray mancozeb @ 2 kg or carbendazim @ 500 g/ha |
| **Rust:** *Puccinia melanocephala* | •Spray mancozeb @ 2 kg/ha |
| **Yellow leaf disease:** Sugarcane yellow leaf virus (Vector: *Melanopsis sacchari*) | •Proper nutritional management<br>•Selection of tissue culture seedling from meristem tip culture |

**General Recommendations**

- Select healthy setts for planting. In the seed crop, select plants which do not show symptoms of red rot, smut, grassy shoot and ratoon stunting. Setts showing red colour at the cut end and hollows should be rejected.
- In fields which had shown high level of red rot disease, follow crop rotation with rice.
- Sett treatment with carbendazim before planting (carbendazim 50 WP @ 0.05% along with 1.0% urea for 15 minutes.
- Treat setts with aerated steam at 50°C for one hour to control primary infection of smut and grassy shoot disease.

  Clumps infected by grassy shoot, smut and ratoon stunting diseases should be uprooted and destroyed.

**NEMATODE MANAGEMENT**

| Nematode pest | Control measures |
|---|---|
| Lesion nematode,<br>*Pratylenchus coffeae* | *Apply carbofuran 3 CG at 33 kg/ha at the time of planting or 2 months after or Cartop 1.5 kg ai/ha or apply pressmud at 15 t/ha or poultry manure at 2 t/ha or neem cake 2 t/ha or apply pressmud at 15 t/ha or poultry manure at 1 t/ha before last ploughing in garden lands.<br>* Under wetland conditions, intercropping sunnhemp or marigold or daincha coupled with application of pressmud 25 t/ha or neem cake 2 t/ha. |

# 8. SWEET SORGHUM (Sorghum bicolor)

## Climate Requirement

| T_Max°C | T_Min°C | Optimum °C | Rainfall mm | Altitude m MSL |
|---|---|---|---|---|
| 40 | 7 - 8 | 27 - 35 | 300 - 600 | up to 2300 |

Tropical and sub tropical crop. It can tolerate drought conditions as well as water logging condition. Short day plant. Soil temperature should be above 18°C.

## CROP MANAGEMENT

### 1. TREATMENT OF SEED

**Step 1:** Treat the seeds 24 hours prior to sowing with Captan or Thiram 2 gm/kg of seed or Metalaxyl 4 gm / kg of seed to control downy mildew.

**Step 2:** Treat the seeds required for one hectare with 3 packets (600gm) of Azospirillum using rice gruel as binder.

**Note:** Dissolve 0.5 gm of gum in 20 ml of water. Add 4 ml of Chlorpyriphos 20 EC or Monocrotophos 35 WSC or Phosalone 35 EC. To this add 1.0 kg of seed, pellet and shade dry to control shootfly and stemborer.

### 2. FARM LAND PREPARATION

- Form ridges and furrows at a spacing of 45 cm apart

### 3. SOWING

- Seed rate of 10 kg/ha
- Adopt a spacing of 45 x 15 cm (population 1,48,000/ha)
- Sow the seeds at a depth of 2 cm and cover with soil

Note: Use increased seed rate upto 12.5 kg per hectare and remove the shoot fly damaged seedlings at the time of thinning or raise nursery and transplant only healthy seedlings.

### 4. IMPORTANCE OF INM

Application of inorganic nutrients alone in the long run will lead to soil and environmental pollution. Hence integration organic and inorganic fertilizer will sustain the soil heath and improve the cane yield of the sweet sorghum crop.

### 5. IMPORTANCE OF BALANCED NUTRITION

Application of balanced fertilizer at recommended dose in the right stage of the crop will not only improve the productivity but also improve the soil fertility and reduce the environmental pollution.

### 6. EVALUATION OF FERTILIZER REQUIREMENT

Soil testing is suggested tool for evaluating the fertilizer requirement. It has to be done before the cropping season well in advance so as to ascertain the native fertility of the soil and to recommend the correct dose of fertilizer which will reduce the fertilizer cost.

## 7. RECOMMENDED INM

- Apply 12.5 tons of FYM/ha at last ploughing.
- Soil application of Azospirillum @ 10 packets (2.0 kg/ha) after mixing with 25 kg of FYM + 25 kg of soil may be carried out before sowing/planting.
- 12.5 kg /ha of MN mixture mixed with enough sand to make a total quantity of 50 kg and applied over the furrows and on top 1/3 of the ridges.
- Apply NPK fertilizers as per soil test recommendations. If soil test recommendation is not available adopt a blanket recommendation of 120 : 40: 40 kg of NPK/ha

## 8. STAGES OF APPLICATION OF FERTILIZERS

- Apply azospirillum and MN mixtures as basal
- Apply half dose of N and full dose of $P_2O_5$ and $K_2O$ basally before sowing.
- Apply the balance N in two splits of 25% each on 15$^{th}$ and 30$^{th}$ day of sowing.

## CROP PROTECTION

### Downy mildew

- Rogue downy mildew infected plants up to 45 days after sowing
- Spray any one of the fungicides like Metalaxyl 500 g or Mancozeb 1000g/ha after noticing the symptoms of foliar diseases, for both transplanted and direct sown crops.

**Leaf diseases:** *Cercospora* leafspot, Rust, *Colletotrichum* leaf spot

- Spray Mancozeb @ 1kg/ha. Repeat fungicidal application after 10 days if necessary

### Grain mould

- Spray any one of the fungicides like Mancozeb @ 1000g/ha in case of intermittent rainfall during earhead emergence and repeat if necessary another spray 10 days later

### Ergot

- Spray any one of the following fungicide at emergence of earhead (5 - 10% flowering stage) followed by a spray at 50% flowering and repeat the spray after a week if necessary

# 9. TROPICAL SUGARBEET

## PRODUCTION TECHNOLOGY

### Introduction

Tropical sugarbeet (*Beta vulgaris* spp. *Vulgaris var altissima Doll*) is a biennial sugar producing tuber crop, grown in temperate countries. This crop constitutes 30% of total world production and distributed in 45 countries. Now tropical sugarbeet hybrids are gaining momentum in tropical and sub tropical countries including Tamil Nadu as a promising energy crop and alternative raw materials for the production of ethanol. Apart from sugar production, the value added products like ethanol can also be extracted from sugarbeet. The ethanol can be blended with petrol or diesel to the extent of 10% and used as bio-fuel. The sugarbeet waste material *viz.,* beet top used as green fodder, beet pulp used as cattle feed and filter cake from industry used as organic manure.

Tropical sugarbeet now emerged as commercial field crop because of the favourable characters like (i) tropical sugarbeet hybrids suitable for Tamil Nadu (ii) Shorter duration of 5 to 6 months (iii) needs moderate water requirement of 60-80 cm. (iv) higher sugar content of 12 – 15% (v) improve soil conditions because of tuber crop and (vi) grow well in saline and alkali soil. The harvesting period of sugarbeet coincides with March – June, the human resource of sugar factory in the off season may efficiently utilized for processing of sugarbeet in the sugar mills, which helps in continuous functioning of sugar mills.

**Hybrids and duration**

The tropical sugarbeet hybrids suitable for cultivation in Tamil Nadu are Cauvery, Indus and Shubhra. The duration of these tropical hybrids will be 5 to 6 months depending on climatic conditions prevailing during crop growth period.

**Climate and season**

Tropical sugarbeet require good sunshine during its growth period. The crop does not prefer high rainfall as high soil moisture or continuous heavy rain may affect development of tuber and sugar synthesis. Tropical sugarbeet can be sown in September– November coincide with North East monsoon with a rainfall of 300 – 350 mm well distributed across the growing period which favours vegetative growth and base for root enlargement. The optimum temperature for germination is 20 – 25$^0$C, for growth and development 30 - 35$^0$C and for sugar accumulation in 25– 35$^0$C.

**Season**

Tropical sugarbeet is sown in September to November and harvested during March and May.

**Field preparation**

Well drained sandy loam and clayey loam soils having medium depth (45” cm) with fairly good organic status are suitable. Tropical sugarbeet require deep ploughing (45 cm) and followed by 2 – 3 ploughing to obtain a good soil tilth condition for favorable seed germination. Ridges and furrows are formed at 50 cm apart.

## Manures and Fertilizers

| S.No | Manures and Fertilizers | Basal Application | Top dressing |
|---|---|---|---|
| 1 | **Manures** | 12.5 tonnes /ha | - |
| 2 | **Biofertilizers**<br>Azospirillum Phosphobacteria | 2 kg /acre (10 pockets)<br>2 kg /acre (10 pockets) | - |
| 3. | **Fertilizers** Nitrogen Phosphorus Potassium | 75kg /ha 75kg /ha 75kg /ha | 37.5 kg / ha each at 25 & 50 DAS |

## Seeds and sowing

Optimum population is 1,00,000 - 1,20,000 /ha. Hence use only pellated seeds 1,20,000 Nos /ha which require 6 pockets (3.6kg / ha.-One pocket contains 20000 seeds (600 g)]. The recommended spacing is 50 x 20 cm. The pellated seed is dippled at 2 cm depth in the sides of ridges at 20 cm apart. 45 x 15 cm spacing found to be optimum for higher root yield.

## Weeding and Earthing up

The crops should be maintained weed free situation upto 75 days. Pretilachlor 50 EC @ 0.5 Kg ai/ha or Pendimethalin @ 1.0 lit /ha can be dissolved in 300 litres of water and sprayed with hand operated sprayer on 0- 2$^{rd}$ day after sowing, followed by hand weeding on 25$^{th}$ day and 50th day after sowing. The earthing up operations coincides with top dressing of N fertilizer.

## Irrigation

Tropical sugarbeet is very sensitive to water stagnation in soil at all stages of crop growth. Irrigation should be based on soil type and climatic condition. Pre-sowing irrigation is essential since at the time of sowing, sufficient soil moisture is must for proper irrigation. First irrigation is crucial for the early establishment of the crop. For loose textured sandy loam soil irrigation once in 5 to 7 days and for heavy textured clay loam soil once in 8 – 10 days is recommended. The irrigation has to be stopped at least 2 to 3 weeks before harvest. At the time of harvest, if the soil is too dry and hard it is necessary to give pre harvest irrigation for easy harvest. Light and frequent irrigation is recommended for maintaining optimum soil moisture. Water requirement is 800 - 850 mm.

## Pest and diseases

Pests - Aphids, Tobacco caterpillar and Flea beetles

Diseases- Root and crown rot, *Cercospora* leaf spot and Root knot nematode

## Integrated pest and disease management

- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seed
- Summer ploughing and exposing the field to sunlight
- Crop rotation for 3 years with Marigold or gingelly or sunnhemp for root rot and nematode
- Soil application of *Trichoderma viride* or *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM before planting
- Sow castor as trap crop around and within fields to attract adult *Spodoptera*

moth for egg laying

- Set up light traps (1 mercury / 5 ha) for monitoring *Spodoptera litura*
- Setting up pheromone -Pherodin SL @ 12/ha for *Spodoptera litura*
- Removal and destruction of *Spodoptera* egg masses, early stage larvae formed in clusters
- Hand picking and destruction of grown up *Spodoptera* caterpillar

**Need based**

- Spraying *Spodoptera* nuclear polyhedrosis virus at 1.5 x 1012 POB/ha
- Spray NSKE 5% for aphids flea beetles and for early instar caterpillars
- Use of poison bait pellets prepared with rice bran 12.5 kg, jaggery 1.25 kg, carbaryl 50% WP 1.25 kg in 7.5 lit water for *Spodoptera litura*
- Spray any one of the following insecticides using a high volume sprayer covering the foliage and soil surface
- Chlorpyriphos 20 EC - 2 ml / lit,Dichlorvos 76 WSC - 1 ml/lit, Fenitrothion 50 EC - 1 ml/lit Spray malathion 50 EC (2 ml/lit) for flea beetle and leaf webber Spray Imidacloprid 200 SL (0.2 ml/lit) or methyl demeton 25 EC (2 ml/lit) or dimethoate 30 EC (2 ml/lit) for aphids
- Applying neem cake @ 150 kg/ha for root rot
- Foliar spray of Mancozeb 2.5 g / lit or Chlorothalonil 2 g / litre of water for *Cercospora* leaf spot
- Neem cake @ 1 t/ha or carbofuran @ 33 kg/ha as spot application on 30 days after sowing for nematode management

**Harvest and yield**

The tropical sugarbeet crop matured in about 5 to 6 months. The yellowing of lower leaf whirls of matured plant, Nitrogen deficiency and root brix reading of 15 to 18% indicate the maturity of beet root for harvest. The average root yield of tropical sugarbeet is 80 – 100 tonnes / ha.

## CROP PROTECTION

**Integrated disease management**

- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seed
- Summer ploughing and exposing the field to sunlight
- Crop rotation for 3 years with Marigold or gingelly or sunnhemp for root rot and nematode
- Soil application of *Trichoderma viride* or *Pseudomonas fluorescens* @ 2.5 kg/ha mixed with 50 kg of FYM before planting

**TEMPLATE FOR TECHNOLOGY**

**Introduction**

Tropical sugarbeet (*Beta vulgaris* spp. *Vulgaris var altissima Doll*) is a biennial sugar producing tuber crop, grown in temperate countries. Now tropical sugarbeet hybrids are gaining momentum in tropical and sub tropical belts including Tamil Nadu as a promising alternative energy crop for the production of ethanol and alternate sugar producing crop. The ethanol can be blended with petrol or diesel to the extent of 10% and used as bio-fuel.

The bi-products of sugarbeet *viz.,* beet top can be used as green fodder, green leaf manure and raw material for vermi compost while beet pulp is used as cattle feed and filter cake used as manure.

**Right seed**

- Use pelleted seed
- Variety -Nil
- Hybrids - Cauvery, Indus and Shubhra
- At present no seed production in India, seeds source- Syngenta India Ltd., (Seeds division,) 1170 / 27, Revenue colony Shivaji nagar, Pune-411005 Phone: 020-2553 5996 Fax:020 -2553 7571

**Right technology**

- Seed Treatment : Already it is treated and marketed as pelleted seed.
- Seeds Rate / ha: One 1.2 lakh pelleted seeds(3.6Kg)
- Land Preparation:
- Thorough land preparation of 45 cm deep ploughing,
- Formation of ridges and furrows with a spacing of 50X20 cm and height of the ridges @15 - 20 cm.
- Sowing: Dibble the seed at 2 cm depth on the top of the ridge with a spacing of 20 cm between plants.
- Weed free environment up to 60$^{th}$ day
- Pre-emergence application of Pretilachlor 50EC 0.5 Kg ai / ha in 500 litre of water or Pendimethalin 30 EC 1.0 Kg ai/ha dissolved in 500 litre of water
- Hand weeding on 25$^{th}$ and 50 $^{th}$ days after sowing

**Right nutrition**

- Balanced application of organic and inorganic fertilizers
- FYM 12.5 t/ha and basal application of 2 kg of Azospirillum and 2 kg of phosphobacteria
- Based on the soil test value, inorganic fertilizer has to be applied. In the absence of soil test value, blanket recommendation of 150:75:75 NPK kg/ha
- Stages of application of fertilizer: Basal 50% N, full P and full K. Remaining 25% N on 20 to 25 days after sowing and 25% N on 40 to 45 days after sowing.
- Timely and need based, placement of fertilizer and earthing up
- Excess N should be avoided

**Right pest and diseases management**

- Pests - Aphid, Tobacco caterpillar and Flea beetles
- Diseases- Root and crown rot, *Cercospora* leaf spot and Root knot nematode

**Integrated pest and disease management**

- Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg of seed
- Summer ploughing and exposing the field to sunlight
- Crop rotation for 3 years with Marigold or gingelly or sunnhemp for root rot and nematode
- Soil application of *Trichoderma viride* or *Pseudomonas fluorescens* @ 2.5 kg/ha

mixed with 50 kg of FYM before planting
- Sow castor as trap crop around and within fields to attract adult *Spodoptera* moth for egg laying
- Set up light traps (1 mercury / 5 ha) for monitoring *Spodoptera litura*
- Setting up pheromone -Pherodin SL @ 12/ha for *Spodoptera litura*
- Removal and destruction of *Spodoptera* egg masses, early stage larvae formed in clusters
- Hand picking and destruction of grown up *Spodoptera* caterpillar

**Need based**

- Spraying *Spodoptera* nuclear polyhedrosis virus at 1.5 x 1012 POB/ha
- Spray NSKE 5% for aphids flea beetles and for early instar caterpillars
- Use of poison bait pellets prepared with rice bran 12.5 kg, jaggery 1.25 kg, carbaryl 50% WP
  - 1.25 kg in 7.5 lit water for *Spodoptera litura*
- Spray any one of the following insecticides using a high volume sprayer covering the foliage and soil surface
- Chlorpyriphos 20 EC - 2 ml / lit
- Dichlorvos 76 WSC - 1 ml/lit
- Fenitrothion 50 EC - 1 ml/lit
- Spray malathion 50 EC (2 ml/lit) for flea beetle and leaf webber
- Spray Imidacloprid 200 SL (0.2 ml/lit) or methyl demeton 25 EC (2 ml/lit) or dimethoate 30 EC (2 ml/lit) for aphids
- Applying neem cake @ 150 kg/ha for root rot
- Foliar spray of Mancozeb 2.5 g / lit for *Cercospora* leaf spot
- Neem cake @ 1 t/ha or carbofuran @ 33 kg/ha as spot application on 30 days after sowing for nematode management

**Water management**

- Optimum EC of irrigation water upto 1 ds/m
- It can be grown in water containing EC: 1 to 2 ds/m
- Irrigation schedule: Life irrigation on $3^{rd}$ day
- For vegetative stage(upto 45 DAS) - 4 irrigation, vegetative to tuber initiation (75 DAS) - 4 irrigation, tuber maturation(upto 125 DAS) - 4 irrigation and Maturity - 2 irrigation – upto 15- 20 DAS maintain optimum soil moisture for good germination and population
- Drip fertigation with 100 % recommended dose of Fertilizer 150:75:75 Kg NPK $ha^{-1}$ found to be better for tropical sugarbeet

**Post harvest management**

- Stop irrigation 15-20 days prior to harvest. This allows sugar accumulation
- Just hand pulling and keeping the tops, store in a shaded conditions
- Roots of sugarbeet reach the factory within 48 hours for processing
- Yield 80 to 100 t/ha, Sugar recovery- 15 -16%

# 10. FORAGE CROPS

## (i) FODDER CHOLAM

### MULTICUT FODDER SORGHUM (*Sorghum bicolour*)

## A. CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/Season | Month | Varieties |
|---|---|---|
| Irrigated | | |
| **All Irrigated districts** | **Jan - Feb and Apr – May** | **CO (FS) 29 and CO31** |

### II. PARTICULARS OF MULTICUT FODDER SORGHUM VARIETIES

| PARTICULARS | CO (FS) 29 | CO 31 |
|---|---|---|
| Parentage | Derivative of the cross TNS 30 x *Sorghum sudanense* | Gamma ray induced mutant of CO (FS) 29 |
| Duration (Days) | Multicut (3 years) | Multicut (3 years) |
| Average green fodder yield (t/ha) | 160-170 (6-7 cuts) | 190 (6-7 cuts) |
| **Morphological characters** | | |
| Plant height (cm) | 260-280 | 270 -290 |
| Number of tillers | 10-15 | 12-17 |
| Number of leaves/stem | 8-10 | 9-11 |
| Leaf length (cm) | 80-90 | 85-95 |
| Leaf breadth (cm) | 3.5-4.6 | 4.5 - 5.0 |
| Leaf stem ratio | 0.2-0.25 | 0.26 |
| **Quality characters** | | |
| Protein content (%) | 8.64 | 9.86 |
| Dry matter (%) | 23.60 | 25.90 |
| Crude fibre (%) | 21.00 | 19.80 |
| IVDMD (%) | 50.30 | 52 |

## B. CROP MANAGEMENT

### I. GREEN FODDER PRODUCTION

### IRRIGATED FODDER CHOLAM

**1. Soil**

All types of soil with good drainage. Does not come up well in flooded or waterlogged conditions.

**2. Preparatory cultivation**

Plough with an iron plough once and with a country plough twice. Form ridges and furrows of 6 m long and 60 cm apart and plant on either side of the ridge

**3 . Sowing**

- Seed treatment: Treat the seeds with 3 packets (600 g)/ha of *Azospirillum* and 3 packets (600g) of *Phosphobacteria* or *Azophos* 6 packets (1200g)
- Seed rate: 5 kg/ha
- Spacing: 30 x 10 -15 cm

**4. Nutrient management**

- Spread 25 tonnes/ha of FYM or compost on the unploughed field, along with 10 packets of *Azospirillum* inoculants (2000 g) and 10 packets of *Phosphobacteria* (2000g) or 20 packets of *Azophos* (4000g)
- Apply 45 : 40 : 40 kg N,P, K/ha as basal and 45 kg N as top dressing on 30 DAS followed by the application of 45 kg N/ha after every cut. After 4$^{th}$ cut, apply 40 kg P and 40 kg K along with 45 kg N to sustain the fodder yield and quality.
- Application of *Azospirillum* (2000g/ha) and *Phosphobacterium* (2000g/ha) together as a mixture or *Azophos* (4000g/ha) along with 75% required dose of N and P fertilizer will enhance the yield besides saving of 25% of fertilizer dose.

**5. Irrigation management**

Irrigate immediately after sowing. Life irrigation on the third day and thereafter once in 10 days,

**6. Weed management**

First hand weeding on the 20$^{th}$ day of sowing and if necessary 2$^{nd}$ hand weeding between 35 - 40 days after sowing. After each harvest a weeding may be given before fertilization**.**

**7. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. Harvesting**

Green fodder should be harvested at 50% flowering stage. First harvest at 65-70 days after sowing and there after the ratoon crop may be harvested once in 50 days depending on flowering**.**

9. **Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 170 to 190 t/ha (6-7 cuts) of green fodder

# (ii) FODDER MAIZE

## CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/Season | Month | Varieties |
|---|---|---|
| **Irrigated** | | |
| All Districts | Throughout the year | African tall |

### II. PARTICULARS OF FODDER MAIZE VARIETIES

| PARTICULARS | African Tall |
|---|---|
| Parentage | Composite |
| Duration (Days) | 60-70 |
| Green fodder yield (t/ha) | 35-40 |
| **Morphological characters** | |
| Plant height (cm) | 302.00 |
| Number of leaves | 13.30 |
| Leaf length (cm) | 81.30 |
| Leaf breadth (cm) | 8.15 |
| Stem thickness (cm) | 1.77 |
| Leaf-stem ratio | 0.21 |
| **Quality characters** | |
| Crude protein (%) | 9.80 |
| Dry matter (%) | 17.65 |

## B. CROP MANAGEMENT

### 1. GREEN FODDER PRODUCTION

**1. Soil**

All types of soil with good drainage. Does not come up well in flooded or waterlogged conditions.

**2. Preparatory cultivation**

Plough the field twice with an iron plough and three or four times with country plough. Form ridges and furrows using a ridger, 30 cm apart and form beds of size 10 $m^2$ or 20 $m^2$ depending on the availability of water and slope of the land.

**3. Nutrient management**

- Spread FYM or compost at 12.5 t/ha along with 10 packets of Azospirillum (2000 g) and 10 packets of Phosphobacteria (2000g) inoculum or 20 packets of Azophos (4000g) and incorporate the manure into the soil during ploughing.
- Apply NPK fertilizers as per soil test recommendation as for as possible. If soil testing is not done, follow blanket recommendation of 30: 40: 20 kg N, $P_2O_5$ and $K_2O$ / ha.

Apply 30 kg N/ha at 30 days after sowing as top dressing.

**4. Sowing**

- Seed treatment: Treat the seeds with Captan @ 2g/kg + Carbaryl @ 200mg/kg$^{-1}$ of seeds 24 hours before sowing.Then,Treat the seeds with 3 packets (600 g) *Azospirillum* inoculant and 3 packets (600 g) of *Phosphobacteria* or 6 packets of *Azophos* (1200 g) before sowing.
- Spacing : 30 x 15 cm,
- Seed rate : 40 kg/ha

**5. Water management**

Irrigate immediately after sowing and give life irrigation on the third day and thereafter once in 10 days.

**6. Weed management**

First weeding at 25$^{th}$ DAS. Next hand weeding may be given as and when necessary.

**7. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. Harvest**

At 50% flowering (65-70 days after sowing)

**9. Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 35 to 40 t/ha of green fodder.

**Note**:

*Fodder maize can be intercropped with fodder cowpea varieties CO 5 or CO (FC) 8 at 3:1 ratio and harvested together to provide balanced nutritious fodder.

TNAU vermicompost at 5 t/ha + 75% recommended dose of fertilizer for intercropping of maize and cowpea produces green fodder yield of 105 t/ha/yr ( 3 crops/year) which is sufficient to maintain 7 adults and 3 calf.

# 2. SEED PRODUCTION

## VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified quality seed production leave a distance of 200 m all around the field from the same and other varieties of the crop.

**Seed rate**

- 20 kg/ha.

**Spacing**

- 60 x 20 cm (65 x 15 cm)

**Fertilizer requirement**

- Apply NPK @ 175 : 90 : 90 kg / ha + 25 kg $ZnSO_4$ / ha as basal application.

**Harvest**

- Seeds attained physiological maturity on $40^{th}$ day after anthesis.

**Seed treatment**

- Treat the seeds with carbendazim @ 2 g / kg of seed along with carbaryl @ 200 mg / kg of seed.
- Treat the seeds with halogen mixture ($CaOCl_2$ + $CaCO_3$ + arappu leaf powder mixed in the ratio of 5:4:1 @ 3 g / kg as eco-friendly treatment.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with seed moisture content of 10 - 12 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with seed moisture content of 8 - 10 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with seed moisture content of less than 8 %.

## (iii) NEELAKOLUKATTAI (BLUE BUFFEL GRASS) - (*Cenchrus glaucus*)

### CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/Season | Month | Variety |
|---|---|---|
| **Rain fed (Pasture grass)** | | |
| **All Districts North-East Monsoon** | Oct - Dec | CO 1 |

### II. PARTICULARS OF NEELAKOLUKATTAI VARIETY

| PARTICULARS | CO 1 |
|---|---|
| Parentage | Clonal selection from Vellakoil local (FS 391) |
| Duration (Days) | Perennial |
| Green fodder yield (t/ha/year) | 40 (4 cuts) |
| Seed yield (kg/ha/year) | 55 - 60 |
| **Morphological characters** | |
| Plant height (cm) | 120-130 |
| Number of tillers | 60-65 |
| Number of leaves | 550--600 |
| Leaf length (cm) | 25-30 |
| Leaf width (cm) | 0.8-1.0 |
| Leaf stem ratio | 0.93 |
| **Quality characters** | |
| Dry matter (%) | 28.00 |
| Crude protein (%) | 9.06 |
| Crude fibre (%) | 34.6 |
| Phosphorus (%) | 0.26 |
| Calcium (%) | 0.58 |
| Manganese (ppm) | 56 |
| IVDMD (%) | 49.4 |

### B. CROP MANAGEMENT

**1. Soil**

Well drained soil with high calcium content is suitable. It can also be grown in saline/alkaline soils.

**2. Preparatory cultivation**

Plough the field twice or thrice with an iron plough to ensure good tilth and form ridges and furrows at 50 cm spacing.

**3. Nutrient management**

- Spread FYM or compost at 5 t/ha and incorporate the manure into the soil during ploughing.
- Apply NPK fertilizers as per soil test recommendations. If the soil test is not done, follow the blanket recommendation of 25: 40: 20 kg N, P and K per hectare.

- Basal dressing: Apply full dose of NPK before sowing.
- Top dressing: After every harvest apply 25 kg N/ha during the rainy season.

**4. Sowing/planting**

- Seed treatment: Fresh seeds have dormancy for 6 - 8 months. To break dormancy, soak the seeds in 1 % potassium nitrate solution for 48 hours prior to sowing.
- Seed rate: 6 - 8 kg/ha or 40,000 rooted slips/ha.
- Spacing: 50 x 30 cm.

**5. Weed management**

Hand weeding can be done as and when necessary.

**6. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**7. Harvest**

First cut on $70^{th}$ or $75^{th}$ day after sowing and subsequent 4 - 6 cuts depending on growth.

**8. Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 40 t/ha/year (4 – 6 harvests) of green fodder.

**Note:**

- Tolerant to drought conditions.
- Kolukattai grass can be intercropped with *Stylosanthes scabra* in the ratio of 3:1.

**VARIETAL SEED PRODUCTION**

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified quality seed production, leave a distance of 10 m all around the field from the same and other varieties of the crop.

**Pre-sowing seed treatment**

- Scarify the seeds with sand at 2:1 ratio for 2 min. for improved seed germination.

**Harvest**

- Harvest the crop when the panicle dried completely.

**Seed grading**

- Grade the seeds with BSS 14 x 14 wire mesh sieve.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 10 - 12 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 - 10 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

# (iv) GUINEA GRASS (*Panicum maximum*)

## A. CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/ Season | Month | Varieties |
|---|---|---|
| **Irrigated** | | |
| All Districts | Throughout the year | CO 2 and CO (GG) 3 |
| **Rain fed** | | |
| All Districts | Jun – Sep / Oct - Nov | CO 2 and CO (GG) 3 |

### II. PARTICULARS OF GUINEA GRASS VARIETIES

| PARTICULARS | CO 2 | CO (GG) 3 |
|---|---|---|
| Year of Release | 2000 | 2009 |
| Year of Notification | SO.821(E)/13.09.2000 | SO.1919(E)/30.07.2014 |
| Parentage | CO 1 x Centenario | Clonal selection from Mumbasa |
| Duration (Days) | Perennial | Perennial |
| Green fodder yield (t/ha/year) | 270 (7harvests) | 340-360 (7harvests) |
| **Morphological characters** | | |
| Plant height (cm) | 150-200 | 210-240 |
| Number of tillers/clump | 80-100 | 40-50 |
| Leaf length (cm) | 65-75 | 97-110 |
| Leaf width (cm) | 2.5-2.9 | 3.2 - 4.5 |
| Leaf-stem ratio | - | 0.73 |
| **Quality characters** | | |
| Dry matter (%) | 25.94 | 20.2 |
| Crude protein (%) | 8.92 | 6.35 |
| Crude fibre (%) | 34.6 | 30.3 |
| Phosphorus (%) | 0.29 | 0.19 |
| Calcium (%) | 0.59 | - |
| Magnesium (ppm) | 0.38 | - |
| IVDMD (%) | 49.5 | - |

## B. CROP MANAGEMENT

**1. Soil**

All types of soil with good drainage.

**2. Preparatory cultivation**

Plough 2 to 3 times to obtain a good tilth and form ridges and furrows at 50 cm spacing.

**3. Nutrient management**

- Spread FYM or compost at 25 t/ha and incorporate the manure into the soil during ploughing.
- Apply NPK fertilizers as per soil test recommendation as for as possible. If soil testing is not done, follow the blanket recommendations of 100:50:40 of NPK in kg/ha. Apply full dose of P, K and 50% N basally before planting.
- Top dressing of 50% N on 30 DAP.
- Repeat the application of 75 kg N/ha after each cut for sustaining higher yield.

**4. Planting**

i. Irrigate through the furrows and plant one rooted slip per hill.
ii. Spacing 50 x 50 cm and 40,000 rooted slips are required to plant one hectare.

**5. Irrigation management**

Immediately after planting, give life irrigation on the third day and thereafter once in 10 days.

**6. Weed Management**

Hoeing and weeding on 30th day after planting. Earthing up should be practiced once after every three harvests.

**7. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. Harvest**

First harvest on 75 - 80 days after planting. Subsequent cuts at the interval of 45 days.

**9. Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 270 to 360 t/ha of green fodder.

**Note**:

- Guinea grass can be intercropped with *Desmanthus* (Velimasal) at 3:1 ratio and can be harvested together and fed to the animals.
- Rooted slips uprooted from 90 days old crop can be used for further propagation

## (v) DEENANATH GRASS (*Pennisetum pedicellatum*)

### CROP MANAGEMENT

1. **SOIL**

   All types of soil with good drainage. Does not come up well on heavy clay soil or flooded or waterlogged conditions.

2. **PREPARATORY CULTIVATION**

   Plough 2-3 times to obtain good tilth and form beds and channels.

3. **MANURING**

   Basal: FYM 25 t/ha NPK 20 : 25 : 20 kg/ha
   Top dressing: 20 Kg N on 30th day after sowing 50% of this has to be applied for rainfed crop

4. **SEED RATE**

   2.5 kg/ha

5. **SPACING**

   35 x 10 cm or solid sowing in lines 30 cm apart.

6. **AFTER CULTIVATION**

   Hoeing and weeding on 30th day after sowing

7. **IRRIGATION**

   Once in ten days or depending on soil condition

8. **PLANT PROTECTION**

   Generally not recommended

9. **HARVEST**

   55-60th day after sowing.

10. **GREEN FODDER YIELD**

    Irrigated crop : 25-30 t/ha first crop. Ratoon crop : 15-20 t/ha
    Rainfed crop : 15-20 t/ha

### SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified quality seed production, leave a distance of 10 m all around the field from the same and other varieties of the crop.

**Pre-sowing seed management**

- Scarify the seeds in a defluffer followed by soaking in $GA_3$ (200 ppm) + $KNO_3$ (0.25 %) solution for 16 hours.
- Pellet the seed with DAP @ 60 g / kg and arappu leaf (*Albizzia amara*) powder @ 500 g / kg of seed to enable easy handling of seed during sowing and also for better establishment.

**Harvest**

- Harvest the crop when the panicle dried completely.
- Delayed harvesting resulted in shattering loss.

**Pre- storage seed treatment**

- Treat the seeds with carbendazim @ 4 g / kg of seed.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 9 - 10 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

# (vi) CUMBU NAPIER HYBRIDS

## A. CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/Season | Month | Varieties |
|---|---|---|
| **Irrigated** | | |
| All Districts | Throughout the year | KKM 1, CO 3, CO (CN) 4, CO (CN)5 |

### II. PARTICULARS OF CUMBU NAPIER GRASS VARIETIES

| PARTICULARS | KKM 1 | CO 3 | CO (CN)4 | CO (BN) 5 |
|---|---|---|---|---|
| Year of Release | 2000 | | 2008 | 2012 |
| Year of Notification | So.161(E)/04.02.2004 | | | SO.1146(E)/24.04.2014 |
| Parentage | IP 15507 x FD 429 | PT 1697 x *Penneisetum purpureum* | CO 8 x FD 461 | IP 20594 x Napier grass FD 437 |
| Duration (Days) | Perennial | **Perennial** | **Perennial** | **Perennial** |
| Green fodder yield (t/ha/yr) | 288 | 350 (7 harvests) | 375-400 (7 harvests) | 360 (7 harvests) |
| **Morphological characters** | | | | |
| Plant height (cm) | 155-160 | 300 – 360 | 400-500 | 400-500 cm |
| No. of leaves per clump | 165-170 | 400-450 | 400-450 | 400-430 |
| No. of tillers per clump | 10-15 | 30 – 40 | 30 – 40 | 30-40 |
| Leaf stem ratio | - | 0.70 | 0.71 | 1.19 |
| Leaf length (cm) | 110-115 | 80 – 95 | 110-115 | 100-110 cm |
| Leaf width (cm) | 4.5-5.0 | 3.0 – 4.2 | 4.0-5.0 | 4.0-5.0 cm |
| **Quality characters** | | | | |
| Dry matter yield (t/ha/yr) | 47.23 | 65.12 | 79.87 | 79.20 |
| Crude protein yield (t/ha) | 4.65 | 5.40 | 8.71 | 11.08 |
| Dry matter (%) | 16.4 | 17.0 | 21.3 | 22.0 |
| Crude protein (%) | 9.85 | 10.5 | 10.71 | 14.0 |

## B. CROP MANAGEMENT

**1. Soil**

All types of soil with good drainage.

**2. Preparatory cultivation**

Plough with an iron plough two to three times to obtain good tilth. Form ridges and furrows of 6 m long and 60 cm apart.

**3. Nutrient Management**

- Spread FYM or compost at 25 t/ha along with 10 packets of Azospirillum (2000 g) and 10 packets of Phosphobacteria (2000g) inoculum or 20packets of Azophos (4000g) and incorporate the manure into the soil during ploughing.
- Apply NPK fertilizers as per soil test recommendation as for as possible. If soil testing

is not done, follow the blanket recommendations of 150:50:40 of NPK in kg/ha. Apply full dose of P, K and 50% N basally before planting.

- Top dressing of 50% N on 30 DAS.
- Repeat the application of 75 kg N after each cut for sustaining higher yield.
- Application of *Azospirillum* (2000g) and *Phosphobacterium* (2000g) or *Azophos* (4000g) along with 75% of recommended dose of N and P fertilizers enhanced the yield besides saving of 25% of fertilizer dose.

**4. Planting**

i. Irrigate through the furrows and plant one rooted slip/two budded stem cutting per hill.

ii. Spacing 60 x 50 cm and 33,333 planting material are required to plant one hectare.

**5. Irrigation management**

Immediately after planting, give life irrigation on the third day and thereafter once in 10 days. Sewage or waste water can also be used for irrigation.

Paried row drip system (60/90 cm x 50 cm) + drip irrigation at 125% PE + nitrogen fertigiation at 100% RDN was found to be suitable for obtaining similar green fodder yield as that of surface irrigation with 12.6% water saving in Bajra Naiper hybrid grass,

**6. Weed management**

Hand weeding can be done whenever necessary.

**7. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. Harvesting**

First harvest is to be done on 75 to 80 days after planting and subsequent harvests can be done at intervals of 45 days.

**9. Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 360 to 400 t/ha of green fodder.

**Note**

- Quartering has to be done every year or whenever the clumps become unwidely and large.
- Wherever necessary to alleviate the ill effects of oxalates in this grass, the following steps are suggested.
  i. Feeding 5 kg of leguminous fodder per day per animal along with these grasses or
  ii. Providing calcium, bone meal or mineral mixture to the animal or
  iii. Giving daily half litre of supernatant clear lime water along with the drinking water or sprinkling this water on the fodder
  iv. Cultivation o 14 cents of green fodder (Cumbu Napier hybrid grass: 9 cents and *Desmanthus:* 5 cents) are needed for a milch animal with a milk yield of 10 lit/day/animal.
  v. Cultivation of 2.5 cents of green fodder (Cumbu Napier hybrid grass: 1.5 cents and *Desmanthus:* 1.0 cent) are needed for a goat with average body weight of body weight of 40 kg.

# (vii)LUCERNE - KUDIRAI MASAL (*Medicago sativa*)

## A. CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/Season | Month | Variety |
|---|---|---|
| **Irrigated** | | |
| Coimbatore, Thiruppur, Erode, Krishnagiri and Dharmapuri | Throughout the year | CO 2 and CO3 |

### II. PARTICULARS OF LUCERNE VARIETY

| PARTICULARS | CO 2 | CO 3 |
|---|---|---|
| Year of Release | 2013 | 2017 |
| Year of Notification | SO.268(E)/28.01.2015 | SO. 1498 (E) / 0104.2019 |
| Parentage | Polycross derivative involving CO 1 | Polycross derivative involving CO 1 |
| Duration (Days) | Perennial | Perennial |
| Green fodder yield (t/ha/year) | 120.6 (14 harvests) | 115 days (12-14 harvests) |
| Seed yield (kg/ha) | 240-250 | 200-230 |
| **Morphological characters** | | |
| Plant height (cm) | 70-80 | 75-80 |
| No. of branches per plant | 15-20 | 15-20 |
| No. of pods per plant | 18-20 | 20-22 |
| No. of seeds per pod | 4-6 | 4-6 |
| **Quality characters** | | |
| Protein content (%) | 23.5 | 22.4 |
| Dry matter (%) | 16.8 | 17.0 |
| Dry matter yield (t/ha/year) | 20.16 | 21.94 |
| Crude fibre (%) | 19.0 | 19.0 |
| Phosphorous | 0.45 | 0.43 |
| Potassium | 3.83 | 3.75 |
| Calcium | 1.89 | 1.90 |
| Magnesium | 0.37 | 0.32 |
| Iron | 420 | 410 |
| Zinc | 288 | 220 |

## B. CROP MANAGEMENT

I. GREEN FODDER PRODUCTION

**1. Soil**

Well drained black cotton soils are well suited. It can be raised in alkaline soils also.

**2. Preparatory cultivation**

Plough three or four times with iron plough to obtain good tilth. Form beds of size 10 $m^2$ or 20 $m^2$ depending on the availability of water and slope of land.

**3. Nutrient management**

- Spread FYM or compost at 25 t/ha and incorporate the manure into the soil during ploughing.

- Apply NPK fertilizers as per soil test recommendations as for as possible. If soil testing is not done, follow the blanket recommendation of 25:120:40 kg NPK/ha.
- Apply the full dose NPK of 25:120:40 basally before sowing.

**4. Sowing**

- Seed treatment: Treat the seeds with 3 packets (600 g) *of Rhizobium* and 3 packets (600 g) *Phosphobacteria* before sowing.
- Seed rate: 20 kg/ha. Good quality seeds free from *Cuscuta* seeds should be used.
- Spacing: 25 cm x 10 cm

**5. Irrigation management**

Irrigate immediately after sowing, life irrigation on the third day and thereafter once in a week.

**6. Weed management**

Hand weeding is given as and when necessary.

**7. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. Harvesting**

First harvest at 65 – 70 days after sowing. Subsequent harvests are made at intervals of 20 – 25 days.

**9. Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 80-130 t/ha/year (14 harvests) of green fodder.

## II.SEED PRODUCTION

**1. Season**

Seed production is practiced once in a year during summer months. The crop should be harvested during first week of March and allowed for seed production in such a way that the peak period of flowering should coincide with summer days.

**2. Isolation**

Adopt 100 m for certified seed production and 400 m for foundation seed production

**3. Foliar spray**

- Boron application in the form of Borax (150 ppm) increases the seed quality.
- Foliar spraying of $ZnSO_4$ + Borax at 0.3% improves pod and seed weight and also increases the germination potential and vigour of seeds.

**4. Harvesting**

Hand picking of pods would be done at physiological maturity stage.

**5. Other management practices**

As given in crop management techniques for green fodder production.

**6. Seed Yield**

240 kg/ha

# (viii) HEDGE LUCERNE - VELIMASAL (*Desmanthus virgatus*)

## A. CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/ Season | Month | Varieties |
|---|---|---|
| **Irrigated** | | |
| All Districts | Throughout the year | CO 1 |
| **Rain fed** | | |
| All Districts | June - October | CO 1 |

### II. PARTICULARS OF VELIMASAL VARIETY

| PARTICULARS | CO 1 |
|---|---|
| Parentage | Introduction |
| Duration (Days) | Perennial |
| Green fodder yield (t/ha/year) | 90-100 (7 harvests) |
| Seed yield (kg/ha) | 200 - 250 |
| **Morphological characters** | |
| Plant height (cm) | 110-120 |
| No. of branches per plant | 15-20 |
| No. of pods per plant | 75-100 |
| No. of seeds per pod | 6-10 |
| **Quality characters** | |
| Protein content (%) | 20 - 22 |
| Dry matter (%) | 18 - 20 |
| Dry matter yield (t/ha/year) | 16.2-20.0 |

## B. CROP MANAGEMENT

## I. GREEN FODDER PRODUCTION

**1. Soil**

All types of soils with good drainage.

**2. Preparatory cultivation**

Plough with an iron plough once and three or four times with country plough to obtain good tilth. Form beds of size 10 $m^2$ or 20 $m^2$ depending on the availability of water and slope of land.

**3. Nutrient management**

- Spread FYM or compost at 25 t/ha and incorporate the manure into the soil during ploughing
- Apply NPK fertilizer as per soil test recommendations as far as possible. If the soil testing is not done, follow the blanket recommendations of 25: 40:20 kg NPK/ha.
- Apply full dose of NPK basally before sowing.

**4. Sowing**

- Seed treatment: To get better germination seeds must be treated in hot water at 80$^o$C for 5 minutes (boiling water removed from the flame and kept for 4 minutes to attain 80$^o$C). After hot water treatment, seeds should be washed with cold water and soaked in cold water over a night. Seeds should be shade dried before sowing.Treat the seeds with 3 packets (600 g) *of Rhizobium* and 3 packets (600 g)

*Phosphobacteria* before sowing.

- Seed rate: 20 kg/ha
- Spacing; 50 cm x solid row

**5. Irrigation management**

Irrigate immediately after sowing, life irrigation on the third day and thereafter once in a week.

**6. Weed management**

Hoeing and weeding are given as and when necessary.

**7. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. Harvesting**

First cut on $90^{th}$ day after sowing at 50 cm height and subsequent cuts at intervals of 40 days at the same height.

**9. Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 120 t/ha of green fodder.

## II.SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Pre-sowing seed treatment**

- Scarify the seeds with commercial sulphuric acid @ 200 ml / kg of seed for 15 min. to break the seed coat dormancy.

**Spacing**

- 60 x 20 cm

**Fertilizer**

- Apply NPK @ 25:40:20 kg / ha as basal for the first crop.

**Foliar application**

- Foliar spray of 200 ppm salicylic acid thrice at 10 days interval after 50 per cent flowering to improve seed set.

**Harvest**

- Harvest the pods in pickings.
- Delayed harvest leads to 100 % shattering loss.

**Seed size**

- Grade the seed using BSS 14 x 14 sieve.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 9 - 10 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

# (ix) FODDER COWPEA (*Vigna unguiculata*)

## A. CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/ Season | Month | Varieties |
|---|---|---|
| **Irrigated** | | |
| Erode, Madurai, Dindigul, Theni, Cuddalore, Villupuram and Tiruvannamalai | June-July | CO 9 |

### II. PARTICULARS OF FODDER COWPEA VARIETIES

| PARTICULARS | CO 9 |
|---|---|
| Year of Release | 2016 |
| Year of Notification | SO.1379(E)/ 27.03.2018 |
| Parentage | Cross derivative from CO 5 x Bundel Lobia 2 |
| Duration (Days) | 50-55 |
| Green fodder yield (t/ha) | 23 |
| Seed yield (kg/ha) | 745 |
| **Morphological characters** | |
| Plant height (cm) | 130-140 |
| No. of branches | 4-5 |
| Leaf length (cm) | 12.0 |
| Leaf width (cm) | 10.0 |
| Leaf stem ratio | |
| **Quality characters** | |
| Dry matter content (%) | 16.86 |
| Crude protein content (%) | 21.56 |

## B. CROP MANAGEMENT

### I. GREEN FODDER PRODUCTION

**1. Soil**

All types of soils with good drainage.

**2. Preparatory cultivation**

Plough twice with an iron plough and three or four times with country plough to obtain good tilth.

Form ridges and furrows of 6 m length and 30 cm apart. If ridges and furrows are not made, form beds of size 20 $m^2$ depending on the availability of water.

**3.. Sowing**

- Seed treatment: Treat the seeds with 3 packets (600 g) *of Rhizobium* and 3 packets (600 g) *Phosphobacteria* before sowing.
- Seed rate: 25 kg/ha.
- Spacing: 30 x 15 cm

**4. Nutrient management**

- Spread FYM or compost at 12.5 t/ha and incorporate the manure into the soil during ploughing
- Apply NPK fertilizer as per soil test recommendations as far as possible. If the soil

testing is not done, follow the blanket recommendations of 25:40:20 kg NPK/ha.
- Apply full dose of NPK basally before sowing.

**5. Irrigation management**

Irrigate immediately after sowing, life irrigation on third day and thereafter once in ten days.

**6. Weed management**

Hoeing and weeding are given as and when necessary.

**7. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. Harvesting**

Harvest 50 - 55 days after sowing (50% flowering stage).

**9. Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 18-25 t/ha of green fodder.

## II.SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production, leave a distance of 25 m all around the field from the same and other varieties of the crop.

**Sowing Season**

- October to January.

**Pre-sowing seed treatment**

- Scarify the seeds with conc. $H_2SO_4$ acid @ 200 ml / kg for 4 min.
- After scarification, soak the seeds in $KNO_3$ @ 0.25 % for 3 h to improve germination.

**Seed grading**

- Grade the seeds using BSS 16 x 16 wire mesh sieve.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 9 - 10 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

# (x) MUYAL MASAL (STYLO) - ( *Stylosanthes scabra* )

## CROP IMPROVEMENT

### 1. SEASON

June - July to September - October.

### 2. VARIETIES

a. *S.hamata* (Annual)
b. *S.scabra* (Perennial)

## CROP MANAGEMENT

### 1. APPLICATION OF FYM

Apply and spread 10 t/ha of FYM or compost

### 2. FORMING BEDS

Form beds of size $10^2$ m or $20^2$ m

### 3. APPLICATION OF FERTILIZER

a. Apply NPK fertilizers as per soil test recommendation as for as possible. If the soil testing is not done, follow the blanket recommendation of 20:60:15 kg NPK/ha.
b. Apply full dose of NPK basally.

### 4. SOWING

a. Seed are to be treated with 3 pockets rhizobium culture (600 g/ha).
b. For line sowing (30 x 15 cm) the seed rate is 6 kg/ha and for broadcasting 10 kg/ha.
c. Stylo seeds possess hard seed coat. So acid scarification is to be done by dipping the
seeds in concentrated sulphuric acid for three minutes and washing thoroughly with tap water and scarified seeds are again to be presoaked in cold water overnight. (or) Seeds can also be scarified in hot water by immersing the seeds for 4 minutes in hot water of 80º C and the seeds are again to be presoaked in cold water overnight.

### 5. WATER MANAGEMENT

It is a rainfed crop. But during the period of establishment, care should be taken to provide sufficient moisture.

### 6. WEED MANAGEMENT

Hand weeding may be given as and when necessary.

### 7. Plant Protection:

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. HARVESTING**

First harvest can be taken 75 days after sowing at flowering stage and subsequent harvests depending upon the growth.

**9. GREEN FODDER YIELD**

It is to be noted that during the first year, the establishment after sowing is very slow and the yield is low. Later on when the crop establishes well due to self seeding, it yields about 30 to 35 t/ha/year from the third year onwards.

## VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For certified / quality seed production, leave a distance of 25 m all around the field from the same and other varieties of the crop.

**Sowing Season**

- October to January.

**Pre-sowing seed treatment**

- Scarify the seeds with conc. $H_2SO_4$ acid @ 200 ml / kg for 4 min.
- After scarification, soak the seeds in $KNO_3$ @ 0.25 % for 3 h to improve germination.

**Seed grading**

- Grade the seeds using BSS 16 x 16 wire mesh sieve.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 9 - 10 %.
- Store the seeds in polylined gunny bag for medium term storage (12 - 15 months) with a seed moisture content of 8 - 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content less than 8 %.

# (xi) LEUCAENA - SOUNDAL

## A. CROP IMPROVEMENT

### I. SEASON AND VARIETIES

| Zone District/Season | Month | Varieties |
|---|---|---|
| **Rain fed** | | |
| All Districts | June - October | CO 1 (*Leucaena leucocephala*) and Pudia Soundal (*Leucaena diversifolia*) |

### II. PARTICULARS OF SOUNDAL VARIETIES

| PARTICULARS | CO 1 | Pudia Soundal (*Leucaena diversifolia*) |
|---|---|---|
| Parentage | *Leucaena leucocephala* | *Leucaena diversifolia* K – 186 Introduced from Australia |
| Duration | Perennial tree | Perennial tree |
| Green fodder yield (t/ha/yr) | 35 | 40 |
| **Morphological characters** | | |
| Tree height (cm) | 35’ | 30’ in about six years |
| Leaf stem ratio | - | 1.8 |
| **Quality characters** | | |
| Dry matter content (%) | 24.94 | 25.02 |
| Crude protein content (%) | 26.12 | 26.00 |
| Crude fat (%) | 9.51 | 9.85 |
| Phosphorous (%) | 0.09 | 0.37 |
| Potassium (%) | 6.4 | 3.2 |
| Calcium (%) | 0.9 | 2.4 |
| Magnesium (%) | 0.88 | 1.32 |
| IVDMD (%) | 46.01 | 46.25 |
| Mimosine content (%) | 3.07 | 3.00 |
| Tannin content (%) | 3.04 | 1.95 |
| Carotene content (mg/100g) | 11.39 | 11.54 |
| Resistance to pests | - | Resistant to Psyllids |

## B. CROP MANAGEMENT

**1. Soil**

All types of soils with good drainage.

**2. Preparatory cultivation**

Plough with an iron plough twice and three or four times with country plough to obtain good tilth. Form ridges and furrows at 6 m x 1 m.

**3. Nutrient management**

- Spread FYM or compost at 25 t/ha and incorporate the manure into the soil during ploughing
- Apply NPK fertilizer as per soil test recommendations as far as possible. If the soil testing is not done, follow the blanket recommendations of 10:60:30 kg NPK/ha.
- Apply full dose of NPK basally before sowing.

**4. Sowing**

- Seed treatment: Seeds are hard and require scarification to obtain high and uniform germination. Scarification of seeds can be done by pounding the seeds with sand in mortar. Acid scarification can also be done by dipping the seeds in concentrated sulphuric acid for three minutes and washing thoroughly with tap water. Another easiest method is hot water treatment by soaking the seeds in hot water ($80^{o}$ C) for 4 minutes (boiling water removed from the flame and kept for 4 minutes comes down to $80^{o}$ C). A still simpler method would be to bring water to boil ($100^{o}$ C) in a vessel, take it out of the flame and immediately pour it over the seeds and keep them for 3 to 4 minutes. Then, the hot water may be poured out and cold water added to steep the seeds over night. Seeds can also be simply soaked in plain water for 72 hrs before sowing. Treat the seeds with 3 packets (600 g) *of Rhizobium* and 3 packets (600 g) *Phosphobacteria* before sowing.

- Seed rate: 10 kg/ha.
- Spacing: 2 m x 1 m

**5. Irrigation management**

This may be done when the crop is raised under irrigated condition. Once established, this plant can withstand several months of dry weather. However, to ensure rapid seedling growth, the land should be adequately moist up to 5 - 6 months. In summer, irrigation once in 6 weeks is adequate.

**6. Weed management :** Hoeing and weeding are given as and when necessary.

**7. Plant protection**

As per CIB&RC, insecticide is not recommended for the management of pests in fodder crops. No insecticide is registered/label claimed against the pests of fodder crops.

**8. Harvesting**

Plant can be harvested as short as 6 months after planting. However, the initial cutting should not be done until the trunk has attained at least 3 cm diameter or the plant has completed one seed production cycle. Harvests can be repeated once in 40 - 80 days depending upon growth and season. In drought prone areas, allow the trees to grow for two years to ensure deep root penetration before commencing harvest. The trees can be cut at 90 to 100 cm height from ground level. For poles and fuel, allow the tree to grow straight without cutting for 2.5 or 5 years as the case may be.

**9. Green fodder yield**

As green fodder under irrigated conditions, a pure crop yields about 80 to 110 t/ha of green fodder. Under rainfed conditions 40 t/ha of green fodder is obtained after 2 years of initial growth and pruning to a height of 100 cm.

**II.SEED PRODUCTION**

**1.Sowing**

- Spacing: 2 m x 1.5 m
- Seed rate: 10 kg

**2. Harvest**

Seed attains physiological maturity at 35 days after anthesis, when the pods turn brown and seeds become shiny brown.

**3. Other management practices**

As in crop management technique for green fodder production.

**4. Seed Yield :** 500 kg/ha

# 11. **GREEN MANURE CROPS**

## (i) DAINCHA - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For foundation / quality seed production leave a distance of 10 m all around the field from the same and other varieties of the crop.
- For certified quality seed production leave a distance of 5 m all around the field from the same and other varieties of the crop.

**Season**

- Rabi and summer are best seasons.
- October-November sowing will give better seed yield.

**Seed rate**

- 20 - 30 kg / ha.

**Seed treatment**

- Seed pelleting with *Rhizobium* @ 5 packets / ha.
- Treat the seed with carbendazim @ 2 g / kg of seeds.
- For hard seeds treat with sulphuric acid @ 100 ml / kg of seed for 10 - 20 minutes.

**Spacing**

- 60 x 20 cm (vary based on soil fertility and type of soil as 45 x 20 cm, 75 x 45 cm).

**Fertilizer**

- 20:40:20 kg / ha (vary based on soil fertility and type of soil as 10:40:30, 10:30:30 and 20:50:70 kg of NPK / ha).

**Foliar application**

- Spray 2 % DAP at 35 and 45 days after sowing.

**Harvest**

- Picking as once over harvest.

**Seed grading**

- Grade the seeds with BSS 7 x 7 wire mesh sieve.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content of 8 %.

## (i) SUNNHEMP - VARIETAL SEED PRODUCTION

**Land requirement**

- Land should be free of volunteer plants. The previous crop should not be the same variety or other varieties of the same crop. It can be the same variety if it is certified as per the procedures of certification agency.

**Isolation**

- For foundation quality seed production leave a distance of 250 m all around the field from the same and other varieties of the crop.
- For certified quality seed production leave a distance of 100 m all around the field from the same and other varieties of the crop.

**Season**

- Rabi and summer are best seasons.
- October-November sowing will give better seed yield.

**Seed rate**

- 20 - 30 kg / ha.

Seed treatment

- Seed pelleting with *Rhizobium* @ 5 packets / ha.
- Treat the seed with carbendazim @ 2 g / kg of seeds.
- For hard seeds treat with sulphuric acid @ 100 ml / kg of seed for 10 - 20 minutes.

**Spacing**

- 30 x 30 cm (vary based on soil fertility and type of soil as 45 x 20 cm, 75 x 45 cm)

**Fertilizer**

- 20:40:20 kg / ha (vary based on soil fertility and type of soil as 10:40:30,10:30:30 and 20:50:70 kg of NPK / ha).

**Foliar application**

- Spray 1% sulphate of potash at 40 and 60 days after sowing.

**Harvest**

- Picking as once over harvest.

**Seed grading**

- Grade the seeds with 10 / 64" round perforated sieve.

**Storage**

- Store the seeds in gunny or cloth bags for short term storage (8 - 9 months) with a seed moisture content of 9 %.
- Store the seeds in 700 gauge polythene bag for long term storage (more than 15 months) with a seed moisture content of 8 %.

# 12. MUSHROOM CULTIVATION

Agriculture will continue to be the main strength of Indian economy. With the variety of agricultural crops grown today, we have achieved food security by prodding about 240 million tonnes of food grains. However, our struggle to achieve nutritional security is still on. In future, the ever increasing population, depleting agricultural land, changes in environment, water shortage and need for quality food products at competitive rates are going to be the vital issues and secondary agricultural vocations are going to occupy a prominent place to fill the void quality food requirements. The demand for quality food and novel products is increasing with the changes in life style and income. To meet these challenges and to provide food and nutritional security to our people, it is important to diversify the agricultural activities in areas like horticulture. Diversification in any farming systems imparts sustainability. Mushrooms are one such component that not only impart diversification but also help in addressing the problems of quality food, health and environmental sustainability. The present century is going to be a century of functional foods from synthetic chemicals and mushroom cultivation fits very well into this category and is going to be an important vocation.

Mushrooms represent microbial technology that recycles agricultural residues into food and manure. It is solid state fermentation system in which crop residues are converted into valuable food rich in microbial protein. These are important source of quality protein, minerals and various novel compounds of medicinal value, do not compare for land and have very high productivity per unit area and time. These are considered to be the highest protein per unit area and time due to utilization of vertical space and short crop cycle. Due to their cultivation under controlled conditions the water requirements is less than any other crop grown in the field and has all the potentials of being a major crop in coming years.

Mushroom farming today is being practiced in more than 100 countries and its production is increasing at an annual rate of 6-7%. In some developed countries of Europe and America, mushroom farming has attained the status of a high-tech industry with very high levels of mechanization and automation. China leads in mushroom production and China alone is reported to grow more than 20 different types of mushroom at commercial scale and mushroom cultivation has become China’s sixth largest industry. The USA is the second largest producer of mushroom sharing 16% of the world output. Presently, three geographical regions- Europe, America and East Asia contribute to about 96% of world mushroom production. With the rise in the income level, the demand for mushrooms at very low costs with the help of seasonal growing, state subsidies and capturing the potential markets in the world with processed mushrooms at costs not remunerative to the growers in other mushroom producing countries.

Commercial production of edible mushrooms represents unique exploitation of the microbial technology for the bio conversion of the agricultural, industrial, forestry and household waste into nutritious and proteinaceous food. Our country can emerge as a major player in mushroom production in wake of availability of plenty of agricultural residues and labour.Integrating mushroom cultivation in wake of availability of plenty of agricultural residues and labour. Integrating mushroom cultivation in the existing farming systems will not only supplement the income of the farmers but also will promote proper recycling of agro-residues thereby improving soil health and promoting organic agriculture. In India, mushroom research started in1960s and the cultivation picked up in 1970s and new varieties were evolved in button and oyster mushroom during 1980s and 1990s. Since the year 2000, our country is progressing keeping in pace with global growth by developing technologies for cultivation of medicinal mushrooms.

India has varied agro-climate, abundance of agricultural residues and plenty of manpower making it suitable for cultivating different mushrooms. Our country produces about 600 million tonnes of agricultural waste per annum and a major part of it is let out to decompose naturally or burnt *in situ*. This can effectively be utilized to produce highly nutritive food such as mushrooms and spent mushroom substrate can be converted into organic manure and vermi-compost. Mushrooms are grown seasonally as well as in state-of-art environment controlled cropping rooms all the year round in the commercial units. Mushroom growing is a highly labour oriented venture and labour availability is no constraint in the country and two factors, that is, availabilities of raw materials and labour make mushroom growing economically profitable in India. Moreover, scope for intense diversification by cultivation of other edible mushrooms like oyster, shiitake, milky and other medicinal mushrooms are additional opportunities for Indian growers.

At present, four mushrooms *viz.*, Button mushroom (*Agaricus bisporus*), Oyster Mushroom (*Pleurotus* spp), Paddy straw mushroom (*Volvariella* spp.) and Milky mushroom (*Calocybe indica*) have been recommended for round the year cultivation in India.

India produces about 600 million tonnes of agricultural by products, which can profitably be utilized for the cultivation of mushrooms. Currently, we are using 0.04% of these residues for producing around 1.29 lakh tons of mushrooms of which 85% is button mushroom. India contributes about 3% of the total world button mushroom production. Even if we use 1% of the residues for mushroom production, we can produce 3.0 million tons of mushrooms, which will be almost equal to current global button mushroom production (current world production 3.4 million tons). To remain competitive it will be important to harness science and modern technologies for solving the problems of production and bio–risk management. Mushroom being an indoor crop, utilizing vertical space offers a solution to shrinking land and better water utility.

Mushrooms have been reported to be capable of transforming agro wastes like paddy straw into protein rich food and have been confirmed to be sources of single cell protein. Mushrooms contain rich source of carbohydrates, proteins, amino acids and dietary fibre. Vitamins such as riboflavin, niacin and pantothenic acid, and the essential minerals selenium, copper and potassium are abundant in mushrooms. The foremost importance is that mushrooms do not have cholesterol, instead contain ergosterol that act as a precursor for vitamin D synthesis in human body. Mushrooms are believed to help fight against cancer, relieves hypertension, imparts protection from heart diseases. Mushroom crop is in fact a boon that can solve several problems like the protein malnutrition, unemployment issues and environmental pollution.

Mushrooms are cultivated indoors and do not require arable land and mushroom is a short duration crop with high yield per unit time. For small farmers and landless workers mushroom cultivation is highly suitable for the economic and social security of this group. This hi-tech horticulture venture relieves the pressure on arable land, because it cultivation is indoors, and is also more suited to the women folk. Mushrooms supplement and complement the nutritional deficiencies and are regarded as the highest producers of protein per unit area and almost 100 times more than the conventional agriculture and animal husbandry.

At present, in Tamil Nadu the annual production of mushroom is around 11,000 tonnes, button mushroom accounts for 7,500 tonnes, Oyster mushroom accounts for 2700 tonnes and milky mushroom contributes for 800 tonnes. During the past two decades, the Mushroom Research and Training Centre of the Department of Plant Pathology, Tamil Nadu Agricultural University, Coimbatore has made tremendous efforts on transfer of mushroom cultivation technology by imparting trainings. By this way it has contributed for the establishment of about 50 spawn producers and 600 oyster mushroom growers accounting for 7- 8 tonnes / day, 50 button mushroom growers producing 18-20 tonnes / day and 35 milky mushroom growers contributing 1-2 tonnes / day in Tamil Nadu. This account for around 8 per cent of total mushroom production of the country.

**Mushroom varieties/strains released from TNAU for commercial cultivation**

| Scientific Name | Variety/strain name | Place of release |
|---|---|---|
| **Oyster mushroom** | | |
| *Pleurotus sajorcaju* | M2 | Dept. of Plant Pathology, TNAU, Coimbatore |
| *P. citrinopileatus* | CO1 | Dept. of Plant Pathology, TNAU, Coimbatore |
| *P. djamor* | MDU 1 | Dept. of Plant Pathology,AC&RI, Madurai |
| *P. eous* | APK 1 | Regional Research Station, Aruppukottai |
| *P. ostreatus* | Ooty 1 | Horticultural Research Station,Uthagamandalam |
| *P. florida* | Pf | Dept. of Plant Pathology,TNAU, Coimbatore |
| *P.platypus* | Pp | Dept. of Plant Pathology, TNAU,Coimbatore |
| *P. flabellatus* | MDU 2 | Dept. of Plant Pathology, AC&RI Madurai |
| *Hypsizygus ulmarius* | CO2 | Dept. of Plant Pathology,TNAU, Coimbatore |
| **Milky mushroom** | | |
| *Calocybe indica* | APK 2 | Regional Research Station, Aruppukottai |
| *Tricholoma giganteum* | CO 3 | Dept. of Plant Pathology, TANU, Coimbatore |
| **Button mushroom** | | |
| *Agaricus bisporus* | Ooty 1<br>Ooty 2 | Horticultural Research Station, Vijayanagaram<br>Horticultura Research Station, Vijayanangaram |

**Mushroom Cultivation techniques for Oyster and Milk mushroom**

**Base culture/ Nucleus culture**

Tissue culture technique is used to bring the edible mushroom to pure culture so that the mushroom fungus can further be used to prepare spawn. Which is an essential material for mushroom cultivation.

- This nucleus culture is grown on Potato Dextrose Agar medium in test tubes.

- A small tissue from a well-grown mushroom is aseptically transferred to agar medium in a test tube in a culture room.
- The test tubes are incubated under room temperature for 10 days for full white growth of fungal cultue. This is called base culture/nucleus culture and further used for preparation of Mother Spawn.

**Mother spawn**

Mother spawn is nothing but the mushroom fungus grown on a grain based medium. Among the several substrate materials tested by TNAU, Coimbatore, sorghum grains are the best substrate for excellent growth of the fungus. Well-filled, disease-free sorghum grains are used as substrate for growing the spawn materials. The various steps involving in preparation of mother spawn are listed below here under.

- The sorghum grains are washed in water thoroughly to remove chaffy and damaged grains.
- The grains are half cooked in an autoclave / vessel for 30 minutes to soften them.
- The half cooked grains are spread evenly over hessian cloth on a platform to remove the excess water.
- Calcium carbonate is mixed thoroughly with the cooked, dried grains@ 20g/Kg.
- The grains are filled inn polypropylene bags up to $3/4^{th}$ height (approximately 300-330 g/bag).
- A one inch diameter PVP ring is inserted on open end of the bag and plugged with non-absorbent cotton wood.
- The bags are arranged inside an autoclave and sterilized under 20-lbs,pressure for 2 hours.
- The bags after cooling are kept inside the culture room under the UV light for 20 min.
- After 20 minutes the UV light is put off and the fungal culture is transferred in to the sterilized cholam bags.
- The inoculated bags are kept in a clean room under temperature for 10 days for further preparation of bed spawn.

**Bed Spawn**

The method of preparation of bed spawn was same as that of mother spawn. The cooking, filling and sterilization were similar to that of mother spawn. After sterilization, the bags are taken and the fully grown mother spawn is used for inoculation to prepare bed spawn. Thirty bed spawn can be prepared from a single mother spawn. The bags are incubated at room temperature (27±2˚C) for 10 days and used as bed spawn.

**Cultivation of Oyster mushroom**

The oyster mushrooms can be grown indoors in cropping house where a temperature of 25-30$^{o}$ C and relative humidity of 80-85 per cent can be maintained.

- Paddy straw is used as the raw substrate which has to be soaked in water for 4 hours and boiled or steamed in autoclave for 45 minutes and shade dried until 65-70% moisture.
- Cylindrical beds are prepared using 60x30 cm polythene bags with a thickness of 80 gauge.

- Paddy straw and spawn are filled as alternate layers in polythene bags and 10-12 holes are made in the beds.
- The bags are placed in the cropping house/shed in racks or in hanging rope system. After 15-16 days when the paddy straws in the bags are covered with white mycelia growth, pinheads start emerging where water spray is essential to prevent drying of buds.
- First harvest begins from 3-4 days after in head emergence and likewise at 5-7 days internal three harvests can be done.
- Total cropping cycle is around 40-45 days.
- The average bio efficiency ranges (100-150 per cent) depending on the variety.

**Cultivation of Milky mushroom**

The milky mushroom requires a temperature of 30-35˚C and relative humidity of 85-90 per cent. For cultivation of this mushroom two shed are needed.

- Thatched shed / cropping house (28±2˚C).for Spawn running
- A sunken blue poly house (For Cropping)
- Three feet deep pit is dug out and sides are lined with hollow blocks and semicircular structure is built with GI pipe of Langley and covered with Blue silpaulin sheet.
- Paddy straw is processed as in oyster mushroom cultivation and cylindrical beds are prepared with 90x30 cm polythene bags and stored at 30$^{o}$ C in thatched sheds (spawn running room).
- After 18-20 days when the paddy straws in the bags are covered with white mycelial growth, the beds are cut in to two halves and casing soil (autoclaved garden soil) is layered on to the cut halves for 2 cm height and sprayed with water.
- The cased beds are placed in poly houses and the required tem premature is maintained.
- The pinheads emerge from the cut halves over the casing soil on 25-26$^{th}$ day.
- First harvest begins on 28$^{th}$ day and likewise three- five harvests can be done. The total cropping cycle is around 45-50 days. The average bio efficiency ranges from 150-160 per cent.

**Economics of Spawn Production (100 spawn bags per day)**

| Sl. No. | Item | Quantity | Rate (Rs.) | Total (Rs.) |
|---|---|---|---|---|
| **A.** | **Capital investment** | | | |
| 1. | Autoclave | 1 | 70,000 | 70,000 |
| 2. | Boiler (GL drum 100 lit. Capacity) | 2 | 2,500 | 5,000 |
| 3. | Culture room with work table (low cost) | 1 | 20,000 | 20,000 |
| 4. | UV lamp with fittings | 1 | 2,500 | 2,500 |
| 5. | Tube light fittings | 1 | 1000 | 1000 |
| 6. | Advance for LPG gas | 2 | 3,000 | 6,000 |
| 7. | Spawn storage room | 1 | 30,000 | 30,000 |
| 8. | Bunsen burner | 1 | 300 | 300 |
| 9. | Hear efficient chulah | 1 | 1000 | 1000 |
| 10. | Glass wares & chemicals | | | 5000 |
| | **Total** | | | **1,40,800** |

| | | | | |
|---|---|---|---|---|
| **B.** | **Fixed cost** | | | |
| 1. | Interest on capital investment @ 15% | | | 21,120 |
| 2. | Depreciation (Item 3&7 @ 5%) | | | 2,500 |
| 3. | Depreciation (Item 1 2,4,5,8 & 9, 10-10%) | | | 9,080 |
| | **Total** | | | **32,700** |
| **C.** | **Recurring cost (100 spawn x300 days)** | | | |
| 1. | Polypropylene bags | 150Kg | 140 | 21,000 |
| 2. | Cholam grains | 8000Kg | 26 | 2,08,000 |
| 3. | Calcium carbonate (commercial grade) | 160Kg | 25 | 4000 |
| 4. | Non-absorbent cotton (400 g rolls) | 600 | 110/roll | 66,000 |
| 5. | Electricity & Fuel | -- | -- | 60,000 |
| 6. | Labor @ 2 men per day for 300 days | 300 | 360/day | 2,16,000 |
| 7. | Miscellaneous | -- | -- | 10,000 |
| | **Total** | | | **5,85,000** |

Total cost of Spawn production / Year (Rs)—

| | | |
|---|---|---|
| Working expenditure | : | 5,85,000 |
| Total fixed cost | : | 32,700 |
| Total Cost | : | **6,17,700** |
| **Income (Rs.)** | | |
| By sale of 30,000 spawn bags @ Rs. 40 per bag | : | 12,00,000 |
| Total cost | : | **6,17,700** |
| Net income per year | : | **5,82,300** |

**Economics of Oyster mushroom production (10 Kg/day/300 days)**
**Low cost Investment**

| Sl. no. | Item | Quantity | Rate (Rs.) | Total (Rs.) |
|---|---|---|---|---|
| A. | **Capital Investment** | | | |
| 1. | Thatched House (15’ x 25’ | 1 | 30,000 | 30,000 |
| 2. | Chaff cutter (Lever type) | 1 | 2000 | 2,000 |
| 3. | Boiler | 1 | 2,000 | 2,000 |
| 4. | Drum | 1 | 1,000 | 1,000 |
| 5. | Spraying systems | 1 | 1,000 | 1,000 |
| 6. | Biomass stove | | 1,000 | 1,000 |
| | **Total** | | | **37,000** |
| B. | **Fixed cost** | | | |
| 1. | Interest on A @ 15% | | | 5,550 |
| 2. | Depreciation (Item 1 @ 30%) | | | 9,000 |
| 3. | Depreciation (Item 2,3,4,5,& 6 @ 10%) | | | 700 |
| | **Total** | | | **15,250** |
| C. | **Recurring Cost** | | | |
| 1. | Paddy straw cost + transport | 3.5t | 7000 | 24,500 |
| 2. | Spawn @ Rs. 40 / No | 2000 | 40 | 80,000 |
| 3. | Polythene bags for bed & packing | 25Kg | 135 | 3,375 |
| 5. | Labour @ 1 Per day | 300 | 360/day | 1,08,000 |
| 6. | Others | -- | | 5,000 |
| | **Total** | | | **2,20,875** |

Total cost of mushroom production / Year (Rs.)

Working expenditure : 2.20.875
Total fixed cost : 15,250
**Total Cost : 2,36,125**

Income (Rs.)
By sale of 10Kg/day @ Rs. 135 for300 days : 4,05,000
Total cost : 2,36,125
Net Income per year : **1,68,875**

**Economics of Milky mushroom production (10 Kg/day/300 days)**
**Low cost Investment**

| Sl. No. | Item | Quantity | Rate (Rs.) | Total (Rs.) |
|---|---|---|---|---|
| A. | **Capital Investment** | | | |
| 1. | Thatched House (15'x 20')<br>Blue Poly house- 20'x50' area (1000 sq.ft) | 1<br>1 | 20,000<br>60,000 | 80,000 |
| 2. | Chasff cutter (Lever typw) | 1 | 2000 | 2,000 |
| 3. | Boiler | 1 | 2,000 | 2,000 |
| 4. | Drum | 1 | 1,000 | 1,000 |
| 5. | Spraying systems | 1 | 1,000 | 1,000 |
| 6. | Biomass stoce | | 1,000 | 1,000 |
| | **Total** | | | **87,000** |
| **B.** | **Fixed cost** | | | |
| 1. | Interest on A @ 15 % | | | 13,050 |
| 2. | Depreciation Item 1 @ 10 %) | | | 8,000 |
| 3. | Depreciation (Item 2,3,4,5, & 6 @ 10%) | | | 700 |
| | **Total** | | | **21,750** |
| **C.** | **Recurring Cost** | | | |
| 1. | Paddy straw cost + transport | 3.5 t | 7000 | 24,500 |
| 2. | Spawn @ 40 / day | 1600 | 40 | 64,000 |
| 3. | Polythene bags for bed & packing | 25Kg | 135 | 3,375 |
| 4. | Labour @ 1 per day | 300 | 360/day | 1,08,000 |
| 5. | Others | -- | | 5,000 |
| | **Total** | | | **2,04,875** |

Total cost of mushroom production / Year (Rs.)
Working expenditure : **2,04,875**
Total fixed cost : **21,750**
**Total Cost : 2,26,625**

**Income (Rs.)**
By sale of 10Kg/day @ Rs. 145 for 300 days : 4,35,000
Total cost : 2,26,625
Net Income per year : **2,08,375**

# 13. COMPOSTING AND INDUSTRIAL WASTE WATER UTILIZATION

## I. CROP RESIDUE COMPOSTING

Crop residues are the plant parts that are left in the field after harvest. The harvest refuses include straws, stubble, stover and haulms of different crops. Crop remains are also from thrashing sheds or that are discarded during crop processing. This includes process wastes like groundnut shell, oil cakes, rice husks and cobs of maize, sorghum and cumbu. The greatest potential as a biomass resource appears to be from the field residues of sorghum, maize, soybean, cotton, sugarcane etc. In Tamil Nadu 190 lakh tonnes of crop residues are available for use. These residues will contribute 1.0 lakh ton of nitrogen, 0.5 lakh ton of phosphorus and 2.0 lakh tons of potassium. However crop residues need composting before being used as manure.

**Waste collection**

Crop residues accumulated in different locations are to be brought to compost yard. The compost yard should be located in anyone corner of the farm with accessibility via good road. Water resource should also be available in sufficient quantity. The crop residues that are brought to compost yard should be heaped in one corner for further processing.

**Shredding of waste materials**

Particle size is one of the factor that influence the composting. It is advisable to shred all the crop residues that are used for composting. Shredding the waste manually is labour intensive. Shredder machine can be employed to shred all the crop residue biomass. Particle size of 5 cm is recommended for quick composting.

**Mixing of green waste and brown waste**

Carbon and nitrogen ratio decides the initiation of composting process. If C:N ratio is wide (100:1) composting will not take place. Narrow C:N ratio of 30:1 is ideal for composting. To get a narrow C:N ratio, carbon and nitrogen rich material should be mixed together. Green coloured waste materials like glyricidia leaves, parthenium, freshly harvested weeds, sesbania leaves are rich in nitrogen, whereas brown coloured waste material like straw, coir dust, dried leaves and dried grasses are rich in carbon. In any composting process these carbon and nitrogen rich material is to be mixed together to make the composting quicker rather than putting green waste alone or brown color waste alone for composting. Animal dung is also a good source of nitrogen. While making heap formation, alternative layers of carbon rich material, animal dung and nitrogen rich material are to be heaped to get a quicker result in composting.

**Compost heap formation**

Minimum 4 feet height should be maintained for composting. The composting area should be elevated one and have sufficient shade. While heap formation, all the crop residues should be mixed together to form a heterogeneous material rather than a single homogenous material. Alternate layers of carbon and nitrogen rich material with intermittent layers of animal dung are essential. After heap formation the material should be thoroughly moistened.

**Bioinputs for composting**

TNAU Biomineralizer consortium contains groups of microorganisms, which accelerate the composting process. If this inoculum is not added to the composting material, natural microorganisms establish on the waste material on its own and do the composting work. This process takes longtime. But if external source of inoculum is added, the microbial activity starts earlier and composting period will be reduced.

For one tonne of crop wastes 2 kg of TNAU Biomineralizer is recommended. This two kg Biomineralizer should be mixed with 20 liters of water and made slurry. When the compost heap is formed in between layers the slurry should be inoculated, so that it mixes with the waste material thoroughly for uniform coating of microorganism on the waste material. Cow dung slurry is also a good source for microbial inoculum. But it carries unwanted microorganisms also which may compete with composting organism. But when TNAU Biomineralizer is not available, cow dung slurry is a good source material. For one tonne of crop residues 40 kg fresh cow dung is required. This 40 kg fresh cow dung is mixed with 100 litres of water and it should be thoroughly poured over the waste material. Cow dung slurry acts as nitrogen source as well as source of microbial inoculum.

**Aerating the compost material**

Sufficient quantity of oxygen should be available inside the compost heap. For this external air should be freely get in and comes out of the material. Normally to allow the fresh air to get inside, the compost heap should be turned upside down, once in fifteen days. In this process top layer comes to bottom and bottom layer goes to top. This process also activates the microbial process and compost process is hastened. In some cases air ventilating pipe maybe inserted vertically and horizontally, to allow the air to pass through. The wood chip that is available as waste in wood processing industry may also be used as bulking agent in the composting process. This bulking agent gives more air space to the compost material.

**Moisture maintenance**

Throughout the composting period 60% moisture should be maintained. On any situation, compost material should not be allowed to dry. If the material becomes dry, all the microorganisms present in the crop residues will die and the compost process gets affected.

**Compost maturity**

Volume reduction, black colour, earthy odor, reduction in particle size are all the physical factors to be observed for compost maturity. After satisfying with the compost maturity index, the compost heap can be disturbed and spread on the floor for curing. After curing for one day, the composted material is sieved through 4 mm sieve to get uniform composted material. The residues collected after composting has to be again composted to finish the composting process.

**Compost enrichment**

The harvested compost should be heaped in a shade, preferably on a hard floor. The beneficial microorganisms like *Azotobacter*or, *Azospirillum, Pseudomonas, Phosphobacteria* (0.2%) and rock phosphate (2%) have to be inoculated for one ton of compost. Forty per cent moisture should be maintained for the maximum growth of inoculated microorganism.

This incubation should be allowed for 20 days for the organism to reach the maximum population. Now the compost is called as enriched compost. The advantage of enriched compost overnormal compost is the quality manure with higher nutrient status with high number of beneficial microorganisms and plant growth promoting substances.

**Nutritive value of Biocompost**

The nutritive value of biocompost varies from lot to lot because of varying input materials. But in general biocompost contains all the macro and micro nutrients required for crops, which is given in the following table. Even though the quantity available is low it covers all the requirements of the crop.

**Nutrient content of biocompost prepared from different wastes**

| Biocompost | Nutrient content (%) | | |
|---|---|---|---|
| | Nitrogen | Phosphorous | Potash |
| **Animal refuse** | | | |
| Cattle dung | 0.3 - 0.4 | 0.1 – 0.2 | 0.1 – 0.3 |
| Horse dung | 0.4 – 0.5 | 0.3 – 0.4 | 0.3 – 0.4 |
| Sheep dung | 0.5 – 0.7 | 0.4 – 0.6 | 0.3 - 0.1 |
| Night soil | 1.0 – 1.6 | 0.8 – 1.2 | 0.2 – 0.6 |
| Poultry manure | 1.8 – 2.2 | 1.4 – 1.8 | 0.8 – 0.9 |
| Sewage sludge | 2.0 – 3.5 | --- | --- |
| Cattle urine | 0.9 – 1.2 | Trace | 0.5 – 1.0 |
| Horse urine | 1.2 – 1.5 | Trace | 1.3 – 1.5 |
| Sheep urine | 1.5 – 1.7 | 0.1 – 0.2 | 0.1 – 0.3 |
| **Wood Ash** | | | |
| Ash coal | 0.73 | 0.45 | 0.53 |
| Ash wood | 0.1 – 0.2 | 0.8 – 5.9 | 1.5 – 36.00 |
| Habitation waste & factory waste | | | |
| Rural compost | 0.5 – 1.0 | 0.4 – 0.8 | 0.8 – 1.2 |
| Urban compost | 0.7 – 2.0 | 0.9 – 3.0 | 0.3 – 1.9 |
| Farmyard manure | 0.4 – 1.5 | 0.3 – 0.9 | 2.0 – 7.0 |
| **Straw and stalk** | | | |
| Pearl millet | 0.65 | 0.75 | 2.50 |
| Cotton | 0.44 | 0.10 | 0.66 |
| Banana pseudo stem | 0.61 | 0.12 | 1.00 |
| Sorghum | 0.40 | 0.23 | 2.17 |
| Maize | 0.42 | 1.57 | 1.65 |
| Paddy straw | 0.36 | 0.08 | 0.71 |
| Tobacco | 1.12 | 0.84 | 0.80 |
| Pigeon pea | 1.10 | 0.58 | 1.28 |
| Sugarcane trash | 0.53 | 0.10 | 1.10 |
| Wheat | 0.53 | 0.10 | 1.10 |
| Tobacco dust | 1.10 | 0.31 | 0.93 |

**Benefits of biocompost**

- Quality and enriched manure from the crop and animal residues available in the farm. The manure contains both nutrients and beneficial microorganisms.
- There is improvement in the physical, chemical and biological properties of the soil due to regular addition of biocompost.
- Quality products will be obtained from the crop due to improvement in the soil fertility status.
- Soil organic matter content increased and soil biodiversity also improved due to enhanced soil organic matter content.

**Compost application**

Organic manures are highly regarded as good source of material to maintain soil health and increasing soil organic carbon content. Organic manures cannot be equated with inorganic fertilizers. But organic manures deliver all the nutrients to the soil but with little quantity. For one hectare of land 5 tons of enriched biocompost is recommended. It can be used as basal application in the field before taking up planting work.

**Limitation in biocompost application**

- While preparing the biocompost, it should be ensured that the material is composted thoroughly.
- If the materials are not fully composted, the material should be sieved through 4 mm sieve and sieved material will be taken as well as composted one. The residues will be put back for another round of composting.
- It is better avoid woody material like heavy branches from pruned trees and other wooden materials. It will take long time and it interferes with other material for composting.

## II. ENRICHED ORGANIC MANURE FROM COIR DUST

Enriched organic manure from coir dust is nutrient rich organic manure obtained by composting coir dust along with poultry manure, rock phosphate and microbial inoculants *Pleurotus sajor-caju*, *Bacillus* sp,*Trichoderma* sp and *Pseudomonas* sp. This is a simple and rapid technique to compost coir dust within 60 days.

**Inputs**

| | | |
|---|---|---|
| Coir dust | : | 1tonne |
| Poultry manure | : | 200 kg |
| Rock phosphate | : | 10 kg |
| *Pleurotussajor-caju* | : | 2kg |
| Microbial inoculants | : | 2kg |

(*Bacillus* sp + *Trichoderma* sp + *Pseudomonas* sp)

## Methodology

A partially shaded area should be selected for composting of coir dust. The floor of the selected area must be hard to prevent leaching of water or nutrients from the compost. Spread one tonne of coir dust over the floor selected for composting. A hard-cemented surface is ideal for composting. Otherwise the floor should be hardened by putting stones and other hardy materials. Poultry manure (200 kg) and rock phosphate (10 kg), *Pleurotus sajor caju* (2 kg), microbial inoculums (2 kg) consists of *Bacillus, Trichoderma,* and *Pseudomonas* are added to the coir dust. All the above materials are mixed together thoroughly with one tonne of coir dust. After thorough mixing it should be sprinkled with water and formed in to a heap. The moisture level should be maintained at 60% level through out the composting period. However water should not be dripped out of the composting material. For uniform composting of coir dust, the compost should be turned once in every 10 days. There will be reduction in volume of coir dust and all the material will be changed to black in color after 60$^{th}$ day with an earthy odor from the composted material. It will have high water holding capacity. The enriched coir dust compost contains the following nutrients.

## Nutritive value of Enriched Organic Manure from Coir Dust

| S. No. | Parameters | Composition |
|---|---|---|
| 1. | Carbon | 28 % |
| 2. | Nitrogen | 1.82 % |
| 3. | Phosphorus | 2.34 % |
| 4. | Potassium | 0.91 % |
| 5. | Cellulose | 4.20 % |
| 6. | Lignin | 15.39 % |
| 7. | C/N ratio | 15.94 1 |
| 8. | Iron | 1419 mg $kg^{-1}$ |
| 9. | Manganese | 116 mg $kg^{-1}$ |
| 10. | Zinc | 169 mg $kg^{-1}$ |
| 11. | Copper | 115 mg $kg^{-1}$ |

## Advantages of Enriched Organic Manure from Coir Dust

1. The enriched organic manure from coir dust is produced with in a period of 60 days, whereas in other methods the compost is produced 90 to 120 days.
2. The enriched organic manure from coir dust is environment friendly organic manure, suitable for all soils and crops. It is processed from natural biomass adopting organic method and utilizing bio-agents for decomposition of coir dust.
3. Application of the enriched organic manure from coir dust improves the physico-chemical properties of the soil by increasing the nutrient availability in the soil and improving the soil structure, aggregation, porosity and water holding capacity. The soil fertility is enhanced.
4. The enriched organic manure from coir dust supplies macronutrients (Nitrogen, Phosphorus and Potassium) as well as micronutrients (Iron, Manganese, Copper and Zinc) to the corps.

5. It is an excellent organic medium and basal manure for application in planting pits for crops and forest trees especially in areas of water scarcity and drought.
6. The enriched organic manure from coir dust is an excellent soil ameliorant and soil conditioner for correcting soil problems.Hence it can be used as a component of biological reclamation system for bringing alkaline, saline and also ill drained soils back to remunerative farming.

## III. COMPOSTING OF POULTRY WASTES

**Value addition of Poultry Waste through Composting technology**

Poultry industry is one of the largest and fastest growing livestock production systems in the world. In India, there are about 3430 million populations of poultry with a waste generation of 3.30 million tonnes per year. The localized nature of poultry production also means that it can represent a large percentage of the agricultural economy in many states or regions. Although economical and successful, the poultry industry is currently facing with a number of highly complex and challenging environmental problems, many of which are related to its size and geographically concentrated nature. From an agricultural perspective, poultry wastes play a major role in the contamination of ground water through nitrate nitrogen. Also, the eutrophication of surface water due to phosphorus, pesticides, heavy metals and pathogens present in the poultry wastes applied to soils are the central environmental issues at the present time.

Among the animal manures, poultry droppings have higher nutrient contents. It has nitrogen (4.55 to 5.46 %), phosphorus (2.46 to 2.82 %), potassium (2.02 to 2.32 %), calcium (4.52 to 8.15 %), magnesium (0.52 to 0.73 %) and appreciable quantities of micronutrients like Cu, Zn, Fe, Mn etc. In addition to this cellulose (2.26 to 3.62%), hermicellulose (1.89 to 2.77 %) and lignin (1.07 to 2.16 %) are also present in poultry waste. These components upon microbial action can be converted to value added compost with high nutrient status. In poultry droppings, nearly 60% of nitrogen which is present as uric acid and urea is lost through ammonia volatilization by hydrolysis. This loss of nitrogen reduces the agronomic value of the product, besides causing atmospheric pollution. Composting with amendment seems promising in conservation of nitrogen in poultry droppings. Nitrogen in poultry waste can be effectively conserved by composting with suitable organic amendment. The technologies developed will be highly useful to the poultry farmers.

**Method of preparation of poultry waste compost using coir pith**

**Inputs required**

- Poultry droppings
- Coirpith
- *Pleurotus sajor-caju*

**Method**

A known quantity of the poultry waste as collected above along with coir pith is inoculated with *Pleurotus sajor-caju*@ 2 packets per tonne *to* speed up the composting process. This mixer should be placed under shade as heap. The moisture content of the heap should be maintained at 50 to 60%. Periodical turning must be given on 21$^{st}$, 28$^{th}$ and 35$^{th}$ days of composting. Another two packets of *Pleurotus sajor-caju* is to be added during turning given on the 28$^{th}$ day of composting. Good quality compost will be attained after 45$^{th}$ day of composting. The nutrient contents of the composts of poultry litter collected from caged system and deep litter systems are as below;

| Nutrient content | |
|---|---|
| Nitrogen (%) | 2.08 – 2.13 |
| Phosphorous (%) | 2.40 -2.61 |
| Potassium (%) | 2.03-2.94 |
| C:N ratio | 13:1-14:1 |

**Points to be remembered**

- Elevated shady place is highly suitable.
- Within a period of 10 to 15 days, the temperature of the heap will raise to maximum. If the temperature drops below 50º C, the heaps should be spread and moistened with water to bring the moisture content to 60%.
- Colour of the compost will turn from brown to black.
- The matured compost will be odourless.
- The volume of the compost heap will be reduced to 1/3.
- Temperature of the heap will be same as the ambient air temperature and stable.
- Matured compost will be light and fine textured.
- Moisture content of the heap can be measured using moisture meter or by taking handful of compost from the heap and squeezing it with the fingers. If excess water drips out from the compost, then it is considered to have >60 % moisture. If small quantity of water oozes out as drops, then moisture content is considered to be optimum *i.e.*, 60%.
- Each compost heap should have a minimum of one tonne to retain the heat for post decomposition.

**Value**

Animal manures especially poultry manure are rich in N and the nutrient value of the manure is reduced by loss of N through ammonia volatilization and denitrification. Good quality poultry manure can be obtained by mixing the poultry waste with selective carbonaceous material such as coirpith and inoculation with suitable microorganism. It can be used as an eco-friendly technique for the conversion of poultry waste into valuable compost.

**Benefits**

Poultry wastes contain higher concentrations of nitrogen, calcium and phosphorus than wastes of other animal species and the presence of nutrients provides more incentive for the utilization of this resource. The loss of nitrogen from poultry droppings can be effectively conserved by composting with coir pith and serves as a good source of organic nutrients to agricultural fields. To make the organic nutrients present in poultry waste available to plants, the waste has to be composted suitably to minimize the volatilization of ammonia.

**Applications**

The poultry waste compost will be a very good organic manure@6 ton / ha for all the crops.

**Limitations**

The uninterrupted availability of the raw materials has to be ensured for continuous production on a commercial scale.

## IV. VERMICOMPOST

Earthworms live in the soil and feed on decaying organic material. After digestion, the undigested material moves through the alimentary canal of the earthworm, a thin layer of oil is deposited on the castings. This layer erodes over a period of 2 months. So although the plant nutrients are immediately available, they are slowly released to last longer. The process in the alimentary canal of the earthworm transforms organic waste to natural fertilizer. The chemical changes that organic wastes undergo include deodorizing and neutralizing. This means that the pH of the castings is 7 (neutral) and the castings are odorless. The worm castings also contain bacteria, so the process is continued in the soil, and microbiological activity is promoted.

*Vermicomposting* is the process of turning organic debris into worm castings. The worm castings are very important to the fertility of the soil. The castings contain high amounts of nitrogen, potassium, phosphorus, calcium, and magnesium. Castings contain: 5 times the available nitrogen, 7 times the available potash, and 1 ½ times more calcium than found in good top soil. Several researchers have demonstrated that earthworm castings have excellent aeration, porosity, structure, drainage, and moisture-holding capacity. The content of the earthworm castings, along with the natural tillage by the worms burrowing action, enhances the permeability of water in the soil. Worm castings can hold close to nine times their weight in water. "Vermiconversion," or using earthworms to convert waste into soil additives, has been done on a relatively small scale for some time. A recommended rate of vermicompost application is 15-20 per cent. Vermicomposting is done on small and large scales.

**Materials for preparation of Vermicompost**

Any types of biodegradable wastes can be used for vermicomposting

1. Crop residues
2. Weed biomass
3. Vegetable waste
4. Leaf litter
5. Hotel refuse
6. Waste from agro-industries
7. Biodegradable portion of urban and rural wastes

**PHASE OF VERMICOMPOSTING**

| | | |
|---|---|---|
| Phase 1 | : | Processing involving collection of wastes, shredding, mechanical separation of the metal, glass and ceramics and storage of organic wastes. |
| Phase 2 | : | Pre digestion of organic waste for twenty days by heaping the material along with cattle dung slurry. This process partially digests the material and fit for earthworm consumption. Cattle dung and biogas slurry may be used after drying. Wet dung should not be used for vermicompost production. |
| Phase 3 | : | Preparation of earthworm bed. A concrete base is required to put the waste for vermicompost preparation. Loose soil will allow the worms to go into soil and also while watering, all the dissolvable nutrients go into the soil along with water. |

| | | |
|---|---|---|
| Phase 4 | : | Collection of earthworm after vermicompost collection. Sieving the composted material to separate fully composted material. The partially composted material will be again put into vermicompost bed. |
| Phase 5 | : | Storing the vermicompost in proper place to maintain moisture and allow the beneficial microorganisms to grow. |

**Bedding**

Bedding is any material that provides the worms with a relatively stable habitat. This habitat must have the following characteristics:

**High absorbency**

Worms breathe through their skins and therefore must have a moist environment in which to live. If a worm's skin dries out, it dies. The bedding must be able to absorb and retain water fairly well if the worms are to thrive.

**Good bulking potential**

If the material is too dense to begin with, or packs too tightly, then the flow of air is reduced or eliminated. Worms require oxygen to live, just as we do. Different materials affect the overall porosity of the bedding through a variety of factors, including the range of particle size and shape, the texture, and the strength and rigidity of its structure. The overall effect is referred to in this document as the material's bulking potential.

**Low protein and/or nitrogen content (high Carbon: Nitrogen ratio)**

Although the worms do consume their bedding as it breaks down, it is very important that this be a slow process. High protein/nitrogen levels can result in rapid degradation and its associated heating, creating inhospitable, often fatal, conditions. Heating can occur safely in the food layers of the vermiculture or vermicomposting system, but not in the bedding.

**VERMICOMPOST PRODUCTION METHODOLOGY**

**i) Selection of suitable earthworm**

For vermicompost production, the surface dwelling earthworm alone should be used. The earthworm, which lives below the soil, is not suitable for vermicompost production. The African earthworm (*Eudrillus engeniae),* Red worms (*Eisenia foetida)* and composting worm (*Peronyx excavatus)* are promising worms used for vermicompost production. All the three worms can be mixed together for vermicompost production. The African worm (*Eudrillus eugeniae)* is preferred over other two types, because it produces higher production of vermicompost in short period of time and more young ones in the composting period.

**ii) Selection of site for vermicompost production**

Vermicompost can be produced in any place with shade, high humidity and cool. Abandoned cattle shed or poultry shed or unused buildings can be used. If it is to be produced in open area, shady place is selected. A thatched roof may be provided to protect the process from direct sunlight and rain. The waste heaped for vermicompost production should be covered with moist gunny bags.

**iii) Containers for vermicompost production**

A cement tub may be constructed to a height of 2½ feet and a breadth of 3 feet. The length may be fixed to any level depending upon the size of the room. The bottom of the tub is made to slope like structure to drain the excess water from vermicompost unit. A small sump is necessary to collect the drain water.In another option over the hand floor, hollow blocks / bricks may be arranged in compartment to a height of one feet, breadth of 3 feet and length to a desired level to have quick harvest. In this method, moisture assessment will be very easy. No excess water will be drained. Vermicompost can also be prepared in wooden boxes, plastic buckets or in any containers with a drain hole at the bottom.

**iv) Vermiculture bed**

Vermiculture bed or worm bed (3 cm) can be prepared by placing after saw dust or husk or coir waste or sugarcane trash in the bottom of tub / container. A layer of fine sand (3 cm) should be spread over the culture bed followed by a layer of garden soil (3 cm). All layers must be moistened with water.

**v) Worm Food**

Compost worms are big eaters. Under ideal conditions, they are able to consume in excess of their body weight each day, although the general rule-of-thumb is ½ of their body weight per day. They will eat almost anything organic (that is, of plant or animal origin), but they definitely prefer some foods to others. Manures are the most commonly used worm feedstock, with dairy and beef manures generally considered the best natural food for *Eisenia*, with the possible exception of rabbit manure. The former, being more often available in large quantities, is the feed most often used.

**Common Worm Feed Stocks**

| Food | Advantages | Disadvantages |
|---|---|---|
| Cattle manure | Good nutrition; natural food, therefore little adaptation required | Weed seeds make pre-composting necessary |
| Poultry manure | High N content results in good nutrition and a high-value product | High protein levels can be dangerous to worms, so must be used in small quantities; major adaptation required for worms not used to this feedstock. May be pre-composted but not necessary if used cautiously |
| Sheep/Goat manure | Good nutrition | Require pre-composting (weed seeds); small particle size can lead to packing, necessitating extra bulking material |
| Hog manure | Good nutrition; produces excellent vermicompost | Usually in liquid form, therefore must be dewatered or used with large quantities of highly absorbent bedding |
| Rabbit manure | N content second only to poultry manure, there-fore good nutrition; contains very good mix of vitamins & minerals; ideal earth-worm feed | Must be leached prior to use because of high urine content; can overheat if quantities too large; availability usually not good |

| | | |
|---|---|---|
| Fresh food scraps (e.g., peels, other food prep waste, leftovers, commercial food processing wastes) | Excellent nutrition, good moisture content, possibility of revenues from waste tipping fees | Extremely variable (depending on source); high N can result in overheating; meat & high-fat wastes can create anaerobic conditions and odours, attract pests, so should NOT be included without pre-composting |
| Pre-composted food wastes | Good nutrition; partial decomposition makes digestion by worms easier and faster; can include meat and other greasy wastes; less tendency to overheat. | Nutrition less than with fresh food wastes. |
| Biosolids (human waste) | Excellent nutrition and excellent product; can be activated or non-activated sludge, septic sludge; possibility of waste management revenues | Heavy metal and/or chemical contamination (if from municipal sources); odour during application to beds (worms control fairly quickly); possibility of pathogen survival if process not complete |
| Seaweed | Good nutrition; results in excellent product, high in micronutrients and beneficial microbes | Salt must be rinsed off, as it is detrimental to worms; availability varies by region |
| Legume hays | Higher N content makes these good feed as well as reasonable bedding. | Moisture levels not as high as other feeds, requires more input and monitoring |
| Corrugated cardboard (including waxed) | Excellent nutrition (due to high-protein glue used to hold layers together); worms like this material; possible revenue source from WM fees | Must be shredded (waxed variety) and/or soaked (non-waxed) prior to feeding |
| Fish, poultry offal; blood wastes; animal mortalities | High N content provides good nutrition; opportunity to turn problematic wastes into high-quality product | Must be pre-composted until past thermophillic stage |

**vi) Selection for vermicompost production**

Cattle dung (except pig, poultry and goat), farm wastes, crop residues, vegetable market waste, flower market waste, agro industrial waste, fruit market waste and all other bio degradable waste are suitable for vermicompost production. The cattle dung should be dried in open sunlight before used for vermicompost production. All other waste should be predigested with cow dung for twenty days before put into vermibed for composting.

**vii) Putting the waste in the container**

The predigested waste material should be mud with 30% cattle dung either by weight or volume. The mixed waste is placed into the tub / container upto brim. The moisture level should be maintained at 60%. Over this material, the selected earthworm is placed uniformly. For one-meter length, one-meter breadth and 0.5-meter height, 1 kg of worm (1000 Nos.) is required. There is no necessity that earthworm should be put inside the waste. Earthworm will move inside on its own.

**viii) Watering the vermibed**

Daily watering is not required for vermibed. But 60% moisture should be maintained throughout the period. If necessity arises, water should be sprinkled over the bed rather than pouring the water. Watering should be stopped before the harvest of vermicompost.

**ix) Harvesting vermicompost**

In the tub method of composting, the castings formed on the top layer are collected periodically. The collection may be carried out once in a week. With hand the casting will be scooped out and put in a shady place as heap like structure. The harvesting of casting should be limited up to earthworm presence on top layer. This periodical harvesting is necessary for free flow and retain the compost quality. Otherwise the finished compost get compacted when watering is done. In small bed type of vermicomposting method, periodical harvesting is not required. Since the height of the waste material heaped is around 1 foot, the produced vermicompost will be harvested after the process is over.

**x) Harvesting earthworm**

After the vermicompost production, the earthworm present in the tub / small bed may be harvested by trapping method. In the vermibed, before harvesting the compost, small, fresh cow dung ball is made and inserted inside the bed in five or six places. After 24 hours, the cow dung ball is removed. All the worms will be adhered into the ball. Putting the cow dung ball in a bucket of water will separate this adhered worm. The collected worms will be used for next batch of composting.

**xi) Nutritive value of vermicompost**

The nutrients content in vermicompost vary depending on the waste materials that is being used for compost preparation. If the waste materials are heterogeneous one, there will be wide range of nutrients available in the compost. If the waste materials are homogenous one, there will be only certain nutrients are available. The common available nutrients in vermicompost is as follows

| | | |
|---|---|---|
| Organic carbon | : | 9.5 – 17.98% |
| Nitrogen | : | 0.5 – 1.50% |
| Phosphorous | : | 0.1 – 0.30% |
| Potassium | : | 0.15 – 0.56% |
| Sodium | : | 0.06 – 0.30% |
| Calcium and Magnesium | : | 22.67 to 47.60 meq/100g |
| Copper | : | 2 – 9.50 mg kg-1 |
| Iron | : | 2 – 9.30 mg kg-1 |
| Zinc | : | 5.70 – 11.50 mg kg-1 |
| Sulphur | : | 128 – 548 mg kg-1 |

**xii) Storing and packing of vermicompost**

The harvested vermicompost should be stored in dark, cool place. It should have minimum 40% moisture. Sunlight should not fall over the composted material. It will lead to loss of moisture and nutrient content. It is advocated that the harvested composted material is openly stored rather than packed in over sac. Packing can be done at the time of selling. If it is stored in open place, periodical sprinkling of water may be done to maintain moisture level and also to maintain beneficial microbial population. If the necessity comes to store the material, laminated over sac is used for packing. This will minimize the moisture evaporation loss. Vermicompost can be stored for one year without loss of its quality, if the moisture is maintained at 40% level.

**4. Advantages of vermicompost**

- Vermicompost is rich in all essential plant nutrients.
- Provides excellent effect on overall plant growth, encourages the growth of new shoots / leaves and improves the quality and shelf life of the produce.
- Vermicompost is free flowing, easy to apply, handle and store and does not have bad odour.
- It improves soil structure, texture, aeration, and waterholding capacity and prevents soil erosion.
- Vermicompost is rich in beneficial micro flora such as a fixers, P- solubilizers, cellulose decomposing micro-flora etc in addition to improve soil environment.
- Vermicompost contains earthworm cocoons and increases the population and activity of earthworm in the soil.
- It neutralizes the soil protection.
- It prevents nutrient losses and increases the use efficiency of chemical fertilizers.
- Vermicompost is free from pathogens, toxic elements, weed seeds etc.
- Vermicompost minimizes the incidence of pest and diseases.
- It enhances the decomposition of organic matter in soil.
- It contains valuable vitamins, enzymes and hormones like auxins, gibberellins etc.

**5. Pests and diseases of vermicompost**

Compost worms are not subject to diseases caused by micro-organisms, but they are subject to predation by certain animals and insects (red mites are the worst) and to a disease known as “sour crop” caused by environmental conditions.

## INDUSTRIAL WASTE UTILIZATION FOR LAND RECLAMATION AND CROP PRODUCTION

**Application of Untreated Distillery Effluent (Spentwash) for the Reclamation of Sodic Soils**

Amendments generally used to reclaim sodic soils are gypsum, phosphogypsum, iron pyrites and elemental sulphur. All these are inorganic in nature. Some of the organic amendments to reclaim the sodic soils are press-mud, farmyard manure (FYM), coir dust and green manures. The direct discharge of untreated distillery effluent (spentwash) to reclaim and improve the productivity of the sodic soils is now advocated. Untreated distillery effluent (spentwash) is acidic (pH: 3.8 – 4.2) with considerable quantity of potassium, calcium and magnesium and traces of micronutrients. Organic compounds, mainly the humic related melanoidins improve the bio-catalytic potential of the treated soil.

Hence, only one time application of 3.75 to 5.00 lakhs litres of untreated distillery effluent (spentwash) per hectare of sodic soils in summer months is recommended. Natural oxidation can be induced for a period of six weeks with two intermittent dry ploughing at a particular interval. Then, after 45 – 60$^{th}$ day of application, soil is to be irrigated with fresh water and drained. This treatment reduces the pH and exchangeable sodium percentage to normal level and increases the productivity of the sodic soils. After this reclamation practice, rice crop can be raised in the effluent applied field adopting the conventional cultivation technique. Application of this effluent again to the next crop/season or year after year and also to the land nearby drinking water sources is not advocated.

**Application of Treated Distillery Effluent to Crops**

- Treated distillery effluent contains nitrogen 1200 mg $L^{-1}$, phosphate 500 mg $L^{-1}$, potash 12000 mg $L^{-1}$, calcium 1800 mg $L^{-1}$ and iron 300 mg $L^{-1}$. Since the effluent has higher dissolved salts, 50 times diluted effluent can be irrigated to sugarcane, banana, ragi, sunflower, grasses, cotton and soybean.

- It can also be used as one time application to fallow land at the rate 20,000 to 40, 000 litres per hectare. It should be allowed for complete drying over a period of 20 to 30 days. The effluent applied field is to be thoroughly ploughed two times for the natural oxidation and mineralization of organic matter. After that, crops can be raised in the effluent applied field adopting the conventional methods. Application of this effluent again to the next crop/season or year after year and also to the land nearby drinking water sources is not advocated.

**Irrigation of Pulp and Paper Mill Effluents**

Pulp and paper effluents contain lot of dissolved solids and stabilized organic matter. The properly treated effluent with EC less than 1.2 $dSm^{-1}$ as such can safely be used for irrigation with appropriate amendments *viz.,* pressmud @ 5 tonnes $ha^{-1}$ (or) fortified pressmud @ 2.5 tonnes $ha^{-1}$ or daincha as in -situ green manure (6.25 tonnes $ha^{-1}$).

Though there were perceptible changes in soil pH, EC, available NPK, exchangeable cations, exchangeable sodium per cent and sodium absorption ratio, there is no detrimental effect due to sodium either on soil or plants grown in sandy loam soils with good drainage facilities. This treated effluent can be used for irrigation in these soils for the following crops and varieties along with recommended doses of amendments *viz.,* pressmud @ 5 tonnes $ha^{-1}$, or fortified pressmud @ 2.5 tonnes $ha^{-1}$ or daincha as in situ green manure (6.25 tonnes $ha^{-1}$).

| Crops | | Varieties |
|---|---|---|
| Rice | : | IR 20, TRY 1, CO 43. |
| Maize | : | CO 1 |
| Sunflower | : | CO 2 |
| Groundnut | : | TMV 7 |
| Soybean | : | CO 1 |
| Sugarcane | : | CO 6304, COSi 86071, COC 95071, CO 86032 |
| Tapioca | : | CO (TP) 4, CO 2, CO 3, MVD 1 |

However, irrigating this treated effluent to oil seed crops like gingelly and castor, pulses like greengram and blackgram is not advocated as they were found to be sensitive for this type of effluent irrigation.

**Reclamation of papermill effluent irrigated soil**

Application of 7.25 t $ha^{-1}$ of gypsum is recommended to reclaim the TEWLIS area soils of Karur district (Moolimangalam, Pandipalayam, Pazhamapuram, Thadampalayam and Ponniagoundanpudur) where the treated paper mill effluent is being continuously used for irrigation since 1995. Application of pressmud @ 6 t $ha^{-1}$ along with Blue Green Algae (15 kg $ha^{-1}$) and Gypsum (50% Gypsum requirement) is also effective in reclaiming the saline sodic soil with continuous papermill effluent irrigation and to increase the green fodder yield of *Lucerne.*

**Crops and Varieties Suitable for Tannery Waste Affected Soils**

Based on the results of field trials conducted at Vellore district, the following crops, trees and their varieties are recommended for the tannery waste affected soils

| Crops | Varieties |
|---|---|
| Cereals | : Rice (TRY 1, CO 43, Paiyur 1, ASD 16) |
| Millets | : Ragi (CO 12, CO 13) |
| Oilseeds | : Sunflower (CO 4, Morden) and Mustard |
| Cash crops | : Sugarcane (COG 94076, COG 88123, COC 771) |
| Vegetables | : Brinjal, Bhendi, Chillies, Tomato (PKM 1) |
| Flowering crops | : Jasmine, Neerium, Tuberose |
| Trees | : Eucalyptus, Casuarinas and Acacia |

**TNAU constructed wetland technology**

TNAU constructed wetland technology is recommended for treating the papermill effluent using species *viz., Typha latifolia, Pharagmitis australis* and *Cyperus pangorei* with plant density of lakhs shoots $ha^{-1}$ (25 shoots $m^{-2}$). Around 1 ha of wetland area is required to treat 1000 $m^3$ of wastewater per day with a retention time of 2 – 3 days.

The wetland beds should be lined with an impermeable liner made of PVC or high-density poly ethylene (HDPE). The bottom most layer of wetland should be filled with ½ to 1” pebbles to a depth of 6 cm followed by Pea gravel of 6 cm, coarse sand and fine sand each of 7 cm and the top layer with soil to a depth of 9 cm.

# 14. SERICULTURE

## A. MULBERRY (*Morus* spp. ) CULTIVATION

### 1. IRRIGATED

**MULBERRY VARIETIES**

Kanva 2 (M 5), MR 2, S 36, S 1635,DD, V1.

**SOIL TYPE**

Deep red soil or red loamy soil. Avoid saline, alkaline or highly acidic soils.

**NURSERY**

- Select 800 $m^2$ area near water source for raising saplings required for planting one hectare of main field.
- Apply 1600 kg of FYM.
- Raise nursery beds of 4 m x 1.5m size. The length can be of convenient size depending upon the slop and irrigation source.
- Semi-hardwood cuttings of 10 to 12 mm diameter, free from pests and diseases are selected from 6 to 8 months old well established garden.
- The cutting should be of 15 to 20 cm length with 3 to 4 active buds and should have 45° slanting sharp clean cut (without splitting the bark) at the bottom end.
- Use power operated mulberry cutter (TNAU stem cutting machine) for quick cutting of propagation material with an output of 1000 cuttings per hour.
- Mix one kg of *Azospirillum* ($A_ZP_2$ culture) in 40 l of water and keep the bottom ends for 30 minutes in it.
- Apply VAM @ 100 g/$m^2$ of nursery area and irrigated.
- Plant the cuttings in the nursery at 15 cm x 7 cm spacing at an angle of 45° Ensure exposure of atleast one active bud in each cutting.
- Dust one kg endosulfan 4D or malathion 5D or quinalphos 1.5D to prevent termite attack. Drench the soil with carbendazim 50 WP (2 g/l) or apply *Trichoderma viride* 0.5 g/$m^2$ to prevent root rot and collar rot.
- After weeding, apply 100 g of urea/$m^2$ of nursery between 45 and 50 days after planting. Transplant 90 to 120 days old saplings.

**MAIN FIELD**

- ➢ Plough the land with disc plough or mould board plough followed by cultivator and otavator.
- ➢ Use chisel plough to break open hard pan by operating the plough in criss-cross direction at 50 cm distance.
- ➢ During the last plough, apply 20 tonnes of FYM /ha or 5.63 tonnes of vermicompost / ha.

**Planting**

- ➢ Plant the saplings in ridges and furrows at 90 cm x 90 cm spacing (normal row) or at 75/105 cm x 90 cm spacing under paired row system.
- ➢ Planting should coincide with onset of monsoon. Gaps should be filled up to maintain a population of 12,345 plants/ha.

**Nutrient management**

Manures and Fertilizers FYM : 20 t/ha/yr

Fertilizers : 300 : 120 : 120 kg NPK/ha/yr Apply in split doses after every pruning

| Application after pruning | Nitrogen (kg) | Phosphorus (kg) | Potassium (kg) |
|---|---|---|---|
| 1st | 60 | 60 | 60 |
| 2nd | 60 | -- | -- |
| 3rd | 60 | 60 | 60 |
| 4th | 60 | -- | -- |
| 5th | 60 | -- | -- |
| **Total** | **300** | **120** | **120** |

For the variety V1, apply 375 : 140 : 140 kg NPK / ha / yr (in equal splits as above)

**Note:** Apply the fertilizers based on the Soil Test recommendations to optimize the NPK requirement.

**Nitrogen**

- Apply *Azospirillum* in five split doses at 4 kg/ha, each time, after every pruning to compensate 25% of inorganic N fertilizer.
- *In situ* growing and incorporation of sunnhemp, combined with bio-fertilizer can save 50% of N.

**Phosphorus**

- Apply phosphorus solubilizing bacteria at 10 kg/ha/yr in two equal splits.
- Apply phosphorus as Enriched FYM (EFYM) in two equal splits along with first and third application of nitrogen.

**Preparation of Enriched Farmyard Manure (EFYM)**

Mix 375 kg Single Super Phosphate with 750 kg FYM, moisten and keep it in an anaerobic condition for 45 days.

**Micronutrients**

Foliar spray of 1% $FeSO_4$ or 0.5% $ZnSO_4$ or both whenever the deficiency symptoms of zinc of iron are noticed.

**Inter Crop**

After every pruning, grow short duration crops like greens, greengram, blackgram, coriander, cowpea, horsegram and sunnhemp.

**Weed Management**

Weeding should be done manually or chemically after pruning, based on need. Apply glyphosate at 7.5 ml with 10 g of ammonium sulphate / litre of water.

**Water Management**

Irrigate the field once in seven to eight days based on the need. Drip irrigation, if followed, can save 40% of water requirement.

**Pruning**

Once in a year, bottom pruning is done leaving a stem of 10 cm height. Other prunings are done at a height of 30-35 cm from ground level. Totally, five prunings are practiced every year.

**Harvesting**

First leaf harvest can be made six months after planting. Subsequent leaf harvests can be taken 45 days after pruning. Five harvests can be had in an year.

| Varieties | Leaf yield (t/ha/yr) |
|---|---|
| Kanva 2, MR 2, S 36, S 1635 | 35 - 40 |
| DD | 40 – 45 |
| V 1 | 55 - 60 |

## 2. Chawki garden

Maintain a separate Chawki garden for rearing young age worms. Otherwise, a part of the main field ( 5% area) can be allotted for this purpose.

Varieties : S 36 (More suitable because of high carbohydrate and protein content) FYM : 40 t/ha/yr
Fertilizers : 225:150:150 Kg NPK /ha/yr in eight splits
Irrigation : Once in five days
Yield : 25 t/ha/yr in 12 harvests.

Note: V 1 is also suitable for chawki rearing with high nutrient input.

**3. RAINFED**

Varieties : S 13, S 34, S 1635, RFS 135, RFS 175,MR2
Spacing : 90 cm x 90 cm in pit system of planting
Manures and Fertilizers :
FYM : 20 t/ha/yr
Fertilizer : 100:50:50 kg NPK/ha/yr Apply in split doses after pruninLeaf yield : 12 -15 t/ha/yr

**4. Pest and Disease management**

**Tukra,Pink mealy bug (*Maconellicoccus hirsutus)***

- Cut and burn the affected shoots
- Spot application of endosulfan 4D or malathion 5D around the bushes to kill the phoretic ants.
- Spray dichlorvos 76 WSC @ 1 ml/litre (safe waiting period – 10 days)
- Release predatory coccinellids, *Cryptolaemus montrouzieri* @ 750 beetles / ha or
- *Scymnus coccivora* @ 1000 beetles / ha, *Chrysoperla carnea* @ 2500 eggs/ha. Spray 3 % neem oil with 0.5 % wetting agent.

**Thrips (*Pseudodendrothrips mori*)**

Spray dichlorvos 76 WSC @ 2 ml/litre or malathion 50 EC @ 2 ml/litre. Spray 3 % neem oil with 0.5 % wetting agent

**Leaf webber (*Diaphania pulverulentalis*)**

Irrigate the mulberry field immediately after pruning to expose the leaf webber pupae. Release pupal parasitoid, *Tetrastichus howardi* @ 50,000/ha next day after pruning Egg parasitoid, *Trichogramma chilonis* @ 5cc/ha at 10 days after pruning.

Spray dichlorvos 76 WSC @ 1 ml/litre (500 ml/ha) on 30 days after pruning. Clip and burn the affected shoots.

**Black Scale (*Saissetia nigra*)**

Scrap with a plate to dislodge the insects. Spray malathion 50 EC @ 2ml/litre.

**Diseases**

**Root rot (*Macrophomina phaseolina, Fusarium* spp.)**

- Apply neem cake @ 1 t/ha in five split doses Uproot and burn the diseased plants
- Apply copper oxychloride @ 2 g/ litre in the affected areas
- Application of *Pseudomonas fluorescens* + *Trichoderma viride* + *Trichoderma harzianum* + FYM (1:1:1:20) @100 g/ plant.

**Powdery mildew (*Phyllactinea corylea*)**

Spray wettable sulphur or carbendazim @ 2g/litre.

## B. SILKWORM (*Bombyx mori*) REARING

**1. Silkworm races**

Multi X Bivoltine (cross breeds):

| | |
|---|---|
| Irrigated areas | : BL24 x NB4D2, PM x CSR2, PM x NB4D2, APM1 x APS8 (Swarnaandhra), BL43 x NB4D2 |
| Rainfed areas | : PM x C.Nichi, BL23 x NB4D2 |
| Bivoltine hybrids | : CSR2 x CSR 4, CSR 18 x CSR 19, KSO1 x NP 2 Double |
| hybrids | : DH1- [(CSR 6 X CSR 26) (CSR 2 X CSR 27)], DH2- [(CSR 2 X CSR 27) (CSR 6 X CSR 26)]. |

**2. Rearing house**

A well ventilated CSB model rearing house with separate ante room, Chawki room, late age worm rearing room and spinning hall should be used for silkworm rearing.

Avoid rearing in dwelling house and in thatched sheds.

**3. General disinfection**

- Spray 2% formalin with 0.3% slaked lime or 2.5% chlorine dioxide with 0.5% slaked lime @ 2 litres/$m^2$ area for disinfecting the rearing house.
- Dip the rearing equipments in 2% bleaching powder solution and sundry before use.
- Dust 5% bleaching powder with slaked lime powder @ 200 g/$m^2$ around the rearing house and the passages, and sprinkle water @ 1 litre/$m^2$ floor area.

**4. Incubation of eggs**

Incubate the eggs at 25°C temperature and 80% humidity. At head pigmentation stage (about 48 hours before hatching), keep in dark condition by wrapping in black paper or by keeping them in a box (black boxing)

**5. Optimum rearing conditions**

| Instar | Period (days) | Temp (°C) | Humidity (%) | Leaf size ($cm^2$) | Size of the cleaning net (mm) | Quantity of leaves (kg) required for 100 DFLs | |
|---|---|---|---|---|---|---|---|
| | | | | | | Cross breeds | Bivoltines |
| Early | | | | | | | |
| I | 3-4 | 27-28 | 85-90 | 0.5-2.0 | 2 | 4-5 | 6-7 |
| II | 2-3 | 26-27 | 80-85 | 2.0-4.0 | 2 | 6-8 | 9-10 |
| Late | | | | | | | |
| III | 4-5 | 25-26 | 75-80 | 4.0-6.0 | 10 | 30-35** | 35-40** |
| IV | 4-5 | 24-25 | 70-75 | Entire | 20 | 80-90** | 120-150** |
| V | 7-9 | 22-24 | 70-75 | Entire | 20 | 700-800** | 800-950** |
| **Total** | | | | | | **820-938** | **1070-1157*** |

**New CSR breeds / hybrids require 15 to 20% higher quantity of leaves.**

** Note: The ratio between stem and leaves in the shoot ranges from 3:2 to 1:1. The shoots can be harvested and used accordingly for shoot rearing.

**6. Chawki rearing and cleaning:**

In a tray of 120 cm x 90 cm x 10 cm size, 20 DFLs are brushed and reared till the end of second age.

From brushing to the end of second age, the larvae are fed with tender leaves.

The leaves are selected from the largest glossy leaf, 3$^{rd}$ and 4$^{th}$ from the top for I instar larvae. The 5$^{th}$ to 8$^{th}$ leaves are used to rear the second instar larvae.

In the first age, one cleaning is given just a day before the worms settle for moult.

In the second age, two cleanings are given, one after resumption of feeding and the other a day before the second moult.

**7. Shoot rearing for late age worms**

Provide separate rearing house for shoot rearing in shady areas.

Fabricate the rack stand with wood or steel and the rearing seat with wire mesh/bamboo mat. Shoot rearing rack of 1.2m x 11m size is sufficient to rear 50 DFLs.

Provide 15cm border on all sides of the shelf to prevent the dispersal of the larvae.

Arrange the shelves in three tier system with 50 cm space between the tiers. Clean the bed once in each instar.

For cleaning, place two ropes parallelly on the bed and place the new shoots over the ropes. After all the worms have moved on to the new shoots, take the rope from the bed and remove the remains and refuses.

**8. Shoot harvesting and feeding**

Harvest the shoots at 1 m height from ground level at 60 to 70 days after pruning.

Store the shoots vertically upwards in dark cooler room.

Provide thin layer of water (3cm) in one corner of storage room and place the cut ends of shoots in the water for moisture retention.

Provide a layer of newspaper in rearing shelf. Spread the shoot in perpendicular to width of the bed.

Place top and bottom ends of the shoots alternatively to ensure equal mixing of different qualities of leaves.

Transfer the third instar larvae to shoots immediately after moulting.

Apply soya flour twice @ 5g / kg of shoots on first day of first feeding during fourth and fifth instars during first feeding.

**9. Pest and diseases management**

**Pest**

**Uzi fly (*Exorista bombycis*)**

Provide physical barriers like wire mesh or nylon net in the doors and windows of the rearing rooms.

Spray uzicide (1 % benzoic acid) over the larvae to dislodge the eggs.

Dissolve “uzi tables” in water ( 2 tablets /l) or Asiphor 15 ml/l of water in white bowls to attract the adults (uzitrap). Keep them near windows or at the entrance of rearing room.

Release hyperparasitiod, *Nesolynx thymus* @ 20,000 adults / 100 dfls.

Spray uzifly ovo repellant @ 5 ml/ 5 litres on $3^{rd}$, $4^{th}$ and $5^{th}$ instar larvae to ward off uzifly from laying eggs on silkworm larvae.

**SILKWORM DISEASES**

**General precautionary measures to be taken** Proper disinfection of rearing room and appliances. Providing good ventillation

Maintenance of proper temperature and humidity in the rearing room or avoiding fluctuation in temperature and humidity conditions.

Feeding worms with good quality leaves.

Avoiding starvation.

Avoiding over crowding

Avoiding any damage to the skin of worms.

Proper disposal of the dead worms in 2 % bleaching powder + 0.3 % slaked lime solution.

Avoiding borrowing of mountages.

**9.2.2. General bed disinfection**

Keep the rearing bed thin and dry by applying slacked lime at 30 to 50 g/ $m^2$.

Apply bed disinfections such as Sakthi or Vijetha or Resham Jyothi or Sanjeevini @ 4 kg/100 DFLs to prevent the secondary transmission of diseases.

Disinfection of rearing bed with bed disinfectants at dose of 4 kgs/100 dfls and are to be applied at 3g/sq. feet for chawki worms and 5g/sqfeet for late age worms.

**9.2.2. Viral/ Grasserie disease**

Treat the mulberry leaves with aqueous leaf extract of *Psoralea corylifolia or Plectranthus amboinicus* at 0.1 % or 1000 ppm and feed to the worms immediately after second and third moult. Gentamycin 100 ppm is to be administered after fourth moult.

**Bacterial/Flacherie disease (*Streptococcus,Staphylococcus Bacillus, Serratia*)**

Treat the mulberry leaves with aqueous leaf extract of *Aegle marmelos* or *Thuja orientalis* at 0.1% or 1000 ppm after second and third moult and 500 ppm *Streptomycin* sulphate after fourth moult.

**Fungal/Muscadine disease(*Beauveria bassiana, Metarhizium anisopliae, Aspergillus flavus*)**

10 g of dithane M 45 mixed with 1 kg of slaked lime is dusted over chawki worms at 3 g/sq feet. In case of late age worms, 20 g of dithane M 45 is applied at 5 g/ sq.feet. Disinfect rearing rooms and trays with 4% pentachlorophenol to control Aspergillosis.

**Pebrine (*Nosema bombycis*)**

This disease is taken care off in the grainages and only disease free eggs are supplied to farmers. If the disease is chance encountered in the rearing, the diseased eggs, larvae, pupae, moths, bed refuses and faecal pellets should be disposed after thorough disinfection. Storage of leaves in a separate room.

**10. Moulting care**

Apply slaked lime @ 30 to 50 g/$m^2$ when all the worms settle for moult for uniform moulting. Dust 10 g dithane M 45 mixed with 1 Kg of slaked lime over chawki worms at 3 g/ sq. feet. In case of late age worms, 20 g of dithane M 45 is applied at 5 g/ sq. feet.

**11. Mounting**

- For early and uniform spinning of cocoons, apply Sampoorna @ 20 ml (dissolved in 4 litres of water) / 100 DFLs over the leaves and feed to silkworms.
- Spray the mulberry leaves with phytojuvenoid, Illamathi and feed to second day old fifth instar. Avoid hiring of mountages.
- Arrange 800 to 900 worms per $m^2$ on a mountage.
- Mountages should be kept in shade in a well ventilated place in slanting position during spinning. Rotary mountages can also be used (one set of rotary mountage can accommodate 1560 worms).

**12. Harvesting**

Harvest the cocoons of crossbreeds and bivoltines on 5th and 7th day after spinning respectively.

| | | |
|---|---|---|
| Cross breeds | : | Rainfed 20-25 kg/100 DFLs |
| Irrigated 50-60 kg/100 DFLs Bivoltines | : | 60-70 kg/100 DFLs |

# 15. AGROFORESTRY

The present trend of growing trees in the farm lands demands for identification of economically potential tree species suitable to different climatic conditions and soil types. The concept of agroforestry implies sustained, combined management of the same piece of land for silvicultural, agricultural and pastural crops leading to an overall increase of production compared to single crop management. This practice is of immense importance to our country for it is intimately linked with the question of increasing wood and food production to meet the needs of burgeoning population and conservation of soil, land ,moisture resources which is vital for the tropical regions. Properly distributed tree growth acts as a foster mother to agriculture. This is particularly true in dry inhospitable climatic conditions. Tree growth in such cases conserves soil moisture, increasing atmospheric humidity, improves soil fertility, protects field crops against the scorching and desiccating effects of winds and generally makes the climate more equable and pleasant, thereby stepping up agricultural production.

The silviculture of important agroforestry tree species viz., *Eucalyptus sp., Casuarina spp, Ailanthus excels*a, *Melia dubia*, *Tectona grandis, Santalum album , Pterocarpus santalinus, Neolamarckia cadamba* and *Leucaena leucocephala* are given hereunder .

## 1. SILVICULTURE OF EUCALYPTUS

| | | | |
|---|---|---|---|
| **Species** | | : | *Eucalyptus camaldulensis, Eucalyptus tereticornis* |
| **Family** | | : | Myrtaceae |
| **Common Name** | | : | Red gum, Mysore gum |
| **Locality Factors** | Altitude | : | 0 - 1000 m |
| | Mean Annual Rainfall | : | 600 – 1500 mm |
| | Mean Annual Temperature | : | 2°C to 32°C |
| | Soil type | : | Sandy loams<br>Gravels and Alluvial Soil |
| **Phenology** | Flowering | : | Flowering occurs twice a year<br>May to June<br>October to November |
| | Fruit ripening | : | July<br>December |
| **Silvicultural Characters** | | : | Strong light demander<br>Coppice - coppices freely and vigorously |
| **Nursery Techniques** | Seed Propagation | : | Seeds are raised in the mother bed<br>Germinated seedlings are transplanted<br>Six month old seedlings are ready for planting |
| | Vegetative Propagation | : | Clonal technology – mini clonal<br>Establishment of clonal mother garden |

| | | | |
|---|---|---|---|
| | | | management of mother garden with irrigation and fertilizer<br>Induction of micro suits<br>Cutting of 5 to 10 cm<br>Planting in root trainer filled with coir compost<br>Root initiation within 21 days<br>Hardening 45 to 60 days<br>90 days old plants are ready for planting |
| **Silvicultural Treatment** | Spacing | : | 3m x 1.35 m |
| | Pit Size | : | 30 cm x 30 cm x 30 cm |
| | Basal Application | : | 250g of Vermi-compost or 2kg of Farmyard manure per pit with 50-100 g DAP |
| | Planting Time | : | June to October |
| | Irrigation | : | 3 to 6 litres per day |
| | Fertilizer Application | : | 2kg of FYM and 100g – 500g all 19 every six month once |
| | Weeding | : | Two weedings per annum for 2 years |
| | Pruning | : | Self Pruning |
| | Thinning | : | Only dead and diseased |
| **Rate of growth** | | : | Fast growing short rotation trees.<br>It yield an average of 125 - 150 tonnes / ha in 3 years. |
| **Rotation** | | : | 3 Years for Biomass,<br>5-6 Years for Pulpwood<br>6-8 Years for Ply wood |
| **Utilization** | | : | Eucalyptus is an excellent raw material for pulp and paper production due to higher pulp yield ranged between 44 and 48 percent.<br>Fuel wood and charcoal due to high calorific value of over 4500 kcal / kg.<br>Wood is strong and used in particleboard and hardboard industries.<br>The leaves of the Eucalyptus species are rich in essential oils |

**2. SILVICULTURE OF CASUARINA**

| | | | |
|---|---|---|---|
| **Species** | | : | *Casuarina equisetifolia, Casuarina junghuhniana* |
| **Family** | | : | Casuarinaceae |
| **Common Name** | | : | Beefwood, She-oak |
| **Locality Factors** | Altitude | : | 0 - 1000 m |
| | Mean Annual Rainfall | : | 900 – 3800 mm |
| | Mean Annual Temperature | : | 10 - 47° C |

| | | | |
|---|---|---|---|
| | Soil type | : | Best in loose, fine coastal sands.<br>For inland conditions - Well drained sandy soils.<br>It tolerates Lateritic and red soils and also saline, alkaline and acidic conditions. |
| **Phenology** | Flowering | : | Flowering occurs twice a year<br>February to April<br>September to October |
| | Fruit ripening | : | June<br>December |
| **Silvicultural Characters** | | : | Strong light demander and drought resistant.<br>Susceptible to fire.<br>Coppices badly.<br>Tolerate waterlogged conditions |
| **Nursery Techniques** | Seed Propagation | : | Seed treatment – Nil<br>Seeds are raised in the mother bed<br>Germinated seedlings are transplanted<br>Six month old seedlings are ready for planting |
| | Vegetative Propagation | : | Clonal technology – mini clonal<br>Establishment of clonal mother garden<br>management of mother garden with irrigation and fertilizer<br>Induction of micro suits<br>Cutting of 5 to 10 cm<br>Planting in root trainer filled with coir compost<br>Root initiation within 21 days<br>Hardening 45 to 60 days<br>90 days old plants are ready for planting |
| **Silvicultural Treatment** | Spacing | : | 1.5 x 1.5 m to 2 x 2 m |
| | Pit Size | : | 30 cm x 30 cm x 30 cm |
| | Basal Application | : | 250g of Vermi-compost or 2kg of Farmyard manure per pit with 50-100 g DAP |
| | Planting Time | : | South West and North East monsoon |
| | Irrigation | : | 6 to 8 litters per day |
| | Fertilizer Application | : | 100 kg urea first year in three dozes<br>150 kg DAP at four dozes in second year<br>150 complex in three dozes in third year |
| | Weeding | : | Two weedings per annum |
| | Pruning | : | Once in every six months |
| | Thinning | : | Dead and diseases |
| **Rate of growth** | | : | High Yielding short rotation trees.<br>It yield an average of 100 to 150 tonnes / ha in 3 years. |
| **Rotation** | | : | Rotation age of Casuarina is 36 months |
| **Utilization** | | : | Pulp wood: Pulp yield is more than 47 %.<br>Fuel Wood: Calorific value is 4950 Cal/Kg.<br>Timber: Density is 850 Kg/$m^3$. |

| | | | |
|---|---|---|---|
| | | | Wind breaks<br>Poles |

### 3. SILVICULTURE OF MELIA

| | | | |
|---|---|---|---|
| **Species** | | : | *Melia dubia* |
| **Family** | | : | Meliaceae |
| **Common Name** | | : | Malabar Neem, Melia |
| **Locality Factors** | Altitude | : | 1500 to 1800 m |
| | Mean Annual Rainfall | : | 800 – 1000 mm |
| | Mean Annual Temperature | : | 32 - 40° C |
| | Soil type | : | Deep, well drained sandy loam soils |
| **Phenology** | Flowering | : | November – January |
| | Fruit ripening | : | January – February |
| **Silvicultural Characters** | | : | Light demander<br>Susceptible to damage by fires<br>Saplings suffer from browsing |
| **Nursery Techniques** | Seed Propagation | : | Seed has extracted from this stony endocarp and treated with GA at 100 ppm for overnight.<br>Seed are sown sand bed and germination starts in 30 days<br>Germination is only 40%<br>Germinated seedlings are transplanted in poly bags<br>six month old seedlings area ready for planting |
| | Vegetative Propagation | : | Clonal technology – mini clonal<br>Establishment of clonal mother garden<br>management of mother garden with irrigation and fertilizer<br>Induction of micro suits<br>Cutting of 5 to 10 cm<br>Planting in root trainer filled with coir compost<br>Root initiation within 21 days<br>Hardening 45 to 60 days<br>90 days old plants are ready for planting |
| **Silvicultural Treatment** | Spacing | : | Plywood : 4m x 4m (or) 5m x 5m (or) 6 m x6m<br>Pulp & Plywood : a) 6'x 6' (First two years) |
| | Pit Size | : | 30cm x 30cm x 30cm |
| | Planting Time | : | June to October |
| | Irrigation | : | Apply light irrigation once in 7 to 10 days. This could be done through drip irrigation |
| | Fertilizer Application | : | Mixture of compost and organic fertilizers, bio-fertilizer and planting (25-50 g), respectively, to be applied to the pits |
| | Weeding | : | Annual |
| | Pruning | : | Annual |

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| | Thinning | : | Thinning of alternate rows at the beginning of 3rd year<br>Thinning alternate diagonals at the beginning of 5th year<br>Final harvest at the beginning of 7th year |
| **Rate of growth** | | : | For pulpwood: 100-150 tonnes / ha in three years.<br>For Plywood: 200 tonnes / ha in six years |
| **Rotation** | | : | For Plywood: 5-7 Years<br>For Pulp and Paper: 24-36 months |
| **Utilization** | | : | The wood is used for packing cases, cigar boxes, ceiling planks, building purposes, agricultural implements, pencils, match boxes, splints and Catamarans.<br>It is employed for outriggers of boats.<br>It is suitable for musical instruments, tea boxes and ply board.<br>It is a good fuel wood (Calorific value: 3,400 - 4,100 cal.)<br>The fruit of the plant is bitter. It is considered anthelmintic. |

**4. SILVICULTURE OF TEAK**

| | | | |
|---|---|---|---|
| **Species** | | : | ***Tectona grandis*** |
| **Family** | | : | *Verbenaceae* |
| **Common Name** | | : | Teak |
| **Locality Factors** | **Altitude** | : | 0 to 1200 m |
| | **Mean Annual Rainfall** | : | 1000 - 5000 mm |
| | **Mean Annual Temperature** | : | 2°C to 48°C |
| | **Soil type** | : | Deep and well-drained soil<br>Fertile Alluvial-colluvial soil |
| **Phenology** | **Flowering** | : | January to April |
| | **Fruit ripening** | : | May to July |
| **Silvicultural Characters** | | : | Strong light demander<br>Sensitive to frost and drought<br>Good coppicer and pollards vigorously |
| **Nursery Techniques** | Seed Propagation | : | Seeds are treated with alternate wetting and drying for 14 days<br>Seeds sown in mother bed<br>Germinations stars after 3rd week<br>9 – 12 months old seedlings are lifted for stump preparation<br>Stump size 2.5 cm shoot portion 22.5 root portion<br>Stump are used directly for planting |

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| | Vegetative Propagation | : | ❖ Nil |
| **Silvicultural Treatment** | Spacing | : | 2m x 2m |
| | Pit Size | : | 30 cm x 30 cm x 30 cm |
| | Basal Application | : | 2 kg of farmyard manure, 100 g DAP |
| | Planting Time | : | June – July or September - October |
| | Irrigation | : | |
| | Fertilizer Application | : | 2kg of FYM, 100g of complex fertilizer and 100g – 300g all 19 every six month once |
| | Weeding | : | Every 3 month once |
| | Pruning | : | Necessary, Every 6 month once |
| | Thinning | : | Thinning cycle of 4, 8, 12, 18, 26 and 36 years have been followed for 50 years rotation.<br>In Tamil Nadu the thinning cycle of 5, 10, 18, 25 and 36 years are followed for 50 years rotation.<br>In both the cases, the first two thinning are mechanical and the rest are Silvicultural at C grade thinning. |
| **Rate of growth** | | : | Teak is a fast grower and attains a height of 15feet to 20 feet in one year under well managed condition. |
| **Rotation** | | : | 20 years under well irrigated and managed condition<br>40-60 years under forest site condition<br>15 years under bund plantations. |
| **Utilization** | | : | Teak is a moderately strong timber with a density of 660 kg/$m^3$ and is preferred as a most suitable timber both for domestic and industrial utility.<br>Teak is known as a renowned timber due to durability, dimensional stability, working quality and resistant to termites.<br>Teak wood is used in all construction purpose such as beams, columns, doors, windows, flooring, panelling etc.<br>It is one of the best timbers for furniture and cabinet making wagon and railway cadges.<br>For marine construction and ship building teak is preferred due to dimensional stability. |

### 5. SILVICULTURE OF AILANTHUS

| | | |
|---|---|---|
| **Species** | : | ***Ailanthus excelsa*** |
| **Family** | : | *Simaroubaceae* |
| **Common Name** | : | Tree of heaven |

<table>
<tr><td rowspan="4">Locality Factors</td><td>Altitude</td><td>:</td><td>0 to 900 m</td></tr>
<tr><td>Mean Annual Rainfall</td><td>:</td><td>500 - 1900 mm</td></tr>
<tr><td>Mean Annual Temperature</td><td>:</td><td>12.5°C to 47.5°C</td></tr>
<tr><td>Soil type</td><td>:</td><td>Porous sandy loams</td></tr>
<tr><td rowspan="2">Phenology</td><td>Flowering</td><td>:</td><td>February to March</td></tr>
<tr><td>Fruit ripening</td><td>:</td><td>April to may</td></tr>
<tr><td colspan="2">Silvicultural Characters</td><td>:</td><td>Strong light demander<br>Sensitive to drought<br>Moderately frost tender<br>Coppices well and produces root suckers freely.<br>Susceptible to water logging areas</td></tr>
<tr><td>Nursery Techniques</td><td>Seed Propagation</td><td>:</td><td>De winged Seeds soaked in cold water for 5- 7 days by replacing fresh water daily<br>The seeds are dibbled in poly bag and water daily<br>Six month old seedlings are ready for planting.</td></tr>
<tr><td rowspan="8">Silvicultural Treatment</td><td>Spacing</td><td>:</td><td>6m x 6m</td></tr>
<tr><td>Pit Size</td><td>:</td><td>30 cm x 30 cm x 30 cm or 45 cm x 45 cm x 45 cm</td></tr>
<tr><td>Basal Application</td><td>:</td><td>2 kg of farmyard manure, 100 g DAP</td></tr>
<tr><td>Planting Time</td><td>:</td><td>The area is cleared and pits are dug out in the month of February - March and the soil is allowed to weather. The planting in pits is carried out in the month of July.</td></tr>
<tr><td>Irrigation</td><td>:</td><td>5 – 8 litters per day</td></tr>
<tr><td>Fertilizer Application</td><td>:</td><td>5kg of FYM and 100g – 200g complex fertilizer yearly once</td></tr>
<tr><td>Weeding</td><td>:</td><td>Timely and regular weeding for the first two years are very essential</td></tr>
<tr><td>Thinning</td><td>:</td><td>The first silvicultural thinning may be carried out in the seventh or eighth year when the tree attains a height of 10-12 m.</td></tr>
<tr><td colspan="2">Rate of growth</td><td>:</td><td>Ailanthus is a slow growing tree and attains a height of 10 feet to 15 feet in six year under well managed condition.</td></tr>
<tr><td colspan="2">Rotation</td><td>:</td><td>6 – 8 Years</td></tr>
<tr><td colspan="2">Utilization</td><td>:</td><td>This species is extensively used for making matchwood boxes and match splints.<br>The wood is extensively used in cottage industries for making wooden toys and cheap quality cricket bats.<br>The tree is used for making packing cases and wooden boxes.<br>The wood is used for packing cases, fishing floats and sword sheaths.<br>The leaves are rated as highly palatable and protein</td></tr>
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| | | rich nutritious fodder for sheep and goats and are said to augment milk production.<br>The stem and branches are used for fuel wood but it gives poor quality fuel as it burns quickly and does not sustain heat for long.<br>The tree is the most adaptable and pollution tolerant.<br>It is suitable for sloppy, degraded and denuded areas and wasteland.<br>It is also yields gum of inferior quality.<br>The bitter and aromatic leaves of the plant show medicinal properties.<br>The leaves are used for the preparation of lotions for scabies.<br>Quassinoids and ailantic acid are isolated from bark.<br>The dried bark is aromatic and burnt as incense. |

**6. SILVICULTURE OF SUBABUL**

| | | | |
|---|---|---|---|
| **Species** | | : | *Leucaena leucocephala* |
| **Family** | | : | Fabaceae |
| **Common Name** | | : | Subabul |
| **Locality Factors** | Altitude | : | 0 to 1500 m |
| | Mean Annual Rainfall | : | 650 - 3000 mm |
| | Mean Annual Temperature | : | 15°C to 36°C |
| | Soil type | : | Calcareous soils<br>Saline soils and on alkaline soils up to pH 8 |
| **Phenology** | Flowering | : | Two flowering season<br>July – November<br>February – May |
| | Fruit ripening | : | December<br>June |
| **Silvicultural Characters** | | : | Strong light demander<br>Vigorous coppicer<br>Moderate frost tender<br>Drought resistance |
| **Nursery Techniques** | Seed Propagation | : | Seeds are treated with concentrated sulphuric acid and sown directly in the poly bag<br>3 – 4 months old seedlings are ready for planting |
| | Vegetative Propagation | : | Seeds sown in mother bed<br>Germinations starts after 3rd week<br>9 – 12 months old seedlings are lifted for stump preparation |

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| | | | Stump size 2.5 cm shoot portion 22.5 root portion<br>Stump are used directly for planting |
| **Silvicultural Treatment** | Spacing | **:** | 1.5m x 1.5m; 2m x 2m; 3m x 3m |
| | Pit Size | **:** | 30 cm x 30 cm x 30 cm |
| | Basal Application | **:** | 2 kg of farmyard manure, 50 g of super phosphate, 50 g DAP |
| | Planting Time | **:** | 2-4 month old seedlings can be used to planting out in the month of July. |
| | Irrigation | **:** | - |
| | Fertilizer Application | **:** | 2kg of FYM and 100g – 500g all 19 every six month once |
| | Weeding | **:** | 3 month once for first two years |
| | Pruning | **:** | Regular during first one year |
| **Rate of growth** | | **:** | High yielding short rotation tree<br>It yield an average of 100 tonnes/ha in 3 to 4 years |
| **Rotation** | | **:** | 4-6 Years depends on location |
| **Utilization** | | **:** | Subabul is a hard heavy wood (about 800 kg/m) and medium density wood.<br>Subabul is one of the highest quality and most palatable fodder trees.<br>Subabul is an excellent firewood species with a specific gravity of 0.45-0.55 and a high calorific value of 4600 cal/kg. |

**7. SILVICULTURAL OF SANDALWOOD**

| | | | |
|---|---|---|---|
| **Species** | | **:** | ***Santalum album*** |
| **Family** | | **:** | *Santalaceae* |
| **Common Name** | | **:** | East Indian Sandalwood |
| **Locality Factors** | Altitude | **:** | 90 – 1500 m |
| | Mean Annual Rainfall | **:** | 500-2000 mm |
| | Mean Annual Temperature | **:** | 15-35°C |
| | Soil type | **:** | Sandy clayey red lateritic loamy even in black cotton soil<br>Red ferruginous (iron) loam over lying on metamorphic rocks<br>Rocky ground and stony or gravelly soils |
| **Phenology** | Flowering | **:** | Two Flowering Season<br>February – April<br>October - November |
| | Fruit ripening | **:** | May<br>December |
| **Silvicultural Characters** | | **:** | Shade bearer |

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| | | : | Root suckers freely<br>Coppices fairly well |
| **Nursery Techniques** | Seed Propagation | : | The seeds exhibits initial dormancy for 3-4 weeks and after 4 weeks it starts germination which is about 60%<br>The uniform and very good germination can be obtained soaking seeds with 0.05% gibberlic acid over night.<br>The sandal seedlings are transplanted along with host plants *viz.*, Casuarina, Cajanus cajan, Albizia, Alternenthra, Amaranthus etc. |
| | Vegetative Propagation | : | Root cuttings of sandalwood gives only 20 % success. |
| **Silvicultural Treatment** | Spacing | : | 3 X 3 m to 5 X 5 m |
| | Pit Size | : | 30 x 30 x 30 cm (or) 40 x 40 x 40 cm (or) 60 x 60 x 60 cm |
| | Basal Application | : | Soil mixture with neem cake 25-50 g / pits, Chlorpyrifos 2 g powder / pit |
| | Planting Time | : | Monsoon Season |
| | Host | : | Sandal has association with over 150 species of host. Albizia, Terminalia, Lagerstroemia, Dalbergia, Casuarina, *Acacia nilotica*, *Pongamia pinnata, Wrightia tinctoria* and *Cassia siamea* are the major host plants. |
| | Irrigation | : | 4-5 litres / Day based on the growth |
| | Fertilizer Application | : | During soil working periods application of farmyard manure @ 5 kg / plant |
| | Weeding | : | Yearly once |
| | Pruning | : | Pruning is essential to get good heartwood formation |
| **Rate of growth** | | : | Slow growing species<br>The heartwood formation in sandal starts after 10 years.<br>The heartwood forms at the rate of 1 kg/annum after 20 years. |
| **Rotation** | | : | Physical rotation. The dead and naturally fallen trees are harvested |
| **Utilization** | | : | **Sapwood:** Sapwood is white and scentless used for manufacture of agarbattis.<br>**Heartwood:** Heartwood of sandal is moderately hard, heavy and strongly scented, wood and oil are used in incense, perfumes, soap making and medicines.<br>**Religious:** Sandal is considered sacred by Hindus.<br>**Essential oil:** Valuable oil, 'the sandal oil', is distilled from the heartwood (4-13%) and is used in perfumery, soap making and medicines. Seed oil: Seeds yield oil that can be used in the manufacture of paint.<br>**Medicinal uses:** The wood is bitter, dry, antipyretic, |

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| | | aphrodisiac useful in diseases of the heart, burning sensation, cold, bronchitis, vaginal discharges and small pox. |

**8. SILVICULTURAL OF REDSANDER**

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|---|---|---|---|
| **Species** | | : | ***Pterocarpus santalinus*** |
| **Family** | | : | Leguminosaceae |
| **Common Name** | | : | Red sander, Red sandalwood |
| **Locality Factors** | Altitude | : | 150 – 900 m |
| | Mean Annual Rainfall | : | 350 -1350 mm |
| | Mean Annual Temperature | : | 12 – 47°C |
| | Soil type | : | Properly drained red soil<br>Dry rocky soil<br>Quartzite, shale, limestone and lateritic soil |
| **Phenology** | Flowering | : | April to June |
| | Fruit ripening | : | February to March |
| **Silvicultural Characters** | | : | Strong light demander<br>Resistance to fire<br>Excellent coppice<br>Drought resistance even at juvenile stage<br>Produce root suckers freely |
| **Nursery Techniques** | Seed Propagation | : | The seeds are soaked with cow dung slurry for 72 hours or seeds are soaked with water for 72 hours with frequent change of water for every 12 hours.<br>Seed rate per bed: 1 kg<br>Germination Percent: 60-70% |
| | Vegetative Propagation | : | Stump Planting<br>One year old seedlings are preferred for making stumps.<br>The stumps should contain 25-30 cm of roots and 10 – 15 cm of shoot.<br>Survival percentage is 87 % |
| **Silvicultural Treatment** | Spacing | : | 3 m X 3 m to 6 m X 6 m |
| | Pit Size | : | 30cm x 30cm x 30cm |
| | Basal Application | : | 250g of Vermi-compost or 2kg of Farmyard manure per pit with 50-100 g DAP |
| | Planting Time | : | September to December<br>Rainy season |
| | Irrigation | : | Frequent irrigation is essential for initial three years of planting |
| | Fertilizer Application | : | Farmyard manure @ 4 kg / plant/ year<br>DAP @ 100 g / Plant |
| | Weeding | : | 3-4 weeding per year based on weed pressure. |

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| | Pruning | : | Pruning is essential to obtain straight pole. |
| | Thinning | : | Thinning is practiced in every 5 year cycle |
| **Rate of growth** | | : | Slow growing tree<br>The maximum height and girth were 12 m and 66 cm respectively<br>Wavy grained tree is preferable. |
| **Rotation** | | : | 25 years and above |
| **Utilization** | | : | Wood is fine red colour and beautifully streaked. Wood weight is 900 – 1265 kg / cum with very strong and extremely hard.<br>Timber: Excellent timber with little shrinkage.<br>Musical instruments: wood is used as manufacturing of special musical instrument “Shamisen”<br>The dye santalin extracted from wood is used as medicinal values. |

**9. SILVICULTURE OF KADAM**

| | | | |
|---|---|---|---|
| **Species** | | : | ***Neolamarckia cadamba*** |
| **Family** | | : | *Rubiaceae* |
| **Common Name** | | : | Kadamba, Japon, Kalempayam, Vellaikkatambu |
| **Locality Factors** | Altitude | : | 300-800 m |
| | Mean Annual Rainfall | : | 300 - 1600 m |
| | Mean Annual Temperature | : | 5 - 32 $^{o}$C |
| | Soil type | : | Prefers well drained entisols |
| **Phenology** | Flowering | : | May to June |
| | Fruit ripening | : | September to February |
| **Silvicultural Characters** | | : | light demander<br>Tree coppices well |
| **Nursery Techniques** | Seed Propagation | : | The young seedlings are highly susceptible to weeds and should be weeded regularly. 2-month seedlings can be transplanted in nursery beds or into polythene bags, where they can be retained before planting at the start of the monsoon rains |
| | Vegetative Propagation | : | Clonal technology – mini clonal<br>Establishment of clonal mother garden<br>management of mother garden with irrigation and fertilizer<br>Induction of micro suits<br>Cutting of 5 to 10 cm<br>Planting in root trainer filled with coir compost with the treatment of IBA 1000 ppm<br>Root initiation within 21 days |

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| | | | Hardening 45 to 60 days<br>90 days old plants are ready for planting |
| **Silvicultural Treatment** | Spacing | : | 3 m x 3 m |
| | Pit Size | : | 30 cm x 30 cm x 30 cm |
| | Basal Application | : | 250g of Vermi-compost or 2kg of Farmyard manure per pit with 50-100 g DAP |
| | Planting Time | : | June to October |
| | Irrigation | : | 4 to 8 litters per day |
| | Fertilizer Application | : | 2kg of FYM and 100g – 500g all 19 every six month once |
| | Weeding | : | Two weedings per annum |
| | Pruning | : | Once in two months |
| | Thinning | : | Only dead and diseased |
| **Rate of growth** | | : | Fast growing short rotation trees.<br>It yield an average of 125 - 150 tonnes / ha in 3 years. |
| **Rotation** | | : | 3-4 Years for Pulpwood<br>6-8 Years for Ply wood |
| **Utilization** | | : | The wood has a density of 290-560 kg/cu m at 15% moisture content, a fine to medium texture; straight grain; low luster and has no characteristic odour or taste. It is easy to work with hand and machine tools, cuts cleanly, gives a very good surface and is easy to nail<br>The timber is used for plywood, light construction, pulp and paper, boxes and crates, dug-out canoes, and furniture components. Kadam yields a pulp of satisfactory brightness and performance as a hand sheet.<br>A yellow dye can be obtained from the root bark<br>Kadam flowers are an important raw material in the production of 'attar', which are Indian perfumes with sandalwood (*Santalum spp*.) base in which one of the essences is absorbed through hydro-distillation<br>The dried bark is used to relieve fever and as a tonic. An extract of the leaves serves as a mouth gargle |

**MASS MULTIPLICATION OF BAMBOOS USING ENTIRE CULM**

Bamboos are the versatile trees, which flowers only once in its life cycle (40-60 years) and dies what is popularly known as parthenogenesis. Hence, seed availability is very less at the same time the seeds are less viable. This difficulty promoted bamboo propagation through two nodal culm cutting with rooting hormone treatment. This conventional technique accounts only less than 25 percent success rate. The present technology is developed using entire culm without rooting hormone treatment and achieved 90 percent rooting.

Remove one year old culm from the matured mother clump at 5-10 years growth stage. Care should be taken to remove the culm without damaging the culm as well as mother clump. The removed culm should be delimbed carefully by leaving growing buds in the nodes. Then, the culm should be placed it in the raised nursery bed and covered with loose soil and sand mixture for half inch thickness. After providing adequate shade to the culms in the nursery bed with coconut sheaths or rice straw, watering should be done to field capacity. Watering twice a day should be continued and shoot emergence will be observed after one month from all buds present in all nodes of the entire culm. Continue watering up to three months. The root emergence could be observed in 2-3 months. After rooting, the rooted culm should be removed entirely from the soil without any damage. To facilitate uprooting the rooted culms without damage, watering should be done. Each rooted node with shoots should be separated with small hand saw. The separated cutting can be transferred to poly bag.

## MINI CLONAL PROPAGATION FOR TREE CROPS

A mini clonal technology has been developed for casuarinas and Melia which is one of the pioneering attempts in the country for these industrial wood species. Under this technology, the superior clonal plants were planted in a mini clonal garden and are provided with regular irrigation and fertilization in order to enhance shoot multiplication. In this method, the mother plants are planted at 10 cm x 10 cm spacing and 60 days old plants are ready for collection of cuttings.

### Clonal Garden establishment

The clonal garden can be established at a size of 10 x 1 x 0.6 m or 5 x 1 x 0.6 m or 3 x 1x 0.6m using cement trough or GI trough. The bed should be filled with 20 mm stones upto 25 cm and over which finely sewed river sand can be filled. The trough should have facility for drainage. The raised beds can be covered with 100 micron UV stabilized polyethylene film on the top and covered with insect proof mesh to protect the plants and to ensure its freeness from pest and diseases.

### Fertigation

The clonal garden should be maintained with irrigation at an interval of every one hour and supplemented with the following nutrients.

- Urea – 300-400 g/m$^2$
- SSP – 150-175 g/m$^2$
- KCL – 175-250 g/m$^2$
- Micro nutrient mixture – 100 g/m$^2$

The nutrients can be applied twice or thrice depending on the rate of growth of plants.

### Clonal Management

The plants are allowed to grow upto 60 days by applying the required nutrient composition. After 60 days the plants are pruned at required size preferably at half of the plant to induce new shoots. With continuous irrigation and nutrient management the cuttings will start producing shoots from 8-10 days onwards and after 15-20 days the cuttings can be collected and treated with 2% carbendazim solution.

### Clonal Treatment

The newly induced shoots were separated from the plants and are treated with or without 1500 ppm IBA (liquid formulation) and planted in 90 cc root trainers filled with decomposed coir pith. The rooting started in 15 days and 25 days old rooted plants are ready for hardening.

**Green House Conditions**

The root trainers are kept under green house conditions with a temperature regime of 32 – 35°C and a relative humidity of 85-95%. Periodical watering once in every 30 minutes is preferred.

**Acclimatization and Hardening**

The rooted plants are hardened in a shade house condition with 50% shading for 7-15 days and maintained with adequate irrigations. After hardening chamber, the plants are lifted to open nursery for 30 days. Watering is done 2 times a day and the fertilizer of all 19 (N:P:K) can be applied at the rate of 5g/plant. During this hardening, application of carbendazim (2g/l) or triazophos (2ml/lr) is recommended based on the incidence of diseases and pests.

## VALUE ADDITION OF PLANTATION RESIDUES THROUGH BRIQUETTING TECHNLOGY

Briquetting is the process of converting low bulk density biomass into high density and energy concentrated fuel briquettes besides compacting the loose biomass into dense block.

**Raw materials for Briquetting**

Almost all agro and forest residues can be briquetted. Agro and forest residues include saw dust, rice husk, groundnut shell, cotton stalks, wood chips etc. Forest residues such as plantation residues, mill residues (ply wood and match wood residues) can be used for making briquettes. All these residues can be briquetted individually and in combination with or without using binders. The factors that mainly influence the selection of raw materials are moisture content, ash content, flow characteristics, particle size and availability of raw materials. Moisture content in the range of 10-15% is preferred because high moisture content will pose problems in binding and more energy for drying. The ash content of biomass affects its slagging behaviour, operating conditions and mineral composition of ash. Biomass feedstock having upto 4% of ash content is preferred for briquetting. Granular homogeneous materials which can flow easily in conveyers are suitable for briquetting.

**Briquetting Process**

The series of steps involved in the briquetting process are as follows:

**i. Collection of raw material**

In general, any material that will burn but is not in a convenient shape, size or form to be readily usable as fuel is a good candidate for briquetting.

**ii. Preparation of raw materials**

Preparation of raw materials includes size reduction, drying, mixing of raw materials in correct proportion, mixing of raw materials with binders etc.

**iii. Size reduction**

Raw material is first reduced in size by chopping, crushing, breaking, rolling, hammering, milling, grinding, cutting etc. until it reaches a suitably small and uniform sized material (1 to 10). For some material which are available in the size range of 1 to 10 mm need not be sized reduced. Since the size reduction process consumes a good deal of energy, this should be as short as possible. Biomass with irregular size which was difficult to handle. This size of biomass reduced with the help of Shredder machine. Biomass passed through the shredding machine for size reduction and powder of uniform size is made. Shredder size 22” and sharp rotating blades rotated at a speed of 3300 RPM is used. Generally sieve size is 1/16 inch.

**Drying**

Raw materials are available with high moisture content than what is required for briquetting. Drying can be dome in open air (sun), with a heater or with hot air. At the time of harvesting, the biomass contains more than 40 percentage of moisture content. For briquetting we need the moisture content of biomass to be in the range of 10-12 percent. Moisture reduction is done using a solar dryer.

**Raw material mixing**

It is done to make briquettes from more than one raw material. Mixing has to be done in proper way so that the product should have good compaction and high calorific value.

**Mixing of raw material with binders**

Mixing of raw materials with binders in correct proportion is important for the production of briquettes with good compaction. This is best accomplished by a trial and error method of making several briquettes with different mixtures of binding material and testing each for its mechanical strength and burning characteristics. The cost of binding material can be a critical factor for economic success of the project. Natural or synthetic resins, tar, animal manure , molasses, lingo-sulphates, sewage mud, fish water, algae, starch, slime, clay, mud, and cement are some of the binders used in briquetting process.

**Compaction**

Compaction process takes place inside the briquetting machine and the process depends on the briquetting technology adopted.

**Cooling and storage of briquettes**

Briquettes extruding out of the machine are hot with temperatures exceeding 200°c and hence they have to be cooled and stored.

**Parameters considered for design of the briquette machine:**

Bio waste used: saw dust / ground nut / coffee husk / agricultural / forest waste

Max Moisture Level in Bio waste: 8 - 10 %

| **Output Size** | 40 mm | 50 mm | 60 mm | 70 mm | 90 mm |
|---|---|---|---|---|---|
| **Capacity kg/hr** | 200/250 | 250/350 | 650/750 | 900/1100 | 1500/1750 |
| **Length** | 50 - 300 | 50 - 300 | 50 - 300 | 50 - 300 | 50 - 300 |
| **Power Required** | 25 HP | 30 HP | 50 HP | 70 HP | 90 HP |

## MULTIFUNCTIONAL AGROFORESTRY

Agroforestry is one of the oldest land use practices which combines the components of agriculture and forestry production within the same unit area of the land. This agroforestry combines the production of diverse but essential resources for local subsistence. The traditional agroforestry has not seen as an intensive or highly optimised production concept. However, its importance and strength is located within its diverse usability in long term production system and comparatively sustainable impacts in environment and ecosystem functions. The traditional agroforestry system has been utilized as a land use system to increase the livelihood security and reduce the vulnerability to climate and environmental change. The agroforestry systems have provided food, fuel, and fodder besides protecting the natural resources. But today, the rapid phases of population growth coupled with developmental projects have necessitated large volume of wood and wood products from tree outside forests particularly from agroforestry plantations. The industrialization and globalization has made production process more intensified and highly specialized. However, the agroforestry practices are unable to keep up with the higher economic and mono-culture oriented production.

In India, the agroforestry supports nearly 72% of fuel wood demand, over 70% of plywood, 60-80% of pulpwood and around 11% of fodder needs besides satisfying the domestic needs of the society. In case of timber demand the agroforestry is able to meet 2/3$^{rd}$ of the requirement. The role of agroforestry in soil water conservation, Biodiversity conservation and mitigation and adaptation to climate change are very well established. Hence, agroforestry has played a significant role in extending the multifunctional benefits to the society and to the environment. Against this back drop Forest College and Research Institute has conceived and developed a Multifunctional agroforestry model for adoption to double the farmer's income through enhancing productivity per unit area.

## MULTIFUNCTIONAL AGROFORESRY SYSTEM – A PILOT MODEL

The Forest College and Research Institute of Tamil Nadu Agricultural University has designed and established a multifunctional agroforestry model on a pilot basis in 0.75 acre of land. This multifunctional model has been conceptualized with an idea of ensuring monthly income to the farmers practicing the model. This model is conceived based on the fact that the government officials are getting salary on 30$^{th}$ of every month and it is based on this idea the model is conceived and implemented that every month the farmer may also get income from one or other components of multifunctional agroforestry systems. Accordingly the model has been established and it consists of the following components.

**Table 1. Components of Multi-functional Agroforestry Model**

| **Tree Components** | |
|---|---|
| High value trees | *Santalum album, Pterocarpus santalinus, Aquilaria agallocha and Dalbergia latifolia* |
| Timber species | *Tectona grandis, Terminalia tomentosa, Pterocarpus marsupium* |
| Plywood trees | *Melia dubia, Neolamarkia cadamba, Swietenia macrophylla, Melia volkensii* |

| | |
|---|---|
| TBO's | *Jatropha curcus, Pongamia pinnata, Madhuca longifolia, Callophyllum inophyllum.* |
| Medicinal Trees | *Terminalia arjuna, Annona reticulata, Strychnos nuxvomica, Aegle marmelos* |

| **Horticultural components** | |
|---|---|
| Fruit crops | Guava, Custard apple, Amla, Jamun, lemon |
| Leaf crops | Moringa, Curry leaf |
| Flower crops | Jasmine, Marie gold |
| Medicinal plants | *Senna auriculata, Hemidesmus indicus* |
| **Agricultural components** | |
| Agricultural Crops | Greens, Pulses, Vegetable, Oilseeds |
| **Pastoral components** | |
| Grasses | CO-3 and CO-4 |

| Intercrops | No of plants | per plant yield (kg) | total yield (kg/ year | Cost Rs./kg | total cost Rs. |
|---|---|---|---|---|---|
| *Jasminum grandiflorum* | 100 | 2 | 200 | 200 | 40000 |
| Curry leaf | 350 | | 80 | 20 | 1600 |
| *Jasminum officinale* | 72 | 0.8 | 57.6 | 200 | 11520 |
| *Nerium oleander* | 28 | 0.35 | 9.8 | 50 | 490 |
| Fodder | 300 | 8 | 2800 | 2 | 5600 |
| *Moringa oleifera* | 16 | 8 | 128 | 50 | 6400 |
| **Total Income** | | | | | **65610** |

| | | |
|---|---|---|
| **Beneficiary** | : | Family Farming (4 Member Family) |
| **Cost of establishment** | : | 1 lakh / acre including micro irrigation facility |
| **Revenue** | : | Atleast Rs. 550 – 1000 / day |

All these components have been incorporated in a circular model and the same .After three to six months of development, the annual crop components start generating income and after one year, the entire model has become functionally active to generate income on monthly basis to the growers. The functionality and its economic impact are monitored from the inception of the model and will bring good database for promoting multifunctional agroforestry system in a long term approach.

# 16.INTEGRATED FARMING SYSTEMS RESEARCH IN TAMIL NADU

The marginal and small farmers constitute 78.2 per cent of the farming community in India. The unique Indian situation of small fragmented holdings and lack of capital investments is not suitable for single commodity farming being practiced in developed countries. So, the integrated farming system appears to be a viable solution to the Indian agriculture for increasing productivity and income of the small and marginal farmers with constrained resources. Efforts for a holistic integration of different farming enterprises with cropping were carried out for Western, Cauvery delta, Southern and North western zones out of seven agro climatic zones of Tamil Nadu with the objectives of increasing income and recycling of farm wastes and by-products to sustain the soil productivity since 1985. The approaches were to find out viable components for wetland, irrigated upland and rainfed situations existing in different ecological zones.

## INTEGRATED FARMING SYSTEMS

### 1. WESTERN ZONE

**WETLAND**

Integrated farming systems experiments were conducted at wetlands from 1987-onwards at Tamil Nadu Agricultural University, Coimbatore involving different components *viz*., poultry, pigeon, goat, fishery and mushroom.

**Crop + poultry/ pigeon + fish + mushroom**

In this system, the component of integrated farming system involved were crop + fish + mushroom, crop + poultry + fish + mushroom and crop + pigeon + fish + mushroom and was taken from 1993–1995. The efficiency of the component linkages was evaluated predominantly on the basis of productivity, its income and employment generation with the possibility of utilizing recycled organic wastes as nutrient to enrich the soil fertility.

To enhance and sustain the productivity, economic returns, employment generation for the family labour round the year and soil fertility with environmental protection, integration of rice-gingelly- maize and rice- soybean -sunflower cropping each in 0.45 ha with recycled poultry manure as fish pond silt to rice and 75 per cent of the recommended NPK to each crop in the system + poultry (50 layers) + fish (1000 polyculture fingerlings in 0.10 ha of ponded water) comprising catla (20 per cent), silver carp (20 per cent), rohu (20 per cent), mrigal (15 per cent), common carp (15 per cent) and grass carp (10 per cent) fed with poultry dropping + oyster mushroom (5kg/day) for the lowland farmers having one hectare farm.

**Cropping + poultry / pigeon / goat + fishery**

During 1998-2001, the study involved cropping, poultry, pigeon, goat and fishery enterprises in all possible combinations, with a view to recycle the residue and by-products of one component over the other. In one hectare farm, an area of 0.75 ha was assigned for crop activity, 0.10 ha for growing fodder grass to feed the goat unit (20+1), 0.03 ha allotted to goat shed and the remaining 0.12 ha allotted to 3 fish ponds. Three integrated farming systems *viz.,* crop + fish + poultry (20 Bapkok layer birds), crop + fish +

pigeon (40 pairs) and crop + fish + goat (Tellicherry breed of 20 female and 1 male maintained in 0.03 ha deep litter system) were tried for three years. Polyculture fingerlings of 400 numbers (catla, rohu, mirgal/ common carp and grass carp) in the ratio of 40:20:30:10, respectively, reared in 3 ponds of size 0.04 ha (depth of 1.5 m) each.

Integration of crop with fish, poultry, pigeon and goat resulted in higher productivity than cropping alone under lowland. Crop + fish + goat integration recorded higher rice grain equivalent yield of 39610 kg/ha. The highest net return of Rs.131118 and per day return of Rs.511 $ha^{-1}$ were obtained by integrating goat + fish + cropping applied with recycled fishpond silt enriched with goat droppings. Higher net return of Rs.3.36 for every rupee invested was obtained by integration of pigeon + fish + cropping applied with recycled fishpond silt enriched with pigeon droppings. The poultry, pigeon and goat droppings were utilized as feed initially and at the end of a year after the fish harvest, about 4500 kg of settled silt from each pond were collected. The pond silt was utilized as organic sources to supply sufficient quantity of nutrients to the crops.

## IRRIGATED UPLAND

### ***Crop + Dairy + Biogas + Mushroom + Fish***

Integration of 0.32 ha each of sorghum + red gram - sunflower + coriander, maize + fodder cowpea - cotton + coriander and perennial fodder CO3 grass + legume fodder (Lucerne) with dairy (6 cows + 4 calves), biogas (2 $m^3$ capacity) and mushroom (2 kg $day^{-1}$) + spawn production (10 bottles $day^{-1}$) recorded higher productivity than the cropping alone with sorghum - cotton (0.50 ha) and maize - cotton (0.50 ha) cropping systems. Cropping + dairy + biogas + fish + mushroom integration recorded the highest gross, net and per day returns. It also registered the highest benefit cost ratio of 2.41 during 2000-2001.

On farm study was conducted during 2004-2007. The crop activity in integrated farming system consisted of field crop, vegetable crop and fodder crops. The livestock kept were two cross bred milch cows + one calf, ten female tellicherry does + one buck and twenty guinea fowls. Improved farming system gave the maximum maize grain equivalent yield of 22,754 kg/ac/year which was 47.9 % higher than the traditional farming system. The improved system was able to generate employment of 235 man day's $acre^{-1}$ which was higher than traditional farming system (105 man day's $acre^{-1}$). Through recycling of crop residues and livestock manure about 3.72 tonnes of bio-compost and 1.59 tonnes of vermicompost were obtained. This could able to supply 26.0, 22.3, and 26.0 kg N P K to field and fodder crops through biocompost application and 39.4,10.5 and 18.0 kg NPK to vegetable crops as vermicompost application in an acre land area. The returns per rupee of investment from the ratio of gross value of output to total cost (GVCR) was 3.62 and ratio of net value of the products to total cost (NVCR) was 2.80.

## RAINFED LAND

### **Crop + Tree + Goat**

Integrated farming system model involving crop + tree + goat was taken from 1999-2001. Experimental results on integrated farming system revealed that (i) integration of sorghum + cowpea (grain), sorghum + cowpea (fodder) and *C. glaucus* each in 0.33 ha intercropped in *E. officinalis* with Tellichery goat component (5+1) in 0.01 ha resulted in higher productivity, economic returns and provided better employment opportunity and improved soil fertility than raising sole sorghum alone (ii) coir pith mulching and pitcher irrigation increased the tree seedling growth than the control, (iii) tied ridges conserved more moisture and improved the productivity of the crops, (iv) application of 50 per cent N through fertilizer and 50 per cent N through goat manure increased the productivity, enhanced the soil fertility and provided better opportunity for recycling of manure to the crops. Results of on-farm field experiments conducted during 2009 - 2011, revealed that, integration of *Cenchrus setigerus* + *Stylosanthes hamata* and fodder sorghum + *Pillipesara* with sheep (5+1) and buffalo (2 No.'s) could be the best silvipastoral farming system with the application of recommended dose of 25: 45: 19 kg $ha^{-1}$ NPK for *Cenchrus* based system and 30: 20: 10 kg $ha^{-1}$ NPK for fodder sorghum based system along with FYM (10 t $ha^{-1}$) for dry land of Western Zone of Tamil Nadu.

## 2. CAUVERY DELTA ZONE

**Cropping + fish + poultry/duck/goat/dairy**

An experiment was conducted during 1992-1994 in rice based farming system as a demonstration trial at Aduthurai. The components were cropping, fish culture and poultry. An area of 0.40 ha was selected for the farming system study, considering the small and marginal farmers of the state. Conventional cropping as practised by farmers was taken up in an area of 0.96 hectare. In the fish pond with 400 $m^2$, fingerlings belonging to the species *viz.,* Catla (*Catla catla*) (200) Rohu (*Labeo rohita*) (100), Mirgal (*Cirrbinus mrigala*) (100) were stocked.

The economics worked out for the system as a whole was Rs.28.983, in which cropping system contributed Rs.23,709, Poultry and Fisheries contributed additional income of Rs.5,274. Poultry droppings added to the fish pond as feed was 3 tonnes $year^{-1}$ (100g/birds). Mean number of egg production was 262 $year^{-1}$ $bird^{-1}$. In the case of fish pond (0.04) yield recorded was 234 kg. Of the income obtained from the integrated farming system, 78% was from cropping system and poultry cum fisheries generated additional income and employment.

**Cropping** + **duck + fish culture**

Integrated farming system with duck-cum-fish culture as a component was tried during the year 1989. Two farm holdings each with the size of one ha were selected for conducting the study. In one holding, conventional cropping as practiced by farmers was followed. In another one hectare, cropping was practiced in an area of 0.973 ha and an area of 0.027 ha was allotted for duck-cum-fish culture. Economics of IFS was compared with existing cropping systems. Net income of Rs.13790/- was obtained from existing cropping system (*Kuruvai-thaladi* rice - pulse) and a net income of Rs.22676/- was obtained from the modified cropping system (*Kuruvai* - *thaladi* rice - cotton and maize) with an area of 0.973 ha allotted for cropping.

The additional profit from modified cropping alone was Rs.8886/-. From duck-cum-fish culture as a component in mixed farming system, a net profit of Rs.1441/- was obtained from an area of 0.027 ha. Totally an additional income of Rs.10327/- was obtained from the mixed farming system over existing cropping system.

## 3. SOUTHERN ZONE

### WETLANDS OF TAMBIRAPARANI COMMAND AREA

Evaluation of integrated farming system for wetland farms was conducted during 1990-92. The components of the traditional and integrated farming systems are as follows:

| | | |
|---|---|---|
| Traditional system (1 ha) | : | Rice – Rice – Fallow Integrated farming system (1 |
| ha) | : | Crop + dairy + fishery |
| 0.4 ha | : | Rice-rice + soybean (bund) – blackgram |
| 0.2 ha | : | Ragi + sunflower (border) – fodder maize + cowpea – cotton + Greengram |
| 0.2 ha | : | Bajra napier hybrid fodder grass |
| 0.1 ha | : | Desmanthus |
| 0.04 ha | : | Fish pond |
| 0.06 ha | : | Cattle shed for 3 jersey cows and 2 work bullocks |

The integrated farming system provided a net income of Rs.25,215/- which was 100.7 per cent more than the income from the traditional rice farming (Rs.12,662/-

On-farm studies were also undertaken to assess the economic benefits of integrated farming systems actually practised by wetland farmers of Tirunelveli-Kattabomman district during 1990. The study covered four farms in four villages with a farm size of 1-2 ha, raising rice, banana and pulses. The allied activities includes dairy, goat rearing, poultry and fishery. The average monthly income of the farm family practicing the integrated farming system varied from Rs.1,850 to 2,560.

### WETLANDS OF PERIYAR VAIGAI COMMAND AREA

In the Periyar – Vaigai command area, nearly one lakh hectares are raised with a single crop of rice during August – January. The lands are usually left fallow after rice harvest in January. To assess the potential of IFS in such single crop wetlands, experiments were conducted at Agricultural College and Research Institute, Madurai during 1989-91. The results revealed that by crop intensification, diversified cropping and by inclusion of fishery and poultry, the farm income per acre could be increased by Rs.5435 to Rs.6235 per year.

### DRY LANDS OF SOUTHERN ZONE

To identify suitable integrated farming for the dry lands, experiments were conducted at Regional Research Station, Aruppukottai and Agricultural Research Station, Kovilpatti. In the rainfed black soils, the common crops are sorghum, pulses, cotton and sunflower. Introduction of tree legumes like subabul, *Acacia senegal* and *Prosopis cineraria* and perennial fodder grass *Cenchrus ciliaris* and inclusion of goat rearing were evaluated at Regional Research Station, Aruppukottai. Five female and one male goat of Tellicherry breed were raised in deep litter system. The results revealed that the IFS yielded an additional income of Rs.2163 to Rs.2556 per year from a farm area of 1.6 ha. In another study at Aruppukottai proved the IFS system of crop + horticulture + goat proven to be successful in the black soils and increased the profit by Rs.2363 to Rs.4706 per ha over cropping alone.

At Agricultural Research Station, Kovilpatti, studies were taken in farmers' holdings in the dryland red soils. IFS with crop+goat yielded an annual income of Rs.8410 per ha compared to Rs.4654 per ha under traditional cropping alone.

## 4. NORTH WESTERN ZONE

The studies were made under garden land condition. The results revealed that in both Paiyur and Yercaud Centres dairy linked farming system was more remunerative, with more employment generation. The next successful farming system under rainfed condition at Paiyur was sericulture.

**POTENTIAL ALTERNATIVES**

**Western zone**

Wetlands Crop + poultry/ pigeon + fish + mushroom Crop + poultry/ pigeon + goat + fishery

**Upland with supplemental irrigation**

Crop + dairy + biogas + silviculture

Crop + dairy + biogas + mushroom + fish

*Rainfed lands* Crop + goat, Crop + goat + tree

**Cauvery Delta zone**

**Crop + poultry + fish Crop + duck + fish Crop + milch animals Crop + goat + dairy**

**Southern zone**

Wetlands of Tambirabarani Command: Crop + dairy + fishery Wetlands of Periyar Vaigai Command: Crop + fish + poultry Dry lands: Crop + orchard + goat

**North Western zone**

- Crop + dairy + poultry
- Crop + dairy + poultry + sericulture

**Adoption of improved farming system models can result in the advantages listed below.**

- Higher food production to equate the demand of the exploding population of our nation
- Increased farm income through proper residue recycling and allied components
- Sustainable soil fertility and productivity through organic waste recycling
- Integration of allied activities will result in the availability of nutritious food enriched with protein, carbohydrate, fat, minerals and vitamins
- Integrated farming will help in environmental protection through effective recycling of waste from animal activities like piggery, poultry and pigeon rearing
- Reduced production cost of components through input recycling from the byproducts of allied enterprises
- Regular stable income through the products like egg, milk, mushroom, vegetables, honey and silkworm cocoons from the linked activities in integrated farming
- Inclusion of biogas & agro forestry in integrated farming system will solve the prognosticated energy crisis
- Cultivation of fodder crops as intercropping and as border cropping will result in the availability of adequate nutritious fodder for animal components like milch cow, goat / sheep, pig and rabbit
- Firewood and construction wood requirements could be met from the agroforestry system without affecting the natural forest
- Avoidance of soil loss through erosion by agro-forestry and proper cultivation of each part of land by integrated farming
- Generation of regular employment for the farm family members of small and marginal farmers

# 17. WEEDS

## MANAGEMENT OF PROBLEM, PERENNIAL AND PARASITIC WEEDS

### I. *Cynodon dactylon* (*Arugu*) and *Cyperus rotundus* (*Koarai*)

Management of perennial weeds like *Cynodon dactylon* and *Cyperus rotundus* by the application of Glyphosate 15 ml + Ammonium sulphate 20g + activator 1 ml / lit of water

| | | |
|---|---|---|
| Approach | : | Post emergence, total, translocative herbicide |
| Stage of weed | : | Active growing, pre flowering stage |
| Sprayer | : | Hand operated *Knapsack / Backpack* |
| Nozzle | : | WFN 24 & ULV 50 with 30 Psi |
| Spray volume | : | 200-250 litre / ha |

**Application technology**

Non-Crop Situation/Crop Fallow Situation - Blanket application
Cropped Situation - Pre-sowing / planting- Stale seed bed (Blanket application). Established Crops - Directed application using hoods.

**Note:** Rain free period / waiting period: 48 hours

### *II. Solanum elaegnifolium (Kattu kandan kathiri)*

Post-emergence application of Glyphosate 20 ml + Ammonium sulphate 20g/ha+ activator 1ml/litre of water or Glyphosate 10 ml in combination with 2,4-D sodium salt 6 g + activator 1ml / litre

**Note:** The application should be during the active growth / vegetative phase of weed

### *III. Parthenium hysterophorus (Parthenium natchu chedi)*

- Manual removal and destruction of Parthenium plants before flowering using hand glouse / machineries **(or)**
- Pre-emergence application of atrazine 4 g / litre in 500 litres of water / hectare **(or)**
- Uniform spraying of sodium chloride 200g + 2 ml soap oil / litre of water **(or)**
- Spraying of 2,4-D sodium salt 8 g or glyphosate 10 ml + 20g ammonium sulphate + 2 ml soap solution / litre of water before flowering **(or)**
- Post-emergence application of metribuzin 3 g / litre of water under non crop situation.
- Raising competitive plants like *Cassia serecea* and *Abutilon indicum* on fallow lands to replace Parthenium **(or)**
- Biological control by Mexican beetle which is very active during only in monsoon seasons.

**Note:** Parthenium can be decomposed well before flowering and used as organic manure.

### *IV. Ipomoea carnea (Neyveli kattamanakku)*

- Foliar application of 2,4-D sodium salt 8 g + urea 20g + soap oil 2 ml / litre of water and then removal and burning of dried weeds **(or)**
- Manual / mechanical removal of grownup plants in channels during summer.

**Note:** Composted *Ipomoea carnea* can be used as organic manure preferably in rice fields.

### *V. Eichhornia crassipes (Agaya thamarai)*

- Manual / Mechanical removal and drying
- Application of 2,4-D sodium salt 8g + urea 20g or Paraquat 6 ml / litre of water
- Application of Glyphosate 15ml+Ammonium sulphate 20g/ litre of water

**Note:** Vermi-composting and composting of dried water hyacinth and can be used as organic manure in irrigated upland ecosystems.

### *VI. Portulaca quadrifida (Shiru pasari)*

- Post-emergence tank mix directed application of Glyphosate 10 ml / ha + 2, 4-D sodium salt 5g / lit to control *Portulaca quadrifida* in cropped fields.

**Note:** Not to use above herbicides in broadleaved crops particularly cotton and bhendi or other vegetables and pulses as well as oilseed crops.

### *VII. Striga asiatica (Sudu malli)*

- Pre-emergence application of atrazine 1.0 kg/ha on 3$^{rd}$ DAP + hand weeding on 45 DAP with an earthing up on 60 DAP combined with post-emergence spraying of 2,4-D 6 g (0.6%) + urea 20 g (2%) / litre of water on 90 DAP + trash mulching 5 t/ha on 120 DAP

### *VIII. Orabanche (Pukaielai kalan)*

- Pre-emergence application of pendimethalin 1.0 kg/ha or oxyfluorfen 0.30 kg/ha on 3 DATP in tobacco, tomato and brinjal and 3 DAP in potato.
- Plant hole application of neem cake 25 g / plant or drenching of copper sulphate 5% provides partial control of *Orabanche* in tobacco.
- Directed application of paraquat 6 ml/litre of water or glyphosate 8 ml/ litre of water or imazethapyr 3 ml/ litre of water on the Orbanche shoots

# 18. SOIL RELATED CONSTRAINTS AND THEIR MANAGEMENT

A constraint free soil environment is very important for achieving higher food production. The major soil constraints affecting the crop production in Tamil Nadu are

a) Chemical constraints : salinity, sodicity, acidity and nutrient toxicities
b) Physical constraints : high or low permeability, sub soil hard pan, surface crusting, fluffy paddy soils, sandy soils etc.

**1. Saline soils**

Saline soils are characterised by higher amount of water soluble salt, due to which the crop growth is affected. For these soils with electrical conductivity of more than 4 dS $m^{-1}$, provision of lateral and main drainage channels of 60 cm deep and 45 cm wide and leaching of salts could reclaim the soils. Application of farm yard manure at 5 t $ha^{-1}$ at 10 - 15 days before transplanting in the case of paddy crop and before sowing in the case of garden land crops can alleviate the problems of salinity.

**2. Sodic soils**

Sodic soils are characterised by the predominance of sodium in the complex with the exchangeable sodium percentage exceeding 15 and the pH more than 8.5 .To reclaim the sodic soils, plough the soil at optimum soil moisture regime, apply gypsum at 50% gypsum requirement uniformly, impound water, provide drainage for leaching out the soluble salts and apply green manure at 5 t $ha^{-1}$ 10 to 15 days before transplanting in the case of paddy crop.

**3. Acid soils**

Acid soils are characteristically low in pH (< 6.0). Predominance of $H^+$ and $Al^{3+}$ cause acidity resulting in deficiency of P, K, Ca, Mg , Mo and B. This soils are prevalent in a) hilly tracts of Ooty, Kodaikkanal and Yercaud b) Laterite soils of Pudukkottai, Kanyakumari etc Application of lime **(**as per the lime requirement test**)** uniformly by broadcast and incorporation is recommended. The alternate amendments like dolomite, basic slag, flue dust, wood ash, pulp mill lime may also be used on lime equivalent basis**.**

**4. Iron and Aluminum toxicity**

These are characterized by the presence of higher concentration of $Fe^{2+}$ and $Al^{3+}$ more specifically in flooded soils. Prevalent in Kanyakumari and Pudukkottai Districts. Application of lime as per the lime requirement along with the recommended dose of NPK and organic manure will suppress the toxicity.

For ` Ela ` soils of Kanyakumari district (Alfisols, pH : 4-5 ) ,. application of lime as per lime requirement with recommended NPK + foliar spray of 0.5 % ZnSO4 + 0.2% CuSO4 +1% DAP + 1% MOP thrice during AT to PI will help to overcome the problem in rice. Based on the screening tests, the rice cultivars of the region have been rated for their tolerance to Fe toxicity

Highly susceptible : ADT 36
Mod. susceptible : ADT 42, IR 50, CORH 1
Less susceptible : TPS 1, ASD 16 & 18, IR 64, JJ 92, TKM 9, CO 37 & CO 41

**5. Fluffy paddy soils**

The traditional method of preparing the soil for transplanting rice consists of puddling which results in substantial break down of aggregates with uniform structures less mass. Under continuous flooding and submergence of soil in a rice-rice-rice cropping system, the soil particles are always in a state of flux and the mechanical strength is lost leading to the fluffy ness. This is further aggrevated by *insitu* application of rice stubbles and weeds during puddling. They are characterized by low bulk density of the top soil resulting in the sinking of farm animals and labourers as well as poor anchorage to paddy seedlings. For such soils, passing of 400 kg stone roller or oil drum with sand inside eight times at proper moisture level (moisture level at friable condition of soil which is approximately 13 per cent) once in two to three years.

**6. Sandy soils**

Sandy soils are containing predominant amounts of sand resulting in higher percolation rates and nutrient losses. Campacting the soil with 400 kg stone roller or oil drum with sand / stones inside eight times at proper moisture level ( moisture level at friable condition of soil which is approximately 13 per cent ) once in two to three years could reduce the percolation losses. Addition of tank silt for coastal sandy soils is recommended for enhancing their productivity.

**7. Sub Soil hard pan**

**Hard pan occurs in red soil areas due to the movement of clay and iron hydroxides and calcium carbonate and settling at shallow depth, which increases the soil bulk density to more than 1.8 g/cc, their by preventing the root proliferation.** These soils can be reclaimed by chiselling the soils with chisel plough at 0.5 m interval first in one direction and then in the direction perpendicular to the previous one, once in two to three years. Applications of FYM or composted coir pith at 12.5 t ha-1could bring additional yields of about 30 per cent over control. Deep ploughing of the field during summer season can be followed to open up the sub soil. Cultivation of deep rooted crops like tapioca, cotton and semipereneal crop like mulberry encourage natural breaking of the hardpan.

**8. Surface crusted soils**

Surface crusting occurs due to the presence of colloidal oxides of iron and aluminium in Alfisols which binds the soil particles under wet regimes. On drying it forms a hard mass on the surface and prevents the emerging seedlings and arrest the free exchange of gases between the soil and atmosphere. The surface crust can be easily broken by harrowing or cultivator ploughing and its formation can be prevented by improving the aggregate stability by the application of lime or gypsum at 2 t $ha^{-1}$ and FYM at 12.5 t $ha^{-1}$. Sprinkle water at periodic intervals. Bold grain crops like cowpea may be grown

**9. Heavy textured clay soils**

The clay soils are containing major amounts of clay resulting in the poor permeability and nutrient fixation. Such soils can be reclaimed by the addition of river sand at 100 t $ha^{-1}$ or managed by deep ploughing the field with mould board plough or disc plough during summer or forming contour and compartmental bunds and also adoption of ridges and furrows to enhance the infiltration and percolation.

**10. Low permeable black soils**

These soils are having infiltration rate less than 6 cm per day due to high clay content. The amount of water entering in to the soil is reduced, resulting in high run off encouraging the erosion of surface soil with nutrients. Heavy clay and high capillary porosity results in impeded drainage and reduced soil conditions. Application of 100 cart loads of red loam soil or river sand and deep ploughing the field with mould board plough or disc plough during summer to enhance the infiltration and percolation. Application of FYM , composted coir pith or pressmud at 25 t $ha^{-1}$ per year will improve the physical properties and internal drainage of the soil.

**11. High permeable red soils**

These soils are having sand exceeding 70 per cent and are not able to retain water and nutrients. These soils are devoid of finer particles and organic matter, thus aggregates are weekly formed; presence of high non capillary pores results in poor soil structure. Compacting the soil with 15 passes after 24 hours of irrigation, application of tank silt or black soil @ 25 t $ha^{-1}$ per year along with FYM, composted coir pith to improve the water holding capacity of the soil. Providing asphalt, polythene sheet etc below the soil surface will reduce infiltration

# 19. CHISEL TECHNOLOGY

The occurrence of hard pans at shallow depth is the most prevalent soil physical constraint in soils. The agricultural crops are denied of the full benefits of the soil fertility and nutrient use due to this constraint. The sub-soil hard pans are characterized by high bulk density (1.8 g cc.') which in turn lowers infiltration, water storage capacity, available water and movement of air and nutrients, with concomitant adverse effect on the yield of crops. This problem is predominantly present in six districts of Tamil Nadu viz., Coimbatore, Erode, Dharmapuri, Tiruchirappalli, Madurai and Salem particularly under rainfed farming affecting a total of 3.8 lakh hectares of land.

**TECHNOLOGY**

Plough the field with chisel plough at 50 cm interval in both the directions viz., horizontally and vertically. Chiselling helps to break the hard pan in the sub soil. Besides, it ploughs upto 45cm depth. Chisel plough is a heavy iron plough which goes up to 45 cm depth, thereby shattering the hard pans. It is usually drawn by the tractor. Fabrication of chisel plough has been done by the Department of Farm Machinery, Tamil Nadu Agricultural University, Coimbatore.

- Spread 12.5 t of FYM / pressmud / composted coir pith per hectare evenly on the surface.
- Give two ploughings using a country plough for incorporating the added manures. The broken hard pan and incorporation of manures make the soil to conserve more moisture.

**Vegetative barriers for soil moisture conservation**

For better in-situ moisture conservation in drylands of Vertisols, raise vegetative barriers of vettiver or lemon grass across the slope and along the contours at 0.5 m vertical interval.

# 20. SURGE IRRIGATION

Even as advanced pressure irrigation method, such as drip and sprinkler systems are in vogue the traditional gravity surface irrigation methods still remain inevitable due to their simplicity in layouts and low installation and operational expenses. However the short strip furrow and check basin layouts (the primary surface irrigation methods in Tamilnadu) warrant division of the irrigated fields into a number of square or rectangular (2 m x 2 m to 6 m x 6 m ) plots encompassed by criss- cross ridges and feeder channels for facilitating irrigation flow from head to tail end of the field. This eventually results in prolonged irrigation application time and reduced irrigation efficiencies of 55 - 65% only due to excessive seepage, deep percolation and runoff losses (35-45%). Besides, the criss- cross layout with cross ridges and feeder channels leads to land loss of 15 -25%. In view of minimizing the land and water loss and to accomplish high level of irrigation and water use efficiencies a relatively new surface irrigation method called “surge irrigation” was introduced in TNAU with extensive experimental trials on it’s hydraulic performance evaluation and crop compatibility during 1992-95.

**Features of Surge irrigation**

The term “ Surge irrigation” refers to the delivering irrigation flows into individual long furrows (more than 25 m upto 200 m) in an intermittent fashion of predetermined ON-OFF time cycles (5 minute to 10 minutes) with the design duration of irrigation. During the ON time water front advances into the furrow over a certain length and during the subsequent OFF time the water applied partially saturates the soil and infiltration rate gets reduced on the advanced length. When water is delivered in the succeeding ON time, the water front advance gets accelerated due to the reduced intake rate and eventually it reaches the tail end of long furrow with in 30 - 50% of the design duration of irrigation. This process of ON-OFF water supply and cutoff results in highly minimized deep percolation and runoff losses (hardly exceeding 20%). Hence, high uniformity of soil moisture distribution with in the effective root zone is achieved over the entire furrow length resulting in enhanced irrigation efficiencies of more than 85% to 95%. In addition due to the series of long furrows emanating from a single head channel, the criss - cross ridges and feeder channel of division are eliminated thereby limiting the land loss within 5% only.

**Contributions of TNAU in surge irrigation research**

- Manual semi automated and automated surge irrigation layouts were designed and the irrigation parameters such as the individual furrow discharges (30 lit/min to 120 lit/min), surge cycle ON-OFF times (5 min to 30 min), surge cycle ratio (0.25 to 0.66), furrow gradients (0.1% to 0.6%), furrow size (30-120cm) and furrow length (50-200m) could be optimized through mathematical models.
- A significant contribution from TNAU is the development of an original emprical model for the prediction of waterfront advance times and resulting in irrigation water distribution efficiencies.

| | | |
|---|---|---|
| Soil suitability | : | Sandy clay loam and loamy soils only |
| | | Crops tested maize sunflower and sorghum |
| Water saving | : | 25-40% |
| Land saving | : | 15-25% |
| Labour saving | : | 40% |

**Limitations**

Surge irrigation systems do not show marked differences in land and water saving in extremely clay or sandy soils. Besides, surge irrigation technology is still in the infant stage in India and requires popularization through extension methods.

# 21. MICRO IRRIGATION

Micro irrigation is a modern method of irrigation; by this method water is irrigated through drippers, sprinklers, foggers and by other emitters on surface or subsurface of the land. Major components of a micro irrigation system is as follows.

Water source, pumping devices (motor and pump), ball valves, fertigation equipments, filters, control valves, PVC joining accessories (Main and sub main) and emitters. In this system water is applied drop by drop nearer the root zone area of the crop. The drippers are fixed based on the spacing of crop. Many different types of emitters are available in the market. They are classified as Inline drippers, on line drippers, Micro tubes, Pressure compensated drippers.

Drip irrigation is most suitable for wider spacing crops. Micro sprinkler irrigation system is mostly followed in sandy or loamy soils. This system is most suitable to horticultural crops and small grasses. In this method water is sprinkled in a lower height at various directions.

Portable micro sprinklers are also available. They distribute slightly more water than drippers and micro sprinklers. They spray water in not more than one meter. It is used for preparing nursery and lawns in soils with low water holding capacity.

**Advantages of drip irrigation system**

- Water saving and higher yield
- High quality and increased fruit size
- Suitable for all types of soil
- Easy method of fertigation and chemigation
- Saving in labour and field preparation cost

**Disadvantage of drip irrigation system**

- High initial investment
- Clogging of emitters
- Possible damage of system components due to animals, etc.,

**Investment cost mostly differs based on spacing of the crops**

- Generally, the reasons for clogging are solid particles (sand, rust), soft dirt (organic matter, algae, micro organism, salt), sediments (salt in the fertilizers).
- Filtration is the main key factor to the success or failure of the system. The aim of filtration is to stop dirt particles which damage any components of the system.

- To remove salt encrustation, 30 per cent commercial hydrochloric acid can been used at the rate of one liter per one $m^3$ of system discharge.
- To remove algae and fungal clogging 5 to 500 ppm sodium hydrochloride (10 per cent chlorine) can be used.

**Maintenance of drip system**

- Back washing and sand filters has to be cleaned
- Frequent cleaning of emitters and drippers
- Flushing at every irrigation
- Cleaning of sub main and main pipes
- Cleaning of PVC pipes and laterals and acid or chlorine may be used to remove clogging.

**Water used and yield of crops in micro and conventional irrigation methods**

| Crop | Methods of irrigation | Water require-ment (cm) | % water saving | Yield kg $ha^{-1}$ | % increase in yield | Water use efficiency (kg ha $mm^{-1}$) |
|---|---|---|---|---|---|---|
| Banana | Drip | 97.00 | 45.00 | 87500 | 52.00 | 90.20 |
| | Surface | 176.00 | - | 57500 | - | 32.67 |
| Sugarcane | Drip | 94.00 | 56.00 | 170000 | 33.00 | 180.85 |
| | Furrow | 215.00 | - | 128000 | - | 59.53 |
| Grapes | Drip | 27.80 | 48.00 | 32500 | 23.00 | 116.90 |
| | Surface | 53.20 | - | 26400 | - | 49.62 |
| Aerobic rice | Conventional aerobic rice | 74.30 | 38.10 | 4747 | - | 6.39 |
| | Surface drip | 61.90 | 48.40 | 5940 | 14.20 | 9.60 |
| | Sub-surface drip | 61.90 | 48.40 | 6227 | 19.80 | 9.74 |
| | Conventional transplanted | 120.00 | - | 5200 | - | 4.33 |
| Cotton | Drip | 28.00 | 66.27 | 3250 | 25.00 | 116.10 |
| | Furrow | 83.00 | - | 2600 | - | 31.33 |
| Beetroot | Drip | 17.70 | 79.34 | 887 | 55.34 | 50.11 |
| | Surface | 85.70 | - | 571 | - | 6.66 |
| Radish | Drip | 10.80 | 75.72 | 1186 | 13.49 | 109.80 |
| | Surface | 46.40 | - | 1045 | - | 22.52 |
| Papaya | Drip | 73.88 | 67.89 | 23490 | 69.47 | 0.32 |
| | Surface | 225.80 | - | 13860 | - | 0.06 |
| Mulberry | Drip | 20.00 | 60.00 | 71400 | 3.03 | 3570 |
| | Surface | 50.00 | - | 69300 | - | 1386 |
| Tomato | Drip | 18.40 | 39.00 | 48000 | 50.00 | 260.86 |
| | Surface | 30.00 | - | 32000 | - | 106.66 |

(WTC Annual Reports 1985-2003)

**Affordable micro irrigation systems**

Affordable micro irrigation system is mostly suitable to kitchen garden, nursery and ornamental crops.

**1. Bucket kit system**

Bucket kit system is designed for kitchen garden suitable for women, marginal and small farmers. It consists of a bucket (15 lit.) 10 metre long lateral (12mm) fitted with drippers (4 LPH), which can irrigate about 100 plants in approximately 15 $m^2$ area. The bucket is placed at a height of 1m (3 feet) and water is filled for 4 to 5 times daily.

**2. Drum kit system**

This system is ideally suitable to kitchen garden and small commercial vegetable growers. The drum is having 200 liter capacity which would supply water approximately 500 plants by filling the drum twice daily. It consists of lateral (16mm and 12mm). One number of 16mm lateral and five 12mm laterals are used. This system could cover an area of 120 $m^2$ (3 cents).

**3. Micro sprinkler system**

Micro sprinkler kit is suitable for farmers with access to pressurised water. It is very useful for groundnut, vegetables, nurseries home gardens, and lawns etc. It can be connected with a tap from an overhead tank or a domestic water pump. It consists of 15 micro sprinklers with pipes irrigating an area of 250 $m^2$ (6 cents). Fertigation can also be done through this method.

| Sl. No. | Item | Selling Cost/Unit | Area covered by the kits |
|---|---|---|---|
| 1. | Bucket Kit (Drip system) | Rs.225 | 20 $m^2$ (0.5 cent) |
| 2. | Drum Kit (Drip system) | Rs.600 (Excluding Drum Cost) | 120 $m^2$ (3.0 cents) |
| 3. | Micro sprinkler kit | Rs.900 | 240 $m^2$ (6.0 cents) |

**Fertigation**

Fertigation is a method of fertilizer application in which fertilizer is incorporated within the irrigation water by the drip system. In this system fertilizer solution is distributed evenly in irrigation. The availability of nutrients is very high therefore the efficiency is more. In this method liquid fertilizer as well as water soluble fertilizers are used. By this method, fertilizer use efficiency is increased from 80 to 90 per cent.

**Fertilizer efficiencies of various application methods**

| Nutrient | Fertilizer use efficiency (%) | |
|---|---|---|
| | Soil application | Fertigation |
| Nitrogen | 30-50 | 95 |
| Phosphorous | 20 | 45 |
| Potassium | 50 | 80 |

**Advantages of fertigation**

- Nutrients and water are supplied near the active root zone through fertigation which results in greater absorption by the crops.
- As water and fertilizer are supplied evenly to all the crops through fertigation there is possibility for getting 25-50 per cent higher yield.
- Fertilizer use efficiency through fertigation ranges between 80-90 per cent, which helps to save a minimum of 25 per cent of nutrients.
- By this way, along with less amount of water and saving of fertilizer, time, labour

and energy use is also reduced substantially.

**Water saving, yield and profit under drip and drip fertigation systems**

| Crops | Water Saving (%) | Yield (t/ha) | | | Profit (Rs/ha) | | |
|---|---|---|---|---|---|---|---|
| | | Conventional | Drip | Drip+ Fertgn | Conventional | Drip | Drip + Fertgn |
| Banana | 35 | 26 | 30 | 37 | 81000 | 98000 | 120000 |
| Sugarcane | 29 | 120 | 160 | 207 | 30000 | 47000 | 68000 |
| Tomato | 32 | 45 | 56 | 65 | 56000 | 77000 | 95000 |
| Aerobic rice | 48 | 4.75 | 5.58 | 6.23 | 47470 | 55760 | 62270 |

**Fertilizer used in fertigation**

- Urea, potash and highly water soluble fertilizers are available for applying through fertigation.
- Application of super phosphorus through fertigation must be avoided as it makes precipitation of phosphate salts. Thus phosphoric acid is more suitable for fertigation as it is available in liquid form.
- Special fertilisers like mono ammonium phosphate (Nitrogen and Phosphorus), poly feed (Nitrogen, Phosphorus and Potassium), Multi K (Nitrogen and Potassium), Potassium sulphate (Potassium and Sulphur) are highly suitable for fertigation as they are highly soluble in water. Fe, Mn, Zn, Cu, B, Mo are also supplied along with special fertilisers.

**Fertilizers commonly used in fertigation**

| **Name** | **N – $P_2O_5$ – $K_2O$ content** | **Solubility (g/l) at $20^0$ C** |
|---|---|---|
| Ammonium nitrate | 34-0-0 | 1830 |
| Ammonium sulphate | 21-0-0 | 760 |
| Urea | 46-0-0 | 1100 |
| Monoammonium phosphate | 12-61-0 | 282 |
| Diammonium phosphate | 18-46-0 | 575 |
| Potassium chloride | 0-0-60 | 347 |
| Potassium nitrate | 13-0-44 | 316 |
| Potassium sulphate | 0-0-50 | 110 |
| Monopotassium phosphate | 0-52-34 | 230 |
| Phosphoric acid | 0-52-0 | 457 |

**Special water soluble fertilizers**

| **Name** | **N %** | **$P_2O_5$ %** | **$K_2O$ %** |
|---|---|---|---|
| Polyfeed | 19 | 19 | 19 |
| Polyfeed | 20 | 20 | 20 |
| Polyfeed | 11 | 42 | 11 |
| Polyfeed | 16 | 8 | 24 |
| Polyfeed | 19 | 19 | 19 |
| Polyfeed | 15 | 15 | 30 |
| MAP | 12 | 61 | 0 |

| | | | |
|---|---|---|---|
| Multi-K | 13 | 0 | 46 |
| MKP | 0 | 52 | 34 |
| SOP | 0 | 0 | 50 |

**N fertigation**

Urea is well suited for injection in micro irrigation system. It is highly soluble and dissolves in non-ionic form, so that it does not react with other substances in the water. Also urea does not cause precipitation problems. Urea, ammonium nitrate, ammonium sulphate, calcium ammonium sulphate, calcium ammonium nitrate are used as nitrogenous fertilizers in drip fertigation.

**P fertigation**

Application of phosphorus to irrigation water may cause precipitation of phosphate salts. Phosphoric acid and mono ammonium phosphate appears to be more suitable for fertigation.

**K fertigation**

Application of K fertilizer does not cause any precipitation of salts. Potassium nitrate, Potassium chloride, Potassium sulphate and mono potassium phosphate are used in drip fertigation.

**Micro nutrients**

Fe, Mn, Zn, Cu, B, Mo could be used as micro nutrients in drip fertigation.

**Fertigation equipments**

Three main groups of equipments used in drip system are :

- Ventury
- Fertilizer tank
- Fertilizer pump

**Ventury**

Constriction in the main water flow pipe causes a pressure difference (Vaccum) which is sufficient to suck fertilizer solution from an open container into the water flow. It is very easy to handle and it is affordable even by small farmers. This equipment is most suitable for smaller area.

**Fertilizer tank**

A tank containing fertilizer solution is connected to the irrigation pipe at the supply point. Part of the irrigation water is diverted through the tank diluting the nutrient solution and returning to the main supply pipe. The concentration of fertilizer in the tank thus becomes gradually reduced.

**Fertilizer pump**

The fertilizer pump is a standard component of the control head. The fertilizer solution is held in non-pressurised tank and it can be injected into the irrigation water at any desired ratio. Therefore the fertilizer availability to each plants is maintained properly.

**Cost of fertigation equipments**

| Sl.No. | Fertigation devices | Cost (Rs.) |
|---|---|---|
| 1. | Ventury type | 1200 |
| 2. | Fertilizer Tank | 3000 |
| 3. | Injectors | 12000 |

**Economics of drip irrigation system**

The initial investment in drip irrigation system is mainly depends upon the spacing of crops. The initial cost will be almost 75 - 85 thousand rupees per hectare for wider spacing crops such as coconut, mango, grapes and for orchard crops. The initial cost is approximately 1 - 1.25 lakh rupees per hectare for close spacing crops such as sugarcane, banana, papaya, mulberry, turmeric, tapioca, vegetables and flower crops.

**Drip fertigation technology for aerobic rice Surface drip fertigation**

Under aerobic rice conditions, provision of surface drip fertigation (with 0.8 m lateral spacing provided with drippers at 0.3 m distance) scheduled at 125 % Pan Evaporation value for clay soil / 150 % open Pan Evaporation value for sandy soil + STCR based NPK fertigation + biofertigation of *Azophosmet* @ 500 mL $ha^{-1}$ during panicle initiation and flag leaf stages is recommended.

**Sub Surface drip biogation**

Under aerobic rice conditions, provision of sub-surface drip fertigation (10 cm depth with 0.8 m lateral spacing provided with drippers at 0.3 m distance) scheduled at 125 % Pan Evaporation value for clay soil / 150 % open Pan Evaporation value for sandy soil + STCR based NPK fertigation + biofertigation of *Azophosmet* and seaweed extract each @ 500 mL $ha^{-1}$ during panicle initiation and flag leaf stages is recommended.

# 22. AGROMETEOROLOGY

## CROP PLANNING AND MANAGEMENT

### DRYLAND

**1. Length of Growing Period**

Length of growing period is defined as a period in which the available soil moisture is enough to meet the evapotranspiration requirement of dry land crops and hence the dry land productivity is assured. Based on scientific study (Jeevananda Reddy, 1983), length of growing period for different rain gauge stations of each district of different agroclimatic zones of Tamil Nadu have been computed. The length of growing period is given as 'G' with starting and ending of length of growing period in terms of Meteorological standard weeks. If the G is less than 5 weeks period it means that always crop failures will occur. The G period must be a minimum of 14 weeks (98 days) which permit the dry land crop to attain its potential productivity. If the growing period is 14 weeks, a single dry land crop can be cultivated. If G period is between 14 to 20 weeks, suitable inter cropping system can be recommended. If the G period is more than 20 weeks long duration crop / double crop can be organized.

The following information indicates length of growing period for different district of Tamil Nadu. Based on the G period, suitable dry land crop may be selected.

**1. North Eastern Zone**

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| Thiruvaalur | Athipettu | 34-52 | 19 |
| | Ponneri | 33-52 | 20 |
| | Poonamallee | 32-52 | 21 |
| | Saidapet | 32-52 | 21 |
| | Tirutani | 31-50 | 20 |
| | Tiruvallur | 31-51 | 21 |
| Kanchipuram | Chengalpattu | 30-52 | 23 |
| | Cheyur | 33-52,1 | 21 |
| | Covelong | 31-52 | 22 |
| | Kanchipuram | 29-51 | 23 |
| | Madurantakam | 30-52 | 23 |
| | Sriperumudur | 31-51 | 21 |
| | Uttiramerur | 30-51 | 22 |
| | Vayalur | 34-52 | 19 |
| Vellore | Ambur | 33-46 | 14 |
| | Arakkonam | 29-51 | 13 |
| | Gudiyattam | 33-47 | 15 |
| | Sholingnur | 31-49 | 19 |
| | Tiruppattur | 31-45 | 15 |
| | Vaniyambadi | 32-45 | 14 |

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| | Vellore | 30-50 | 21 |
| | Walajapet | 30-50 | 21 |
| Tiruvannamalai | Arani | 30-50 | 21 |
| | Chengam | 31-49 | 19 |
| | Cheyyar | 30-50 | 21 |
| | Polur | 30-50 | 21 |
| | Tiruvannamalai | 31-50 | 20 |
| | Vandavasi | 29-51 | 23 |
| Viluppuram | Gingee | 30-51 | 22 |
| | Tindivanam | 31-52 | 22 |
| | Tirukkovilur | 30-50 | 21 |
| | Ulundurpettai | 32-51 | 20 |
| | Vanur | 32-52,1 | 22 |
| | Viluppuram | 31-51 | 21 |
| Cuddalore | Cuddalore | 32-52,1,2 | 23 |
| | Kurinjippadi | 32-52,1 | 22 |
| | Marakkanam | 32-52 | 21 |
| | Panruti | 31-52 | 22 |
| | Porto Novo | 33-52, 1,2 | 22 |
| | Srimushnam | 33-52 | 20 |
| | Tittagudi | 31-51 | 21 |
| | Vriddhachalam | 31-51 | 21 |
| Perambalur | Chettikulam | 35-48 | 14 |
| | Jayamkonda cholapuram | 35-52 | 18 |
| | Uppiliyapuram | 38-48 | 11 |
| Chennai | Nungambakkam | 32-52 | 21 |

**2. North Western Zone**

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| Dharmapuri | Denkanikota | 32-46 | 15 |
| | Dharmapuri | 32-46 | 15 |
| | Harur | 33-47 | 15 |
| | Hosur | 33-45 | 13 |
| | Krishnagiri | 33-45 | 13 |
| | Palacode | 32-46 | 15 |
| | Pennagaram | 33-45 | 13 |
| | Rayakottai | 33-46 | 14 |
| | Thalli | 31-44 | 14 |
| | Uttangarai | 31-46 | 16 |
| Salem | Attur | 33-48 | 16 |
| | Omalur | 29-45 | 17 |

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| | Salem | 27-45 | 19 |
| | Sankari Durg | 33-45 | 13 |
| | Tammampatti | 34-49 | 16 |
| | Valapadi | 33-46 | 14 |
| Namakkal | Namakkal | 33-46 | 14 |
| | Paramathi | 35-45 | 11 |
| | Rasipuram | 30-45 | 16 |
| | Sendamangalam | 32-45 | 14 |
| Perambalur | Ariyalur | 35-50 | 16 |
| | Perambalur | 35-50 | 16 |

**3. Western Zone**

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| Coimbatore | Annur | 38-47 | 10 |
| | Avanashi | 38-47 | 10 |
| | Coimbatore | 41-47 | 7 |
| | Mettupalayam | 39-50 | 12 |
| | Palladam | 41-47 | 7 |
| | Periyanaiakampalayam | 38-49 | 12 |
| | Pollachi | 24-31, 41-47 | 8, 7 |
| | Sulur | 41-46 | 6 |
| | Tiruppur | 38-47 | 10 |
| | Udumalaipettai | 41-48 | 8 |
| Erode | Bhavani | 34-47 | 14 |
| | Dharapuram | 40-47 | 8 |
| | Erode | 34-47 | 14 |
| | Gopichettipalayam | 35-47 | 13 |
| | Kangayam | 38-47 | 10 |
| | Kodumudi | 38-44 | 7 |
| | Perundurai | 35-47 | 13 |
| | Sathyamangalam | 35-47 | 13 |

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| Karur | Aravakkurichi | 39-46 | 8 |
| | Karur | 39-45 | 7 |
| Dindigul | Nilakottai | 36-47 | 12 |
| | Palani | 40-49 | 10 |
| Theni | Periakulam | 38-49 | 12 |
| | Uttamapalayam | 40-48 | 9 |
| Madurai | Usilampatti | 36-49 | 14 |

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| Tiruchchirapalli | Manaparai | 36-48 | 13 |

**4. Cauvery Delta Zone**

| District | Station | G period Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| Thanjavur | Atirampattinam | 34-52 | 19 |
| | Kattuumvadi | 39-51 | 13 |
| | Kumbakonam | 34-52 | 19 |
| | Papanasam | 35-52 | 18 |
| | Pattukottai | 35-52 | 18 |
| | Thanjavur | 35-51 | 17 |
| | Tirukkatupalli | 35-49 | 15 |
| | Vallam | 33-50 | 18 |
| Thiruvarur | Kudavasal | 35-52,1 | 19 |
| | Mannargudi | 34-52,1 | 20 |
| | Muttupet | 35-52,1,2 | 20 |
| | Nannilam | 35-52,1 | 19 |
| | Neidavasal | 35-52,1,2 | 20 |
| | Nidamangalam | 35-52,1 | 19 |
| | Thiruvaiyaru | 35-50 | 16 |
| | Thiruvarur | 35-52,1,2 | 20 |
| | Tirutturaippundi | 35-52,1,2 | 20 |
| | Valangiman | 35-52 | 18 |
| Nagapattinam | Mayuram | 35-52,1 | 19 |
| | Nagapattinam | 37-52,1,2 | 18 |
| | Sirkazhi | 34-52,1,2 | 21 |
| | Tarangambadi | 35-52,1,2 | 20 |
| | Tiruppundi | 36-52,1,2,3 | 20 |
| | Vedaranniyam | 35-52,1,2,3 | 21 |
| Tiruchchirapalli | Kulattur | 36-48 | 13 |
| | Kulittalai | 38-47 | 10 |
| | Lalgudi | 38-49 | 12 |
| | Manapparai | 36-48 | 13 |
| | Musiri | 38-47 | 10 |
| | Tattayyangarpettai | 36-47 | 12 |
| | Tiruchchirapalli | 36-48 | 13 |
| Perambalur | Turaiyur | 36-47 | 12 |
| Cuddalore | Chidambaram | 33-52,1,2 | 22 |
| | Kattumannarkovil | 33-52,1 | 21 |
| Pudukkottai | Arantangi | 34-50 | 17 |

**5. Southern Zone**

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| Ramanathapuram | Kamudi | 41-47 | 7 |
| | Mudukulattur | 41-49 | 9 |
| | Pamban | 42-52,1 | 12 |
| | Paramakudi | 40-48 | 9 |
| | Ramanathapuram | 41-52 | 12 |
| | Theethanathanam | 41-51 | 11 |
| | Tiruvadanai | 41-50 | 10 |
| | Vattaram | 41-51 | 11 |
| Virudunagar | Arupukottai | 39-48 | 10 |
| | Sattur | 41-48 | 8 |
| | Sivakasi | 41-48 | 8 |
| | Srivilliputtur | 41-49 | 9 |
| | Virudunagar | 38-48 | 11 |
| | Watrap | 39-50 | 12 |
| Tuticorin | Arasadi | 43-49 | 7 |
| | Kayattur | 41-49 | 9 |
| | Kovilpatti | 41-49 | 9 |
| | Kulasekarapatnam | 42-52 | 11 |
| | Morekulam | 42-51 | 10 |
| | Ottappidaram | 41-48 | 8 |
| | Sattankulam | 42-50 | 9 |
| | Srivaikuntam | 42-50 | 9 |
| | Tiruchchendur | 42-52 | 11 |
| | Tuticorin | 43-50 | 8 |
| Tirunelveli | Ambasamudram | 42-52,1 | 12 |
| | Ayikudi | 42-51 | 10 |
| | Kadaiyam | 42-52,1 | 12 |
| | Kadaiyanallur | 42-51 | 10 |
| | Kirnurnam | 43-51 | 9 |
| | Nanguneri | 42-51 | 10 |
| | Palayamkottai | 42-50 | 9 |
| | Radhapuram | 42-49 | 8 |
| | Sankarankovil | 41-49 | 9 |
| | Shencottah | 41-51 | 11 |
| | Sivagiri | 41-52 | 12 |
| | Tenkasi | 41-52 | 12 |
| | Tirunelveli | 42-51 | 10 |
| Sivaganga | Manamadurai | 39-48 | 10 |
| | Sivaganga | 35-48 | 14 |
| | Tirupattur | 33-48 | 16 |
| Madurai | Cholavandan | 36-48 | 13 |

| | | | |
|---|---|---|---|
| | Madurai | 34-48 | 15 |
| | Melur | 33-49 | 17 |
| | Nattam | 33-49 | 17 |
| | Peraiyur | 36-49 | 14 |
| | Tirumangalam | 34-49 | 16 |
| Pudukkottai | Adanakottai | 37-49 | 13 |
| | Alangudi | 36-50 | 15 |
| | Annavasal | 36-47 | 12 |
| | Ilupur | 36-48 | 13 |
| | Karambakkudi | 38-50 | 13 |
| | Kilanilai | 38-49 | 12 |
| | Marungapuri | 35-49 | 15 |
| | Ponnamaravati | 34-48 | 15 |
| | Pudukkottai | 35-49 | 15 |
| | Tirumayam | 36-48 | 13 |
| | Udyalipatti | 37-47 | 11 |
| | Viralimalai | 38-48 | 11 |
| Dindigul | Chattrapatti | 38-50 | 13 |
| | Dindigul | 36-49 | 14 |
| | Vedasunthur | 38-48 | 11 |
| Theni | Bodinayakanur | 39-48 | 10 |

**6. High Rainfall Zone**

| District | Station | G period (Met. Standard week) | No. of G period (No. of weeks) |
|---|---|---|---|
| Kanyakumari | Aramboli | 41-49 | 9 |
| | Eranial | 19-29, 39-48 | 11, 10 |
| | Kalial | 14-50 | 37 |
| | Kolachel | 21-30, 40-48 | 10, 9 |
| | Kottaram | 42-48 | 7 |
| | Kulasegraram | 12-50 | 39 |
| | Kuzhitturai | 15-48 | 34 |
| | Meycode adanadi | 15-49 | 35 |
| | Mulakumood | 15-31, 40-49 | 17, 10 |
| | Nagerkoil | 20-26, 40-48 | 7, 9 |
| | P.P. Channel | 16-29, 40-50 | 14, 11 |
| | Pechiaprai | 13-50 | 38 |
| | Puthendam | 13-50 | 38 |
| | Rajakkammangalam | 19-27, 40-48 | 9, 9 |
| | Seetapal | 19-26, 40-48 | 8, 9 |
| | Shorlakode | 18-25, 36-47 | 8, 12 |
| | Thadikarekonam | 14-49 | 36 |
| | Thamaraikulam | 42-47 | 6 |
| The Nilgiris | Devala | 17-50 | 34 |
| | Glen Morgan | 16-50 | 35 |

| | | | |
|---|---|---|---|
| | Gudalur | 17-49 | 33 |
| | Kallatty | 17-51 | 35 |
| | Ketty | 18-52,1 | 36 |
| | Kodanadu | 18-52,1,2 | 37 |
| | Kotagiri | 14-52,1-3 | 40 |
| | Kundha (Kailkund) | 21-52,1 | 33 |
| | Naduvattam | 16-49 | 34 |
| | Ootacamund | 16-51 | 36 |
| Coimbatore | Anaimalai | 32-52,1 | 22 |
| Dindigul | Kodaikanal | 32-52,1 | 22 |
| Salem | Yercaud | 34-50 | 17 |

**2. Climate of Tamil Nadu**

**South West Monsoon**

| Arid | Semi arid | Humid |
|---|---|---|
| (MI = (-) 66.7 to (-) 100) | (MI = (-) 66.7 to (-) 33.3) | (MI = 20 to 80) |
| Coimbatore, Erode, Tiruchirapalli, Karur, Perambalur, Madurai, Theni, Dindugal, Ramanathapuram, Sivagangai,Viruudunagar, Tirunelveli, Tuticorin | Kanchipuram, Thrivallur Cuddalore, Villupuram Dharmapuri , Krishnagiri Salem ,Namakal Pudukottai Thanjavur ,Nagai & Thiruvarur Kanyakumari Velore, Thiruvannamalai | **The Nilgiris** |

**North East Monsoon**

| Dry sub humid MI= (-) 33 to 0 | Moist sub humid MI= 0 to 20 | Per humid MI=100 and above. |
|---|---|---|
| Coimbatore, Erode, Dharmapuri, Krishnagiri. Salem, Namakal | Triuchirapalli, Karur, Perambalur, Pudukottai, Madurai, Theni, Dindugal, Sivagangai, Vridunagar, Ramanathapuram, Kanchipuram, Thiruvallur, Vellore, Tiruvannamalai, Cuddalore,Villupuram, Thanjavur, Nagai, Thiruvarur, Kanyakumari, Thirunelveli, Tuticorin | The Nilgiris |

## 3. Rain fall pattern in Tamil Nadu

The rainfall pattern of Tamil Nadu based on the criteria of rainfall quantity and Seasons of precipitation is given below: (NCA, 1976)

A = > 30 cm rainfall per month
B = 30-20 cm rainfall per month
C = 20-10 cm rainfall per month
D = 10-5 cm rainfall per month
E = < 5 cm rainfall per month

Three distinct seasons have been considered

Pre monsoon season :
February to May Monsoon season :
June to September Post monsoon season :
October to January

Considering the distribution of rainfall within a season, a standard pattern is developed.

**This is explained through the following example**

$$A_2\ B_2\ (C_1\ B_1\ A_1\ E_1)\ C_2\ D_1\ E_1$$

Where in,

i) Alphabets in bracket denote rainfall in monsoon season months.
ii) Left to bracket denotes rainfall in pre-monsoon months.
iii) Right to bracket denotes rainfall in post monsoon months.
iv) Numerical suffix gives the number of months.

**Rainfall pattern in Tamil Nadu**

| **Rainfall** | **Taluks in which the pattern is seen** |
|---|---|
| $E_4\ (E_4)\ C_2\ E_2$ | Aruppukottai, Paramakudi, Muthukulathur, Thiruvadanai, Sathur, Srivilliputhur, Kovilpatti, Vilathikulam, Sankarankovil, Thoothukudi, Srivaikuntam, Udumalpet, Coimbatore, Dharapuram, Palladam, Gobichettipalayam, Bhavani, Erode, Avinashi, Uthamapalayam, Palani, Kodaikanal, Vedasandur, Dindugul, Nilakottai, Usilampatti, Thirumangalam, Periakulam, Karur |
| $E_4\ (E_4)\ B_1\ C_2\ E_1$ | Tiruchendur, Nanguneri, Tirunelveli, Ambasamudram, Ramanathapuram $E_4\ (E_4)\ A_1\ B_2\ E_1$ Nagapattinam, Thiruthuraipoondi, Lalgudi, Musiri |

| | |
|---|---|
| $E_4 (C_1 E_3) C_2 E_2$ | Thuraiyur, Kulithalai, Tiruchirappalli, Manapparai, Pollachi, Agastheswaram |
| $E_4 (C_1 E_3) A_1B_1 C_1 E_1$ | Mayavaram, Nannilam |
| $E_4 (C_2 E_2) C_1 E_3$ | Vaniyambadi, Thirupathur, Uthankarai, Thirukoilur, Kallakurichi, Perambalur, Kulathur, Alangudi, Thirumayam, Harur, Athur, Thanjavur, Aranthangi, Arakkonam, Walajapet, Cheyyar, Arani, Polur, Chengam, Thiruvannamalai,,Gudiyatham, Vellore, Thiruthani, Madurai North, Madurai South, Melur, Thirupathur, Sivaganga, Chengam, Wandavasi. |
| $E_4 (C_2 E_2) B_1C_2 E_1$ | Virudhachalam, Ariyalur, Udayarpalayam, Kumbakonam, Papanasam, Mannargudi, Pattukottai, Orathanadu, Tenkasi, Shencottai, Thiruvallur, Sriperumpudur, Kanchipuram, Chengalpattu, Maduranthagam, Tindivanam, Villupuram. |
| $E_4 (C_2 E_2) A_1 B_1C_1 E_1$ | Ponneri, Saidapet, Chidambaram, Sirkazhi. $C_1 E_3(C_1 E_3) C_1 E_3$ Hosur, Denkanikottai, |
| $C_1 E_3(C_2 E_2) C_1 E_3$ | Omalur, Krishnagiri, Dharmapuri, Mettur, Salem, Rasipuram, Sangagiri, Thiruchengodu, Namakkal |

**4. Pre monsoon sowing**

Based on the probability of receiving sowing rains, pre monsoon dry seeding weeks have been identified for the different districts of Tamil Nadu, which is feasible in Vertisols.

| Name of the Districts | Sowing STD week | Dates |
|---|---|---|
| 1. Coimbatore & Erode | 37 to 38 | Sep 10 to 23 |
| 2. Dharmapuri | 38 to 39 | Sep 17 to 30 |
| 3. Vellore | 36 to 37 | Sep 3 to 16 |
| 4. Ramanathapuram | 40 to 41 | Oct 1 to 14 |
| 5. Thoothukudi | 39 to 40 | Sep 24 to Oct 7 |
| 6. Thrinelveli | 39 to 40 | Sep 24 to Oct 7 |
| 7. Virudhunagar | 38 to 39 | Sep 17 to 30 |

**5. Water balance study**

Water balance study was conducted for Tamil Nadu based on the Water Requirement Satisfaction Index (WRSI). It is suggested that sorghum can be sown during $36^{th}$ Std week against $16^{th}$ Std week. The data from the Table indicate that if it is sown during $16^{th}$ Std week, the crop may suffer with soil moisture stress. This result is valid for sorghum crop for Manapparai Taluk sowing by $36^{th}$ standard week is recommended.

**Manapparai - Sorghum crop**

| Manapparai (16th week sowing) | | | Manapparai (36th week sowing) | | |
|---|---|---|---|---|---|
| STD week | Date | WRSI | STD week | Date | WRSI |
| 16 | April 16 - 22 | 100.00 | 36 | Sep 3 - 9 | 100 |
| 17 | April 23 - 29 | 100.00 | 37 | Sep 10 - 16 | 100 |
| 18 | April 30-May 6 | 97.78 | 38 | Sep 17 - 23 | 100 |
| 19 | May 7 - 13 | 95.81 | 39 | Sep 24 - 30 | 100 |
| 20 | May 14 - 20 | 92.11 | 40 | Oct 1 - 7 | 100 |
| 21 | May 21 - 27 | 87.59 | 41 | Oct 8 - 14 | 100 |
| 22 | May 28 -Jun 3 | 81.80 | 42 | Oct 15 - 21 | 100 |
| 23 | June 4 - 10 | 74.58 | 43 | Oct 22 - 28 | 100 |
| 24 | June 11 - 17 | 66.13 | 44 | Oct 29 - Nov 4 | 100 |
| 25 | June 18 - 24 | 54.06 | 45 | Nov 5 - 11 | 100 |
| 26 | June 25-July 1 | 48.29 | 46 | Nov 12 - 18 | 100 |
| 27 | July 2 - 8 | 43.93 | 47 | Nov 19 - 25 | 100 |
| 28 | July 9 - 15 | 43.93 | 48 | Nov 26 - Dec 2 | 100 |

Simila study was undertaken for Namakkal Taluk for Groundnut sowing:

The result indicates that, rainfed groundnut sowing can be taken in the order of 28th Std week, 26th Std week, 23rd Std week.

Further studies were made from water balance for rainfed crops of Virudhunagar district and the information are presented in the Table *

| District | Location | Crop | Soil | Sowing week (MSW) | Final harvest (MSW) | Moisture stress period(MSW) |
|---|---|---|---|---|---|---|
| Virudhunagar | Aruppukottai | Cotton | Black | 36 | 4 | 1 to 4 |
| Virudhunagar | Rajapalayam | Cotton | Black | 36 | 4 | 3 to 4 |
| Virudhunagar | Sattur | Cotton | Black | 36 | 4 | 1 to 4 |
| Virudhunagar | Srivilliputtur | Cotton | Black | 36 | 4 | 2 to 4 |
| Virudhunagar | Tiruchuli | Cotton | Black | 36 | 4 | 1 to 4 |
| Virudhunagar | Virudhunagar | Cotton | Black | 36 | 4 | 1 to 4 |
| Virudhunagar | Aruppukottai | Cotton | Black | 37 | 5 | 1 to 5 |
| Virudhunagar | Rajapalayam | Cotton | Black | 37 | 5 | 2 to 5 |
| Virudhunagar | Sattur | Cotton | Black | 37 | 5 | 1 to 5 |
| Virudhunagar | Srivilliputtur | Cotton | Black | 37 | 5 | 2 to 5 |
| Virudhunagar | Tiruchuli | Cotton | Black | 37 | 5 | 51to 5 |
| Virudhunagar | Virudhunagar | Cotton | Black | 37 | 5 | 2 to 5 |
| Virudhunagar | Aruppukottai | Cotton | Black | 38 | 6 | 1 to6 |
| Virudhunagar | Rajapalayam | Cotton | Black | 38 | 6 | 2 to 6 |
| Virudhunagar | Sattur | Cotton | Black | 38 | 6 | 1 to 6 |
| Virudhunagar | Srivilliputtur | Cotton | Black | 38 | 6 | 2 to 6 |
| Virudhunagar | Tiruchuli | Cotton | Black | 38 | 6 | 51to 6 |
| Virudhunagar | Virudhunagar | Cotton | Black | 38 | 6 | 1 to 6 |
| Virudhunagar | Aruppukottai | Cotton | Black | 39 | 7 | 1 to 7 |
| Virudhunagar | Rajapalayam | Cotton | Black | 39 | 7 | 2 to 7 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Virudhunagar | Sattur | Cotton | Black | 39 | 7 | 1 to 7 |
| Virudhunagar | Srivilliputtur | Cotton | Black | 39 | 7 | 2 to 7 |
| Virudhunagar | Tiruchuli | Cotton | Black | 39 | 7 | 1 to 7 |
| Virudhunagar | Virudhunagar | Cotton | Black | 39 | 7 | 1 to 7 |
| Virudhunagar | Aruppukottai | Cotton | Red | 36 | 4 | 49 to 4 |
| Virudhunagar | Rajapalayam | Cotton | Red | 36 | 4 | 51 to 4 |
| Virudhunagar | Sattur | Cotton | Red | 36 | 4 | 52 to 4 |
| Virudhunagar | Srivilliputtur | Cotton | Red | 36 | 4 | 50 to 4 |
| Virudhunagar | Tiruchuli | Cotton | Red | 36 | 4 | 49 to 4 |
| Virudhunagar | Virudhunagar | Cotton | Red | 36 | 4 | 51 to 4 |
| Virudhunagar | Aruppukottai | Cotton | Red | 37 | 5 | 50 to 5 |
| Virudhunagar | Rajapalayam | Cotton | Red | 37 | 5 | 51 to 5 |
| Virudhunagar | Sattur | Cotton | Red | 37 | 5 | 50 to 5 |
| Virudhunagar | Srivilliputtur | Cotton | Red | 37 | 5 | 50 to 5 |
| Virudhunagar | Tiruchuli | Cotton | Red | 37 | 5 | 49 to 5 |
| Virudhunagar | Virudhunagar | Cotton | Red | 37 | 5 | 51 to 5 |
| Virudhunagar | Aruppukottai | Cotton | Red | 38 | 6 | 50 to 6 |
| Virudhunagar | Rajapalayam | Cotton | Red | 38 | 6 | 51 to 6 |
| Virudhunagar | Sattur | Cotton | Red | 38 | 6 | 50 to 6 |
| Virudhunagar | Srivilliputtur | Cotton | Red | 38 | 6 | 51 to 6 |
| Virudhunagar | Tiruchuli | Cotton | Red | 38 | 6 | 49 to 6 |
| Virudhunagar | Virudhunagar | Cotton | Red | 38 | 6 | 50 to 6 |
| Virudhunagar | Aruppukottai | Cotton | Red | 39 | 7 | 51 to 7 |
| Virudhunagar | Rajapalayam | Cotton | Red | 39 | 7 | 51 to 7 |
| Virudhunagar | Sattur | Cotton | Red | 39 | 7 | 51 to 7 |
| Virudhunagar | Srivilliputtur | Cotton | Red | 39 | 7 | 51 to 7 |
| Virudhunagar | Tiruchuli | Cotton | Red | 39 | 7 | 50 to 7 |
| Virudhunagar | Virudhunagar | Cotton | Red | 39 | 7 | 50 to 7 |
| Virudhunagar | Aruppukottai | Pulses | Black | 36 | 48 | - |
| Virudhunagar | Rajapalayam | Pulses | Black | 36 | 48 | - |
| Virudhunagar | Sattur | Pulses | Black | 36 | 48 | - |
| Virudhunagar | Srivilliputtur | Pulses | Black | 36 | 48 | - |
| Virudhunagar | Tiruchuli | Pulses | Black | 36 | 48 | - |
| Virudhunagar | Virudhunagar | Pulses | Black | 36 | 48 | - |
| Virudhunagar | Aruppukottai | Pulses | Black | 37 | 49 | - |
| Virudhunagar | Rajapalayam | Pulses | Black | 37 | 49 | - |
| Virudhunagar | Sattur | Pulses | Black | 37 | 49 | - |
| Virudhunagar | Srivilliputtur | Pulses | Black | 37 | 49 | - |
| Virudhunagar | Tiruchuli | Pulses | Black | 37 | 49 | - |
| Virudhunagar | Virudhunagar | Pulses | Black | 37 | 49 | - |
| Virudhunagar | Aruppukottai | Pulses | Black | 38 | 50 | - |
| Virudhunagar | Rajapalayam | Pulses | Black | 38 | 50 | - |
| Virudhunagar | Sattur | Pulses | Black | 38 | 50 | - |
| Virudhunagar | Srivilliputtur | Pulses | Black | 38 | 50 | - |
| Virudhunagar | Tiruchuli | Pulses | Black | 38 | 50 | - |
| Virudhunagar | Virudhunagar | Pulses | Black | 38 | 50 | - |
| Virudhunagar | Aruppukottai | Pulses | Black | 39 | 51 | - |
| Virudhunagar | Rajapalayam | Pulses | Black | 39 | 51 | - |
| Virudhunagar | Sattur | Pulses | Black | 39 | 51 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Virudhunagar | Srivilliputtur | Pulses | Black | 39 | 51 | - |
| Virudhunagar | Tiruchuli | Pulses | Black | 39 | 51 | - |
| Virudhunagar | Virudhunagar | Pulses | Black | 39 | 51 | - |
| Virudhunagar | Aruppukottai | Pulses | Red | 36 | 48 | - |
| Virudhunagar | Rajapalayam | Pulses | Red | 36 | 48 | - |
| Virudhunagar | Sattur | Pulses | Red | 36 | 48 | - |
| Virudhunagar | Srivilliputtur | Pulses | Red | 36 | 48 | - |
| Virudhunagar | Tiruchuli | Pulses | Red | 36 | 48 | - |
| Virudhunagar | Virudhunagar | Pulses | Red | 36 | 48 | - |
| Virudhunagar | Aruppukottai | Pulses | Red | 37 | 49 | - |
| Virudhunagar | Rajapalayam | Pulses | Red | 37 | 49 | - |
| Virudhunagar | Sattur | Pulses | Red | 37 | 49 | - |
| Virudhunagar | Srivilliputtur | Pulses | Red | 37 | 49 | - |
| Virudhunagar | Tiruchuli | Pulses | Red | 37 | 49 | - |
| Virudhunagar | Virudhunagar | Pulses | Red | 37 | 49 | - |
| Virudhunagar | Aruppukottai | Pulses | Red | 39 | 51 | - |
| Virudhunagar | Rajapalayam | Pulses | Red | 39 | 51 | - |
| Virudhunagar | Sattur | Pulses | Red | 39 | 51 | - |
| Virudhunagar | Srivilliputtur | Pulses | Red | 39 | 51 | - |
| Virudhunagar | Tiruchuli | Pulses | Red | 39 | 51 | - |
| Virudhunagar | Virudhunagar | Pulses | Red | 39 | 51 | - |
| Virudhunagar | Aruppukottai | Redgram | Black | 36 | 01 | - |
| Virudhunagar | Rajapalayam | Redgram | Black | 36 | 01 | - |
| Virudhunagar | Sattur | Redgram | Black | 36 | 01 | - |
| Virudhunagar | Srivilliputtur | Redgram | Black | 36 | 01 | - |
| Virudhunagar | Tiruchuli | Redgram | Black | 36 | 01 | - |
| Virudhunagar | Virudhunagar | Redgram | Black | 36 | 01 | - |
| Virudhunagar | Aruppukottai | Redgram | Black | 37 | 02 | - |
| Virudhunagar | Rajapalayam | Redgram | Black | 37 | 02 | - |
| Virudhunagar | Sattur | Redgram | Black | 37 | 02 | - |
| Virudhunagar | Srivilliputtur | Redgram | Black | 37 | 02 | - |
| Virudhunagar | Tiruchuli | Redgram | Black | 37 | 02 | - |
| Virudhunagar | Virudhunagar | Redgram | Black | 37 | 02 | - |
| Virudhunagar | Aruppukottai | Redgram | Black | 38 | 03 | - |
| Virudhunagar | Rajapalayam | Redgram | Black | 38 | 03 | - |
| Virudhunagar | Sattur | Redgram | Black | 38 | 03 | 03 |
| Virudhunagar | Srivilliputtur | Redgram | Black | 38 | 03 | - |
| Virudhunagar | Tiruchuli | Redgram | Black | 38 | 03 | - |
| Virudhunagar | Virudhunagar | Redgram | Black | 38 | 03 | - |
| Virudhunagar | Aruppukottai | Redgram | Red | 36 | 01 | - |
| Virudhunagar | Rajapalayam | Redgram | Red | 36 | 01 | - |
| Virudhunagar | Sattur | Redgram | Red | 36 | 01 | - |
| Virudhunagar | Srivilliputtur | Redgram | Red | 36 | 01 | - |
| Virudhunagar | Tiruchuli | Redgram | Red | 36 | 01 | - |
| Virudhunagar | Virudhunagar | Redgram | Red | 36 | 01 | - |
| Virudhunagar | Aruppukottai | Redgram | Red | 37 | 02 | - |
| Virudhunagar | Rajapalayam | Redgram | Red | 37 | 02 | - |
| Virudhunagar | Sattur | Redgram | Red | 37 | 02 | 02 |
| Virudhunagar | Srivilliputtur | Redgram | Red | 37 | 02 | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Virudhunagar | Tiruchuli | Redgram | Red | 37 | 02 | 02 |
| Virudhunagar | Virudhunagar | Redgram | Red | 37 | 02 | 01 to 02 |
| Virudhunagar | Aruppukottai | Redgram | Red | 38 | 03 | 02 to 03 |
| Virudhunagar | Rajapalayam | Redgram | Red | 38 | 03 | 03 |
| Virudhunagar | Sattur | Redgram | Red | 38 | 03 | 01 to 03 |
| Virudhunagar | Srivilliputtur | Redgram | Red | 38 | 03 | 03 |
| Virudhunagar | Tiruchuli | Redgram | Red | 38 | 03 | 01 to 03 |
| Virudhunagar | Virudhunagar | Redgram | Red | 38 | 03 | 01 to 03 |
| Virudhunagar | Aruppukottai | Sorghum | Black | 36 | 52 | 48 to 52 |
| Virudhunagar | Rajapalayam | Sorghum | Black | 36 | 52 | - |
| Virudhunagar | Sattur | Sorghum | Black | 36 | 52 | 49 to 52 |
| Virudhunagar | Srivilliputtur | Sorghum | Black | 36 | 52 | - |
| Virudhunagar | Tiruchuli | Sorghum | Black | 36 | 52 | 48 to 52 |
| Virudhunagar | Virudhunagar | Sorghum | Black | 36 | 52 | 49 to 52 |
| Virudhunagar | Aruppukottai | Sorghum | Black | 37 | 01 | 49 to 01 |
| Virudhunagar | Rajapalayam | Sorghum | Black | 37 | 01 | - |
| Virudhunagar | Sattur | Sorghum | Black | 37 | 01 | 50 to 01 |
| Virudhunagar | Srivilliputtur | Sorghum | Black | 37 | 01 | - |
| Virudhunagar | Tiruchuli | Sorghum | Black | 37 | 01 | 49 to 01 |
| Virudhunagar | Virudhunagar | Sorghum | Black | 37 | 01 | 50 to 01 |
| Virudhunagar | Aruppukottai | Sorghum | Black | 38 | 02 | 50 to 02 |
| Virudhunagar | Rajapalayam | Sorghum | Black | 38 | 02 | - |
| Virudhunagar | Sattur | Sorghum | Black | 38 | 02 | 51 to 02 |
| Virudhunagar | Srivilliputtur | Sorghum | Black | 38 | 02 | 02 |
| Virudhunagar | Tiruchuli | Sorghum | Black | 38 | 02 | 49 to 02 |
| Virudhunagar | Virudhunagar | Sorghum | Black | 38 | 02 | 51 to 02 |
| Virudhunagar | Aruppukottai | Sorghum | Black | 39 | 03 | 52 to 03 |
| Virudhunagar | Rajapalayam | Sorghum | Black | 39 | 03 | 01 to 03 |
| Virudhunagar | Sattur | Sorghum | Black | 39 | 03 | 51 to 03 |
| Virudhunagar | Srivilliputtur | Sorghum | Black | 39 | 03 | 02 to 03 |
| Virudhunagar | Tiruchuli | Sorghum | Black | 39 | 03 | 50 to 03 |
| Virudhunagar | Virudhunagar | Sorghum | Black | 39 | 03 | 51 to 03 |
| Virudhunagar | Aruppukottai | Sorghum | Red | 36 | 52 | 48 to 52 |
| Virudhunagar | Rajapalayam | Sorghum | Red | 36 | 52 | - |
| Virudhunagar | Sattur | Sorghum | Red | 36 | 52 | 49 to 52 |
| Virudhunagar | Srivilliputtur | Sorghum | Red | 36 | 52 | - |
| Virudhunagar | Tiruchuli | Sorghum | Red | 36 | 52 | 48 to 52 |
| Virudhunagar | Virudhunagar | Sorghum | Red | 36 | 52 | 49 to 52 |
| Virudhunagar | Aruppukottai | Sorghum | Red | 37 | 01 | 49 to 01 |
| Virudhunagar | Rajapalayam | Sorghum | Red | 37 | 01 | 51 to 01 |
| Virudhunagar | Sattur | Sorghum | Red | 37 | 01 | 50 to 01 |
| Virudhunagar | Srivilliputtur | Sorghum | Red | 37 | 01 | 52 to 01 |
| Virudhunagar | Tiruchuli | Sorghum | Red | 37 | 01 | 49 to 01 |
| Virudhunagar | Virudhunagar | Sorghum | Red | 37 | 01 | 49 to 01 |
| Virudhunagar | Aruppukottai | Sorghum | Red | 38 | 02 | 49 to 02 |
| Virudhunagar | Rajapalayam | Sorghum | Red | 38 | 02 | 51 to 02 |
| Virudhunagar | Sattur | Sorghum | Red | 38 | 02 | 50 to 02 |
| Virudhunagar | Srivilliputtur | Sorghum | Red | 38 | 02 | 51 to 02 |
| Virudhunagar | Tiruchuli | Sorghum | Red | 38 | 02 | 49 to 02 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Virudhunagar | Virudhunagar | Sorghum | Red | 38 | 02 | 49 to02 |
| Virudhunagar | Aruppukottai | Sorghum | Red | 39 | 03 | 50 to 03 |
| Virudhunagar | Rajapalayam | Sorghum | Red | 39 | 03 | 51 to 03 |
| Virudhunagar | Sattur | Sorghum | Red | 39 | 03 | 50 to 03 |
| Virudhunagar | Srivilliputtur | Sorghum | Red | 39 | 03 | 51 to 03 |
| Virudhunagar | Tiruchuli | Sorghum | Red | 39 | 03 | 49 to 03 |
| Virudhunagar | Virudhunagar | Sorghum | Red | 39 | 03 | 49 to 03 |
| Virudhunagar | Aruppukottai | Sunflower | Black | 43 | 03 | - |
| Virudhunagar | Rajapalayam | Sunflower | Black | 43 | 03 | - |
| Virudhunagar | Sattur | Sunflower | Black | 43 | 03 | 02 to 03 |
| Virudhunagar | Srivilliputtur | Sunflower | Black | 43 | 03 | - |
| Virudhunagar | Tiruchuli | Sunflower | Black | 43 | 03 | 02 to 03 |
| Virudhunagar | Virudhunagar | Sunflower | Black | 43 | 03 | 02 to 03 |
| Virudhunagar | Aruppukottai | Sunflower | Black | 44 | 04 | 02 to 04 |
| Virudhunagar | Rajapalayam | Sunflower | Black | 44 | 04 | 04 |
| Virudhunagar | Sattur | Sunflower | Black | 44 | 04 | 02 to 04 |
| Virudhunagar | Srivilliputtur | Sunflower | Black | 44 | 04 | 04 |
| Virudhunagar | Tiruchuli | Sunflower | Black | 44 | 04 | 01 to 04 |
| Virudhunagar | Virudhunagar | Sunflower | Black | 44 | 04 | 02 to 04 |
| Virudhunagar | Aruppukottai | Sunflower | Red | 43 | 03 | 52 to 03 |
| Virudhunagar | Rajapalayam | Sunflower | Red | 43 | 03 | 01 to 03 |
| Virudhunagar | Sattur | Sunflower | Red | 43 | 03 | 52 to 03 |
| Virudhunagar | Srivilliputtur | Sunflower | Red | 43 | 03 | 01 to 03 |
| Virudhunagar | Tiruchuli | Sunflower | Red | 43 | 03 | 51 to 03 |
| Virudhunagar | Virudhunagar | Sunflower | Red | 43 | 03 | 52 to 03 |
| Virudhunagar | Aruppukottai | Sunflower | Red | 44 | 04 | 01 to 04 |
| Virudhunagar | Rajapalayam | Sunflower | Red | 44 | 04 | 01 to 04 |
| Virudhunagar | Sattur | Sunflower | Red | 44 | 04 | 52 to 04 |
| Virudhunagar | Srivilliputtur | Sunflower | Red | 44 | 04 | 01 to 04 |
| Virudhunagar | Tiruchuli | Sunflower | Red | 44 | 04 | 51 to 04 |
| Virudhunagar | Virudhunagar | Sunflower | Red | 44 | 04 | 52 to 04 |
| Virudhunagar | Aruppukottai | Groundnut | Red | 26 | 41 | 33 to 41 |
| Virudhunagar | Rajapalayam | Groundnut | Red | 26 | 41 | 31 to 41 |
| Virudhunagar | Sattur | Groundnut | Red | 26 | 41 | 30 to 41 |
| Virudhunagar | Srivilliputtur | Groundnut | Red | 26 | 41 | 29 to 41 |
| Virudhunagar | Tiruchuli | Groundnut | Red | 26 | 41 | 32 to 41 |
| Virudhunagar | Virudhunagar | Groundnut | Red | 26 | 41 | 30 to 41 |
| Virudhunagar | Aruppukottai | Groundnut | Red | 27 | 42 | 33 to 42 |
| Virudhunagar | Rajapalayam | Groundnut | Red | 27 | 42 | 31 to 42 |
| Virudhunagar | Sattur | Groundnut | Red | 27 | 42 | 31 to 42 |
| Virudhunagar | Srivilliputtur | Groundnut | Red | 27 | 42 | 31 to 42 |
| Virudhunagar | Tiruchuli | Groundnut | Red | 27 | 42 | 32 to 42 |
| Virudhunagar | Virudhunagar | Groundnut | Red | 27 | 42 | 32 to 42 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Virudhunagar | Aruppukottai | Groundnut | Red | 28 | 43 | 33 to 43 |
| Virudhunagar | Rajapalayam | Groundnut | Red | 28 | 43 | 31 to 43 |
| Virudhunagar | Sattur | Groundnut | Red | 28 | 43 | 32 to 43 |
| Virudhunagar | Srivilliputtur | Groundnut | Red | 28 | 43 | 32 to 43 |
| Virudhunagar | Tiruchuli | Groundnut | Red | 28 | 43 | 33 to 43 |
| Virudhunagar | Virudhunagar | Groundnut | Red | 28 | 43 | 33 to 43 |

* Note: During moisture stress period suitable agro- techniques may be adopted. If moisture stress period is long concerned sowing week may not be viable.

**6. Weather Based Management Technologies**

**i) Nutrient management for *thaladi* season rice**

Application of 200:75:75kg NPK/ha for November 15$^{th}$ transplanted crop (Co45 or Co43) under split application of N at 40, 20, 20 and 20% respectively during basal, active tillering, panicle initiation and flowering while 75 percent P and K as basal and 12.5 percent P and K as foliar spray twice at panicle initiation and flowering stages.

**ii) Acceptable *insitu* moisture conservation practice for rainfed groundnut – sunflower and maize**

During South West monsoon season groundnut sowing along the contour and ridging to be done three weeks after sowing. During NEM, especially for sunflower, the same technology of contour sowing followed by ridging three weeks latter can be adopted. In respect of maize, sowing and tieing alternate furrows with mulching of locally available material can be practiced.

**iii) Sustainable dryland management for hybrid maize (UMH 28)**

Sowing of dry land hybrid maize at 38$^{th}$ meteorological standard week (17$^{th}$ – 23 Sept.) with modified crop production recommendation based on medium range weather forecast is suggested.

**iv) Time of sowing and nutrient level for sorghum under different rainfall situations in dryland (black soil) of western agro climate zone of Tamil Nadu**

Sowing of sorghum variety CSV15 before the receipt of monsoon rainfall (Premonsoon sowing) is recommended with 60:30:0 kg NPK / ha during above average rainfall year and 40:20:0 Kg NPK / ha during below average rainfall year. The result is applicable when seasonal climate forecast information is available in advance.

**v) Technical feasibility of introducing new irrigated cropping system of Greengram – Maize – Sunflower against the outdated cropping system of Cotton – Sorghum – Finger millet of western agro climatic zone of Tamil Nadu**

Sowing of crops at normal sowing of concerned crops viz.; 33 Meteorological Standard Week (MSW) for (Aug 13-19) greengram, 48$^{th}$ MSW (Nov 26-Dec2) for maize and 15$^{th}$ MSW (April 9-15) for sunflower with 100 percent inorganic source of recommended nutrients for green gram (12.5:50:0 kg NPK / ha) and sunflower (40:20:20 kg NPK/ ha) and 25% organic N alone and 75 percent inorganic source of nutrient recommended to maize (135:62.5: 50 kg NPK/ ha) for the new tailored cropping system of Greengram –Maize – Sunflower.

### vi) Potential season and sowing window for CoH3 Hybrid Maize under irrigated condition

Sowing of irrigated Maize hybrid CoH3 in the second fortnight of August during *Kharif* season with integrated application of both organics and inorganic at 50:50 either as blanket (135:625:50 kg NPK/ha) or as soil test based recommendation.

### vii) Potential transplanting window for hybrid rice

Planting hybrid rice CORH2 either on 26$^{th}$ September or at 3$^{rd}$ October as compared to planting in normal date of planting of 19$^{th}$ September which is recommended for planting rice variety especially for the variety ADT39.

### viii) Polyethylene film mulch for irrigated groundnut

Spreading of seven micron thickness black polyethylene film as mulch to irrigated groundnut along with pre-plant incorporation of fluchloralin @ 1.0 kg ai/ha under flat bed system.

### ix) Forewarning disease incidence in groundnut

Forewarning model was developed against late leaf spot and rust diseases in groundnut. The model was validated and the deviation is around 10 percent. The model was developed for both for Aliyarnagar (mountain climate) and Vridhachalam (Marine climate) domain.

## 7. Basic information

### i. Crop – weather studies

Rice grain yield of *Kuruvai* and *Thaladi* seasons over 30 years (1961 – 1990) were correlated with concerned weather data. Reproductive stage was very critical to prevalence weather parameters both for *Kuruvai* and *Thaladi* seasons. In addition maturity stage of *Kuruvai* and Vegetative stage of *thaladi* season were also critical to weather.

During *Thaladi* season, correlation study indicated the positive relationship for maximum temperature at vegetative and reproductive stages.

### ii. Management response to seasonal climate forecast in cropping system

Two locations viz. Avinashi and Thiruchengodu were considered for the study. Model to simulate the yield of crops (Groundnut, Cotton) was done.

The chance of achieving (65%) at least 1000 kg/ha of peanut occur, when the Southern Oscillation Index (SOI) phase is positive for April / May. Conversely there is only 32% chance of achieving such a yield in years when the SOI is falling. Similar analysis was conducted for cotton and economic performance of both systems was compared on gross margin basis. Results indicate that in positive SOI years, peanuts out performed in cotton in 70 percent of years, but income difference can still range from Rs.(-)15,000 to (+) 15,000 / ha. However under falling SOI conditions peanut only had minor advantage in 40% of years (up to Rs.3,800/ ha).

**iii. Seasonal rainfall Vs El-Nino**

Analyses of long term average of Southwest monsoon rainfall during El-Nino years revealed that during El-Nino years, the amount of rainfall found decreased in all the locations of Tamil Nadu as compared to normal rainfall of this season, except Northeastern parts of Tamil Nadu. Analyses of long term Northeast monsoon rainfall indicate that during El-Nino years there was increase in amount of rainfall than normal in all the locations of Tamil Nadu.

**iv. Tamil years Vs annual rainfall forecast**

The annual rainfall of a particular Tamil year in a cycle of 60 years was not the same for the corresponding Tamil years on the forth coming cycle and one can expect an opposite event.

**v. Stars Vs Seasonal rainfall forecast**

The star Revathi had greater influence on rainfall during hot weather period (March- May) while during Southwest monsoon (June – Sept) and Northeast monsoon seasons (Oct – Dec), stars Maham and Uthiram respectively did influence seasonal rainfall.

In the monthly analysis at 30% probability, the star Uthiram had influenced in getting rainfall of > 20mm during July and November months. While during other months the stars viz. Maham, Pooradam, Kettai, Swathi and Moolam showed their influence to get < 20mm of rainfall.

**vi. Pest and weather relationship study in cotton**

When maximum and minimum temperature got increased, the infestation from American bollworm also got decreased. In contrast, positive relationship existed for pink bollworm for the above weather parameters. In the case of aphid, maximum temperature, diurnal variation, Relative Temperature Disparity, bright sunshine hours, and wind speed, had negative relationship, while positive correlation was observed for minimum temperature.

**vii. Study on the weather relationship of *eriophyid* mite in coconut**

The maximum temperature had negative correlation with nuts affected in all the varieties (Tall (east coast), Dwarf (yellow), Tall X Dwarf, Orange, and Dwarf X Tall) at three months after spathe emergence; where as positive correlation was obtained for maximum temperature one to two months before spathe emergence in respect of Tall (east coast) and Dwarf x Tall varieties. In general *eriophyid* mite affected nuts were either positively and negatively influenced by minimum temperature and relative humidity respectively (0722 IST and 1422 IST). From the stepwise regression analysis made, one to two months earlier or one to two months after spathe emergence, wind speed had higher influence on the nuts affected with mite irrespective of varieties except Tall x Dwarf .

**viii. Probing the association of lunar phases "*Thithies*" with rainfall at Coimbatore**

Based on the interaction between earth and moon in relation to sun, each month is governed by both new moon and full moon. In between these two, there are fourteen *thithies* covering the 14 days interval. A study was undertaken to find out the association between rainfall and the different *thithies*. Results revealed that the first eight *thithies* succeeding new moon, and eight *thithies* preceding the new moon did relate to annual rainfall events. Higher rainfall occurred normally during the eight *thithies* preceding the new moon as compared to *thithies* succeeding the new moon. Almost similar results could be noticed for both Southwest and Northeast monsoon seasons. Analysis also indicated that towards full moon phase, the *thithi* Shasthi (sixth phase) is associated with high rainfall while such effect was noticed at Ekadasi (eleventh phase) *thithi* towards new moon. High intensity events occurred frequently during new moon phase as compared to full moon phase.

**8. Medium range weather forecast**

In Tamil Nadu, about 55.4 per cent of the arable land depends entirely on rainfall for its crop productions. Since rainfall varies in space and time, there is risk in farming for dry land crop production. Proper understanding of the climate and issuing weather forecast based on the dynamic nature of atmosphere would help in multiple ways. Four different weather forecasts are presently made. They are now casting, short range, medium range and long range.

Among the forecasts, the weather forecast given under medium range seems to serve the purpose of the farmers, since it provides enough time to the farmers to change the agricultural operations based on anticipated weather change under dry land environment.

In this context, a project on the establishment of National Centre for Medium Range Weather Forecast (NCMRWF) and Development of Agro-meteorological service was approved by the Government of India and implemented by the Department of Science and Technology (DST) in mission mode. Currently local weather forecast based on Direct Model output of General Circulation Model (GCM) is prepared by NCMRWF and given to Agromet Advisory Service units located at different State Agricultural Universities (SAU) including seven in Tamil Nadu, four under TNAU (Coimbatore, Pechiparai, Kovilpatti and Aduthurai) and two under Tamil Nadu Veterinary and Animal Sciences University (Chennai and Namakkal) and one at Kannivadi (MSSRF). In turn the SAU prepares weather based agro advisory bulletin and communicate to the farmers for making decisions on agricultural activities based on anticipated weather change. The forecast covers, cloud cover, rainfall, wind speed, wind direction, maximum temperature, and minimum temperature. This forecast is given for four days from Tuesday to Friday and again from Friday to Monday and thus it covers a whole week.

Presently TNAU installs Automatic Weather Station at block level and once completed, block level weather forecast with agro advisories will be given.

**9. Seasonal climate forecast**

Seasonal climate forecast is being given to all districts of Tamil Nadu through TNAU Research Stations both for South-west and North-east monsoon seasons with a lead time of 15 days. This forecast contains the seasonal rainfall both in temporal and spatial dimensions. This forecast is based on probability analysis made through Australian Rainman Software. The inputs are location specific past rainfall data more than twenty one years and real time southern oscillation index and sea surface temperature. This type of forecast is being given from 1999 onwards and presently institutionalized by the TNAU. Based on the verification of the forecast, the accuracy goes up to 70 per cent. Since the forecast is given with a lead time the information is highly useful for farm planning and hence it becomes response farming in nature.

**10. Climate change and crop production**

**a) Model result on Temperature and Rainfall**

The results of the projected climate change over Cauvery basin of Tamil Nadu for A1B scenario using PRECIS and RegCM3 regional climate models showed an increasing trend for maximum temperature, minimum temperature and rainfall. Decadal means of maximum and minimum temperatures were generated to understand the variation more clearly and the results revealed that the increase in maximum temperature in PRECIS was 3.7°C and in RegCM3, it was 3.1°C. The increase in minimum temperature in PRECIS model was 4.2°C and in RegCM3, it was 3.7°C during the same period. The increase in minimum temperatures is higher than maximum temperatures in both models.

**b) Model result on rice productivity**

The study on the yield of ADT 43 rice over Cauvery Delta Zone as simulated by Decision support System for Agricultural technology Transfer (DSSAT) under CO2 fertilization, the result had shown that a reduction of 135 Kg $ha^{-1}$ $decade^{-1}$ for PRECIS (Providing Regional Climates for Impact
Studies) model, while there was an increase in yield of24 Kg $ha^{-1}$ $decade^{-1}$ for RegCM3 (Regional Climate Model System 3) model, thus indicating the possibility of change in rice yield under climate change scenario.

**c) Impact of Climate change on crops**

Analysis on the maize crop yield indicated reduction in yield by 3.0, 9.3 and 18.3 per cent respectively during 2020, 2050 and 2080 from the current yield levels in the major maize growing districts of Tamil Nadu with increase in minimum temperature. Sorghum crop yield is expected to decline by 4.5, 11.2 and 18.7 per cent during 2020, 2050 and 2080 from the current yield levels if no management intervention is made in the major sorghum growing districts of Tamil Nadu. This is due to nighttime temperature increase.

**d) Adaptation strategies developed under ClimaRice project for sustaining rice productivity in Cauvery Delta Zone (CDZ) against climate change**

- Introduction of System of Rice Intensification (SRI) under non-rainy season
- Introduction of temperature tolerant rice varieties
- Seed treatment with bio-fertilizer (Azospirillum), application of blue green alage (BGA) and growing azolla as dual crop in rice. This reduces methane emission from the rice field

**Table of Meteorological Standard Week**

| Std. Week. No. | Month | Dates | Std. Week. No. | Month | Dates |
|---|---|---|---|---|---|
| 1 | January | 1-7 | 27 | July | 2-8 |
| 2 | | 8-14 | 28 | | 9-15 |
| 3 | | 15-21 | 29 | | 16-22 |
| 4 | | 22-28 | 30 | | 23-29 |
| 5 | | 29-4 | 31 | | 30-5 |
| 6 | February | 5-11 | 32 | August | 6-12 |
| 7 | | 12-18 | 33 | | 13-19 |
| 8 | | 19-25 | 34 | | 20-26 |
| 9 | | 26-4* | 35 | | 27-2 |
| 10 | March | 5-11 | 36 | September | 3-9 |
| 11 | | 12-18 | 37 | | 10-16 |
| 12 | | 19-25 | 38 | | 17-23 |
| 13 | | 26-1 | 39 | | 24-30 |
| 14 | April | 2-8 | 40 | October | 1-7 |
| 15 | | 9-15 | 41 | | 8-14 |
| 16 | | 16-22 | 42 | | 15-21 |
| 17 | | 23-29 | 43 | | 22-28 |
| 18 | | 30-6 | 44 | | 29-4 |
| 19 | May | 7-13 | 45 | November | 5-11 |
| 20 | | 14-20 | 46 | | 12-18 |
| 21 | | 21-27 | 47 | | 19-25 |
| 22 | | 28-3 | 48 | | 26-2 |
| 23 | June | 4-10 | 49 | December | 3-9 |
| 24 | | 11-17 | 50 | | 10-16 |
| 25 | | 18-24 | 51 | | 17-23 |
| 26 | | 25-1 | 52 | | 24-31** |

# 23. FARM IMPLEMENTS AND MACHINERY

## i. LAND PREPARATION IMPLEMENTS

### TRACTOR OPERATED CHISEL PLOUGH

| | |
|---|---|
| Purpose | Suitable for deep tillage upto a depth of 40 cm for breaking hard soil pan. |
| Type of the implement | Tractor operated |
| Field capacity | 1.4 ha / day at a spacing of 1.5m between rows |
| Cost of the implement | Rs.12000/- (Approximately) |
| Salient Features | Operated by any 35-45 hptractor. The implement is simple in construction and has only three components namely frame, standard and share. The share has a lift angle of 20 degree, width of 25mm and length of 150mm. The implement is protected by shear pin which prevents damage from overloading. |

### TRACTOR OPERATED SUBSOIL COIRPITH APPLICATOR

| | |
|---|---|
| Purpose | The sub soil coir pith mulch is applied at 15-30 cm deep |
| Type of the implement | Tractor operated |
| Field capacity | 0.60 ha/day |
| Cost of the implement | Rs.40,000/- (Approximately) |
| Salient Features | Ensures higher moisture retention, crop growth and yield |

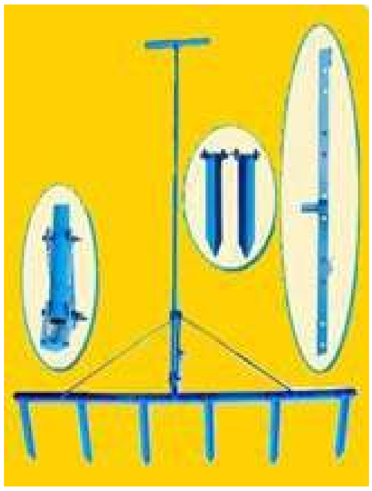
### TRACTOR OPERATED ROTARY SPADING MACHINE


| | |
|---|---|
| Purpose | Primary tillage tools suitable for all soil conditions including wet clay soil and recommended for intercultural operation in coconut orchards |
| Type of the implement | Tractor operated |
| Field capacity | 1.5 ha per day |
| Cost of the implement | Rs. 1,20,000 /- (Approximately) |
| Salient Features | High energy utilization efficiency |

## TWIN ROW PRECISION ORGANIC MANURE CUM FERTILIZER APPLICATOR

| | |
|---|---|
| Purpose | Suitable for accurate and controlled application of organic manure/mulch directly below the root zone. |
| Type of the implement | Tractor operated |
| Field capacity | 1.0 ha per day |
| Cost of the implement | Rs. 1,25,000 /- (Approximately) |
| Salient Features | • Helps in improving the soil nutrient use efficiency, crop yield and soil quality. Adjustable spacing between furrows enables the use at different row spacing<br>• Simultaneous precise placements of organic manure and inorganic fertilizer. |

## MANUALLY OPERATED MARKER



| | |
|---|---|
| Purpose | Marker for line sowing |
| Type of the implement | Manually operated |
| Cost of the implement | Rs. 1800 /- (Approximately) |
| Salient Features | • Easy to operate<br>• Reduced seed rate<br>• Suitable for small and marginal farmers<br>• Reduction in cost of cultivation<br>• Maintenance of optimum plant population<br>• Easy for inter cultural operation (Weeding, Spraying) |

## TRACTOR OPERATED PIT DIGGER FOR SUGAR CANE PLANTING

| | |
|---|---|
| Purpose | Pit Digger for Sugarcane Planting |
| Type of the implement | Tractor operated |
| Field capacity | 250 to 300 holes per hour |
| Cost of the implement | Rs. 1,20,00 /- (Approximately) |
| Salient Features | • At a time two pits of dia 90 cmcan be made<br>• Spacing between the auger is adjustable |

### SYSTEM FOR CONTROLLED LEVEL OF PUDDLING

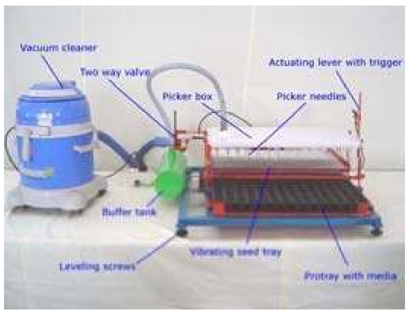
| | |
|---|---|
| Purpose | To control the level of puddling in wetland |
| Type of the implement | Tractor mounted |
| Field capacity | 1.5 ha / day |
| Cost of the implement | Rs.50,000/-(Additional Hydraulic cylinder to the existing laser leveller) |
| Salient Features | • Constant depth of puddle can be maintained accurately, reducing the tillage energy expended by deep puddling.<br>• Reduce water requirement for puddling.<br>• Establishment of a strong sub soil layer that will reduce deep percolation.<br>• Ensures good level surface layer and subsurface layer enabling easy transplanting |

### ii. SOWING IMPLEMENTS

### SEED CUM FERTILIZER DRILL FOR PADDY

| | |
|---|---|
| Purpose | For direct sowing of paddy and simultaneous application of fertilizer |
| Type of the implement | Tractor mounted |
| Field capacity | 3 ha/day |
| Cost of the implement | Rs. 75,000 /- (Approximately) |
| Salient Features | • For dry sowing of paddy seeds in 9 rows at uniform depth and spacing |

### NEEDLE TYPE TRAY SEEDER FOR VEGETABLE NURSERY




| | |
|---|---|
| Purpose | To sow in pro tray cavities |
| Field capacity | Can sow seeds in 60 trays/ hour |
| Cost of the unit | Rs. 35,000 /- (Approximately) |
| Salient Features | • To mechanize placement of seeds in the pro-tray cells<br>• Singulated raw/ pelleted seeds placed in all the cells in a single stroke<br>• Cost of operation is Rs. 280 for sowing 750 trays /day<br>• Saving in time is 300% and saving in labour is 60 |

**AUTOMATIC PROTRAY SOWING MACHINE FORVEGETABLE NURSERY PRODUCTION**

| | |
|---|---|
| Purpose | Filling medium and sowing seeds in protray |
| Field capacity | Can sow seeds in 200 trays/ hour |
| Cost of the implement | Rs. 1,00,000 /- (Approximately) |
| Salient Features | • The automated protray sowing machine provides for automating all the steps involved in the sowing of vegetable seeds in protrays.<br>• The machine is able to provide above 100 per cent saving in cost. |

**TRACTOR DRAWN TURMERIC RHIZOME PLANTER**

| | |
|---|---|
| Purpose | To plant turmeric rhizomes on ridges |
| Type of the implement | Tractor mounted |
| Field capacity | 1.2 ha/day |
| Cost of the implement | Rs. 60,000 /- (Approximately) |
| Salient Features | • Three rows can be planted at a time in the required spacing.<br>• Row spacing is adjustable<br>• Saving in quantity of 500 kg/ ha seed rhizomes |

**SUGARANE SETT CUTTER**

| | |
|---|---|
| Purpose | Cutting sugarcane sett with single bud |
| Field capacity | 1500 setts/hour |
| Cost of the implement | Rs. 5,000 /- (Approximately) |
| Salient Features | • Damage is less when compared to manual cutting<br>• |

## MANUALLY OPERATED CARROT SEEDER

| | |
|---|---|
| Purpose | Suitable for sowing pelletized carrot seeds |
| Type of the implement | Manually operated |
| Field capacity | 0.064 ha/day |
| Cost of the implement | Rs. 30,000 /- (Approximately) |
| Salient Features | • Pelletized carrot seeds can be sown in six rows.<br>• Specially designed conical foam pad metering mechanism to avoid seed damage.<br>• A single person can easy push the seeder easily on the seed beds. |

## iii. INTERCULTURAL EQUIPMENTS

## TWO ROW FINGER TYPE PADDY ROTARY WEEDER

| | |
|---|---|
| Purpose | For weeding in rice crops |
| Type of the implement | Manually operated |
| Field capacity | 0.35 ha/day. |
| Cost of the implement | Rs. 1400 /- (Approximately) |
| Salient Features | • Two row paddy weeder<br>• Row to row spacing is adjustable |

## BATTERY OPERATED PORTABLE WETLAND WEEDER

| | |
|---|---|
| Purpose | For weeding in rice crop |
| Type of the implement | Manually operated |
| Field capacity | 0.3 ha/day |
| Cost of the implement | Rs. 12,000 /- (Approximately) |
| Salient Features | • Single row paddy weeder<br>• No drudgery involved for the operator |

## MULTI ROW POWER WEEDER FOR SRI

| | |
|---|---|
| Purpose | For weeding in rice crop |
| Type of the implement | Self-propelled |
| Field capacity | Can weed 0.75 to 1.0 ha per day |
| Cost of the implement | Rs. 40,000 /- (Approximately) |
| Salient Features | • Weeding done by two rotary weeding units powered by 1.7 HP engine<br>• Can be operated and lifted by one person easily to change rows.<br>• Complete cutting of weeds at a depth of 3 to 4 cm with less than 1% plant damage. |

## SUGARCANE DETRASHER

| | |
|---|---|
| Purpose | For detrashing sugarcane |
| Type of the implement | Manually operated |
| Cost of the implement | Rs. 1200 /- (Approximately) |
| Salient Features | • Labour requirement is less<br>• Easy for handling<br>• Reduced cost of de-trashing<br>• Used for all varieties of cane<br>• Also removes the sprouted buds |

## iv. HARVESTING AND THRASHING MACHINES

## MINI COMBINE HARVESTER FOR PADDY

| | |
|---|---|
| Purpose | For harvesting paddy |
| Type of the implement | Self-propelled |
| Field capacity | 1 ha/day |
| Cost of the implement | Rs. 3,00,000 /- (Approximately) |
| Salient Features | • It performs different operations like paddy Harvesting, threshing, winnowing simultaneously<br>• Suitable for small and medium farms |

## v. HORTICULTURAL IMPLEMENTS

## TRACTOR OPERATED FRUIT-SHAKE HARVESTER

| | |
|---|---|
| Purpose | For harvesting tamarind, and citrus fruits |
| Type of the implement | Tractor operated |
| Cost of the implement | Rs. 6000 /- (Approximately) |
| Salient Features | • Harvesting efficiency is 85 per cent<br>• Savings in time is 95 per cent |

## TRACTOR OPERATED SINGLE / TWO ROW CASSAVA HARVESTER

| | |
|---|---|
| Purpose | To dig cassava tubers in single / two rows |
| Type of the implement | Tractor operated |
| Field capacity | 0.65 ha/day for single row and 0.96 ha/day for double row |
| Cost of the implement | Rs. 45,000/- for single row and Rs. 55,000/- for double row (Approximately) |
| Salient Features | • It is suitable for both single row and two rows operations.<br>• The blade angle of 20 deg is provided for easy penetration in to the soil.<br>• The row spacing can be altered by moving the shanks in the main frame.<br>• The depth wheels are provided to the depth of operation. |

## COCONUTTREE CLIMBER

| | |
|---|---|
| Purpose | To climb coconut trees for harvesting cleaning and other operations |
| Type of the implement | Manual operation |
| Field capacity | 5-6 trees /hour |
| Cost of the implement | Rs. 5000 /- (Approximately) |
| Salient Features | • Even unskilled workers can use it to climb the tree with more stability and comfort.<br>• Seating arrangement provides added comfort and safety.<br>• It eliminates the severe bruises caused in traditional method of climbing due to use of climbing ropes. |

## IMPROVED COCONUT TREE CLIMBER


| | |
|---|---|
| Purpose | To climb coconut trees for harvesting cleaning and other operations |
| Type of the implement | Manual operation |
| Field capacity | 6 trees /hour |
| Cost of the implement | Rs. 5500 /- (Approximately) |
| Salient Features | • Lesser weight of the lower unit (3.0 kg) then existing model (6.0 kg) Lower unit is lifted simultaneously by leg and hand force for continuous operation<br>• Comfortably designed upper frame |

## PALMYRAH TREE CLIMBING DEVICE

| | |
|---|---|
| Purpose | To climb palmyrah trees for harvesting cleaning and other operations |
| Type of the implement | Manual climbing |
| Cost of the implement | Rs. 9000 /- (Approximately) |
| Salient Features | |

- Even unskilled workers can use it to climb the tree with increased stability and comfort.
- The grippers are so positioned that while ascending/descending up/down, the upper frame accommodating the operator is always horizontal to the ground, irrespective of the girth variations in the tree.
- Eliminates the high work stress, severe neck and back pain disorders caused in traditional method of climbing.

## ARECANUT HARVETSER

| | |
|---|---|
| Purpose | To climb arecanut trees for harvesting nuts |
| Type of the implement | Manual climbing |
| Cost of the implement | Rs. 9000 /- (Approximately) |
| Salient Features | |

- Even unskilled workers can use it to climb the tree with increased stability and comfort.
- Lightweight aluminium pole with improved configuration of cutting edge of the knife for easy harvesting
- Seating arrangement (adjustable and pivotable) with back rest for safe and secure operations Rotatable unit to facilitate harvesting of bunches form surrounding trees.

## AERIAL ACCESS HOIST FOR COCONUT HARVESTING

| | |
|---|---|
| Purpose | For harvesting coconut |
| Type of the implement | Tractor mounted |
| Cost of the implement | Rs. 8.50 lakh /- (Approximately) |
| Salient Features | • First machine of its kind in tractor mounted form<br>• A full length chassis from front to rear of the tractor provides support<br>• The entire weight of the hoist and moments transmitted through the chassis to the stabilizers without transferring to the tractor chassis.<br>• Four trees can be accessed from a single position.<br>• The time required for locating unit and operating stabilizers - 1 min.<br>• The time required for positioning against a tree of 10 m height is 2 min.<br>• The positioning of the operator platform can be done by the operator himself |

## TRACTOR OPERATED MULTI-PURPOSE HOIST


| | |
|---|---|
| Purpose | Amenable for fruit plucking, coconut harvesting, training, pruning, lopping and spraying tree crops. |
| Type of the implement | Tractor mounted |
| Cost of the implement | Rs. 55,000 /- (Approximately) |
| Salient Features | • The equipment is attached to the back of a 45 hp agricultural tractor.<br>• Two labourers can stand on the platform and do operations<br>• Platform can reach a maximum height of 8.1 m |

## WORKER FRIENDLY ARECANUT STRIPPER

| | |
|---|---|
| Purpose | Suitable for stripping both green and ripened arecanut. |
| Type of the implement | Electric motor/engine operated |
| Field capacity | Can strip 650-950 Kg of arecanut per hour |
| Cost of the implement | Rs. 25,000 /- (Approximately) |
| Salient Features | • Damage caused to the stripped arecanut is eliminated.<br>• Results in 66 and 77 per cent saving in cost and time when compared to conventional arecanut stripping<br>• Stripping efficiency of 99.5 per cent is achieved |

## TRACTOR OPERATED CLUSTER ONION HARVESTER CUM COLLECTOR

| | |
|---|---|
| Purpose | To dig and collect cluster onion |
| Type of the implement | Tractor mounted |
| Field capacity | 1.2 ha/day |
| Cost of the implement | Rs. 75,000 /- (Approximately) |
| Salient Features | • The cluster onion harvester has a special profile of blade to ensure shallow cut of soil and riddle conveyer for separating the soil from the onion bulbs.<br>• Cross conveyer and also elevating conveyer are provided for easy and continuous movement of onion.<br>• A bag is provided for collection of onion. |

## vi. MISCELLANEOUS MACHINERY

### POWER TILLER OPERATED SLASHER CUM INSITU SHREDDER

| | |
|---|---|
| Purpose | Suitable for shredding vegetable residues of brinjal, chillies, bhendi, etc. left after harvest and parthenium, etc. |
| Type of the implement | Power tiller operated |
| Field capacity | 0.8 hectare can be shredded per day |
| Cost of the implement | Rs. 25,000 /- (Approximately) |
| Salient Features | • Suitable for any make of power tiller of 10-15 HP<br>• Saving in time - 73 %<br>• Saving in cost - 75% |

### SUBSOILER ATTACHMENT FOR STUMP REMOVAL

| | |
|---|---|
| Purpose | Removes stumps in dryland |
| Type of the implement | Tractor operated |
| Cost of the implement | Rs. 14,000 (including subsoiler) |
| Salient Features | • Savings in cost by Rs. 1.50 per stump<br>• Savings in time is 10-12 minutes per stump |

### TRAILER MOUNTED STEERING FOR POWER TILLER – TRAILER SYSTEM

| | |
|---|---|
| Purpose | Steering of power tiller |
| Type of the implement | Power tiller operated |
| Cost of the steering system | Rs. 2,000 Approximately |
| Salient Features | • Avoids the operator getting down and turn the power tiller trailer system.<br>• All the controls are well within the reach of the operator.<br>• Shorter turning radius, enabling the operator to take turns even in very narrow space<br>• Operator feels comfortable while taking a turn.<br>• Reduced discomfort to the operator through elimination of lateral and vertical swing of the handle. |

# 24. AGRICULTURAL PROCESSING EQUIPMENTS

## TAMARIND DESEEDER

**Salient Features:**

- Suitable for deseeding dried dehulled tamarind fruits
- Various sizes of the dehulled tamarind fruits can be used for deseeding
- The roller gap can be adjusted as per the size of the tamarind fruits
- The deseeded fruits are separated into pulp strip, seeds and broken pieces
- The cost of the unit: Rs.1,00,000/-
- Capacity of the machine : 30-40 kg/h
- Cost of operation: Rs. 2.5/kg

## Improved TNAU Dhal Mill

**The salient features of the improved TNAU dhal mill:**

- Suitable for splitting, cleaning and grading of pulses into dhal at the rate of 25-30 kg / hour
- Capable of dry milling of cereals into powder by changing into cast iron rolls
- Easy to operate and run by one H.P. single phase motor
- The unit has pitting unit for enhancing the preconditioning process
- Reduced conditioning time of 4-6 hours compared to 12 hours in conventional method
- Milling and grading efficiencies are more than 80%
- The cost of the unit is Rs.50000/-
- The cost of operation is Rs.2 per kg

# 25. RENEWABLE ENERGY ENGINEERING

## (i) SINGLE POT CHULHA


The single pot chulha has a double wall with a gap of 2.5 cm. It has a grate at the bottom of the combustion chamber. Legs have been provided in the four corners of the chulha (5 cm height) as the ash can be collected below the grate. The outer wall has two rectangular secondary air openings at the lower portion on both sides for air entry. The inner wall has 1 cm diameter holes which maintain a triangular pitch of approximately 3 cm. The secondary air enters through the rectangular opening in the outer wall gets heated in the annular chamber and while moving up it passes through the holes in the combustion chamber. The preheated air helps in proper burning of the fuel. The efficiency of single pot improved chulha is 24%. The cost of the unit is Rs.350/-.

## (ii) DOUBLE POT CHULHA

The TNAU double pot portable chulha (chimneyless) is made with two walls Around the first pot, an annular chamber having a width of 2.5 cm is left and the outer wall is constructed. The outer wall is also extended to cover the second pot in which case the annular chamber width is 3.5 cm, because of the smaller diameter of the second pot hole. Two secondary air inlets are made, one on the outer wall with rectangular shape (17 cm x 1 cm) near the combustion chamber and the other at the bottom of the second pot hole with round shape having a diameter of 5 cm. At the bottom of the first pot hole in the base, a hole of diameter 14 cm is made and a grate (C.I.) is placed over it. For the entry of secondary air to the first pot hole, 1 cm dia holes are made with a triangular pitch of 3 cm on the inner side of first pot hole and also on the tunnel projecting into the second pot hole. The efficiency of double pot improved chulha is 26%. The cost of the unit is Rs.600/-.

## (iii)BIOMASS GAS STOVE

The biomass gas stove has been developed for small scale thermal application in agriculture and allied industries. This stove widens the market for agro wastes, makes possible a higher efficiency and in some cases reduces the time and investment, all by comparison with combustion. The biomass gas stove is a natural convection type updraft gasifier consisting of a cylindrical body made of clay, sand and paddy husk with its top open and bottom closed. The diameters and height of the stove are 290 mm and 630 mm respectively. This can be reduced depending on the applications. An iron grate to hold the biomass is fixed at 50 mm from the base of the reactor. The bottom is provided with an air opening cum ash removal door. At the top, provision is made to place vessel for cooking, boiling etc. The biomass viz., wood chips, agricultural residues like coconut shell, groundnut shell, arecanut husk, tree barks and leaves can be used in this biomass gas stove. The feedstock materials used should preferably be in the form of small chips, splinters and small logs. The fuel consumption is 5 kg/h and its thermal efficiency is 23%. The cost of the unit is Rs.1000/-.

## (iv) DOWNDRAFT GASIFIER FOR WATER PUMPING

A downdraft gasifier along with a gas cleaning system retrofitted with a 5 Hp diesel engine coupled with a centrifugal pump for pumping water for irrigation applications. In order to supply producer gas for running the 5 Hp engine on dual fuel mode, a 10 kg/h capacity downdraft gasifier is required. A maximum of 50 percent diesel can be saved by substituting 50 percent of diesel with the producer gas obtained from biomass. And the cost of operating the gasifier coupled water pumping system is around Rs.50/h.

### (v) SOLAR TUNNEL DRIER

The solar tunnel dryer is commercially used dryer for drying agro food products. Solar tunnel dryer is working based on Green House Effect principle. It results that 15-20°C increase in temperature above ambient temperature inside the solar tunnel dryer to dry the product from initial moisture to safe storage moisture. It mainly consists of semi-cylindrical tunnel structure, solar collector and cement concrete floor with absorber surface (Table 1). The semi cylindrical pipe structure covered with U.V. stabilized semi-transparent polyethylene sheet of 200-micron thickness. Drying floor with absorber surface is a cement concrete flooring laid at a gradient of 5° along the length with special black coating. The dryer is walk-in type and to facilitate loading and unloading of the product to be dried. The trays made of 8 SWG thick galvanized iron mesh with dimension of 1m x 1m can be used to increase the capacity. The dimensions of drying chamber (LxWxH) is 18m x 3.75m x 2.0m. The length can be varied depending upon capacity of the products to be dried.

### (vi) BIOMASS HOT AIR GENERATION SYSTEM INTEGRATED WITH SOLAR TUNNEL DRYER

Renewable energy integrated drying system using solar thermal and biomass hot air with controlled environment can be used for continuous drying of agro-products.

- Solar mode is used for drying during sunshine hours and biomass mode is used during off-sunshine hours, cloudy weather.
- Suitable to dry coconut, turmeric, chillies, medicinal plants, vadam (food) products etc., with hygienic environment and enhanced quality compared to conventional open sun drying.
- Efficient (19 %) biomass combustor with heat exchanger is suitable for various biomass fuel such as coconut husk, coconut shell and wood logs.
- The integrated drying system attains the drying temperature ranged from 45 to 65$^{o}$C and has controls to maintain desired RH and temperature.
- Loading capacity is 500 kg to 2 tonnes per batch
- Drying time for coconut in integrated dryer is 48-52 h and 4-5 days in Solar tunnel dryer
- Cost of installation of integrated dryer is Rs.6.0 lakhs for 500 kg and Rs.8.0 lakhs for 2 tonnes/batch
- Reduces 35% drying time over solar tunnel dryer and 70 % over conventional open sun drying method.

### (vii) NIGHT SOIL BIOGAS PLANT

Night Soil cum Kitchen Waste based Biogas Plant is the integration of modern biogas technology with disposal of night soil and food wastes generated from hostel kitchens and dining halls for harnessing bio-based energy.

- The hydraulic retention time of the plant is 45-55 days and human waste from 40 persons will be required for the production of 1 $m^3$.
- Biogas contains 65-70% methane and 30-35% carbon dioxide with traces of $H_2S$.
- Available at varying capacities from 1 $m^3$ to any higher capacity, based on the feedstock availability.
- Cost of installation is Rs. 30,000 for 1 $m^3$ and about Rs. 6.5 lakhs for 20 $m^3$ capacity.
- Biogas is utilised for cooking, lighting through mantle lamps, running engines, electricity generation, etc.
- Biogas burners, lamps and engines are available with hourly capacities from 8 to 100, 4-5 and from 50 cubic feet, respectively.
- Major advantages are sanitation and hygiene, environmental improvement, energy generation, provision of community facilities, etc.

**(viii) BIODIESEL PILOT PLANT**


The bio-diesel pilot plant consists of a transesterification reactor with heater, a stirrer, chemical mixing tank, glycerol settling tank (2 Nos.) and washing tank. The capacity of pilot bio-diesel plant is 250 litres/day. The cost of the pilot plant is Rs.5 lakhs. oil is mixed with alcohol and catalyst mixture in transesterification reactor. The reactor is kept at reaction temperature for specific duration with vigorous agitation. After reaction, the bio-diesel and glycerol mixture is sent to the glycerol settling tank. The crude bio-diesel is collected and washed to get pure bio-diesel. Depending upon the need, the size of the unit can be scaled up to get higher production.

# 26. HOME SCIENCE

## FOOD PROCESSING TECHNOLOGIES

**Utilization of rice bran in traditional breakfast foods**

- Rice bran is a byproduct of rice, obtained on polishing. The bran is a rich source of protein, essential fats, B and E vitamins, minerals, fiber and antioxidants.
- Rice bran extracts in water can be used as a fiber free nutrient that has a lot of health giving properties.
- The rice oil is high in mono- and polyunsaturated fatty acids.
- Rice bran extracts can be used in a variety of preparations like bakery products and beverages.
- The Home Science College has standardised the preparation of flavored milk with the incorporation of rice bran extract.
- This beverage has antioxidant properties besides the soluble vitamins and proteins of bran.
- The heat stabilized bran can be incorporated in putt mix, ready to cook idiappam mix and spagetti, thus increasing the nutritive value of these products.

**Sorghum Flakes**

- Nutritionally superior to rice flakes.
- Ideal breakfast and snack food.
- Simple and low cost processing technique.
- Quick to cook and easily digestible.
- Good source of minerals and fibre.
- Sorghum flakes (100 g) contains 8.6 g protein, 3.7 g fat, 1.5 g fibre, 69 mg calcium and 16 mg iron.

**Samai Biscuits**

- Little millet (samai) is a good source of minerals, B vitamins and fibre.
- Fat, iron and niacin content are higher in little millet, than in other cereals.
- Calcium, phosphorus and iron content of samai biscuits are 25.8, 150 and 4.21 mg/100g respectively.
- High in fibre (1.40 %), and is important as health food.
- Has a shelf life of upto nine months.

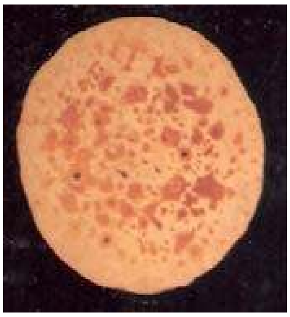
**Health Mix for Geriatrics**

- ❖ The health mix designed for the aged was formulated from cereals, millets, pulses, and vegetables.
- ❖ In combination with milk powder and jaggery improved nutritional status of selected elderly subjects.
- ❖ Significant increase in haemoglobin level.
- ❖ The health mix (100 g) furnished 12 g protein, 2 g fat and 482µg β carotene.

**Millet based health food mix**

- ❖ Can be used for preparing nutritious balls and beverages.
- ❖ Easily digestible and good for children and aged persons.
- ❖ Health mix (100g) contains 9.75% moisture, 16.61% protein, 3.69% crude fibre,
  6.19 % reducing sugar 9.67 % total sugar, 20.68mg calcium, 244.00 mg phosphorous, 5.35 mg, potassium, 7.57 mg iron and 5.32 mg zinc.
- ❖ Has good storage stability.

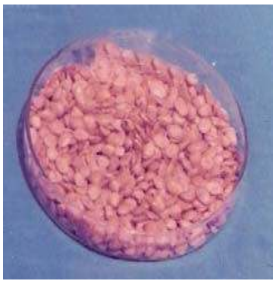
**Khakra**



- ❖ Khakra is Indian flat bread.
- ❖ Traditional food of Gujarat, simulating chapathi in terms of product formulation and is further toasted to a moisture content of 5-6%.
- ❖ Incorporated with defatted soya flour (25%), the product is a rich source of protein.
- ❖ Addition of defatted soya flour increases protein (70%), iron (50%) and calcium (36%)

The product has a shelf life upto 90 days at room temperature.

**Puffed Soya**

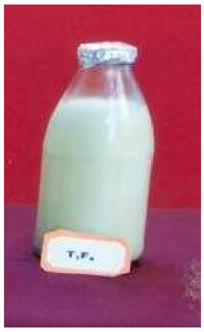


- ❖ Puffing of soya reduces antinutrients and improves bioavailability of nutrients.
- ❖ Rich source of protein.
- ❖ Easily digestible and ideal protein source for vulnerable groups.
- ❖ Provides 32%protein.
- ❖ Low moisture content (6%).
- ❖ Has storage stability upto two months.

**Okara Mix**

- ❖ Okara is a by-product obtained during the processing of soy milk.
- ❖ Cheap source of protein and can be used to enrich traditional food products.
- ❖ Fresh okara contains 80% moisture, 13.7% protein, 1.5% fat, 4 % carbohydrate and 2% fibre.
- ❖ The processed okara in the ready to use form finds application in the preparation of traditional foods, bakery and confectionery products.
- ❖ Okara mix has a shelf life of 4 months.

**Soya milk Fruit Juice**



- ❖ Blending fruit juice and soya milk improves nutritive value and sensory quality.
- ❖ Rose and mango flavoured soya milk is highly acceptable.
- ❖ Contains 4 g protein, 2 g fat, 78 mg calcium, 21 mg phosphorous and 1.5 mg iron per 100 g of the fruit blended soya milk.
- ❖ Has a shelf life of 15 days under refrigerated condition.

  Best used in nutrition intervention programmes for the vulnerable groups.

**Extruded products from texturised soya protein**

- ❖ Extruded products (noodles) incorporated with texturised soya protein are richin protein.
- ❖ Addition of tomato juice further improved the quality of the noodles.
- ❖ Has good sensory appeal
- ❖ Texturised vegetable protein incorporated noodles is suitable for children.

Texturised soya noodles contains 20.3 g protein and 72 mg calcium

**Millet based value added products**

- ❖ Millets are miles ahead of rice and wheat in terms of their nutritional content. Millets are good source of minerals and dietary fibre.
- ❖ The nutrients present in the millets have the capacity for reducing the risk of life style diseases.
- ❖ Due to urbanization, climatic changes, erratic rainfall etc, the farmers are forced to seek alternative crops for rice.
- ❖ Forecasting the future need of our country millet based products like multigrain adai mix, multipurpose snack mix, health mix, samosa mix, karasev mix, pongal mix, priyani mix, flakes etc., were developed.
- ❖ The processed millet based products has six months shelf life and it suits the convenience seeking farmers.

**Sugarcane Syrup**

- Concentrated sugar cane juice.
- Alternative natural sweetener in the place of refined sugar.
- Convenient and ready to use, has wide application in the preparation of traditional, bakery and confectionary products.
- Sugarcane syrup (100 g) contains 43 mg calcium, 42 mg phosphorus and 2 mg iron.
- Has a shelf life of twelve months at room temperature.

At Home Science College and Research Institute, a Food Processing Training Center was established by installing the processing equipments namely Murukku machine, Sieving machine, Mixture machine, Steaming machine, Tray wrapping machine, Handy induction sealing machine, Continuous sealing machine, Nitrogen flush vaccum packaging machine, Pulveriser, Extruder, Milk Extraction unit, Cabiner drier and other processing accessories to train the entreprenuers, farmers, SHGs on processing of millets based value added products. The equipments are available to the budding entrepreneurs on rental basis to utilize the facilities.