Hydroponic Green Fodder Production - TANUVAS Experience

Tamil Nadu Veterinary and Animal Sciences University

National Agricultural Development Programme (NADP)

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FOREWORD

Green fodder feeding to livestock ensures optimization of productivity. Though India is the top producer of milk in the world insufficient livestock feed, fodder is one of the constraints affecting growth, health, production and reproduction potential of livestock. In India only 4.9 % of cropped land area is utilized for cultivating fodder. India faces a deficit of 35.6% green fodder, 26% of dry fodder and 41% of concentrate feed ingredients .In Tamil Nadu 30.7 million heads of livestock are reared ,which depend on 0.17 mill. ha of cultivable fodder area and 0.11 mill. Ha of pasture land. The pasture land has declined over the past. However fodder production is gaining momentum through various Government of Tamil Nadu schemes and this has reduced the deficit of green fodder to 25%.

A novel method called 'Hydroponics' which means growing plants without soil by using nutrient water at desired temperature and humidity. Through hydroponics it is easier and quick to produce nutritive green fodder. Maize, Ragi, Bajra, Cowpea, Horse gram, Sun hemp, Jowar and Foxtail millet seeds are found to be suitable to grow by hydroponic method. Preliminary trials conducted in University Research Farm, Madhavaram, it is observed that through hydroponics the biomass yield varies with the type of crop ranging from 300% (Ragi, Bajra) to 600% (Maize, Cowpea, Horse gram) and maximum of 800% (Sun hemp). Leguminous crops grow well and is encouraging as fodder owing to its high crude protein content, than cereal crops. The hydroponic fodder was fed to small and large ruminants and pigs and found to be highly palatable with no wastage.

The advantage of hydroponic fodder production is that

i. it requires just 480 sq. ft area to produce 1000 kg every day against 5 - 30 acres land under conventional system.
ii. saving of water to the extent of 95% and is recycled.
iii. can be grown throughout the year
iv. harvesting period is just 8 days and
v. it also saves labour, energy and time.

TANUVAS researchers have devised a simple rural friendly low cost hydroponic device to produce 15 - 30 kg of fodder daily targeting resource poor rural farmers, who rear one or two milch animals. Hydroponics may be the farmers' choice of fodder production in future.

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Introduction

Green fodder is the natural diet for livestock. Its production to meet the current demand has become a greatest challenge among livestock farmers. Due to many reasons, green fodder production has been facing a serious crisis and so the livestock productivity. Due to increasing intensive system of rearing livestock, the need for green fodder is enormous. As the gap between the demand and supply of the green fodder for livestock becoming unconquerable, researchers and farmers are in search for an alternative fodder or fodder production method, that would restore fodder and livestock production.

Hydroponics is the state of the art technology that has revolutionised the green fodder production in the 21st century. Hydroponics is a method of growing green fodder without soil in an environmentally controlled houses or machines. Many of the livestock farmers are switching to hydroponic fodder production from conventional production methods, as the fodder produced by this method are highly nutritious, provide sustainable fodder production round the year and conserve water .

Though this method has made a greatest impact in the fodder production system, most of the farmers are facing some practical difficulties in profitably running the hydroponic machine for sustainable fodder production. This manual has been compiled with the essential managemental practices that have to be carried out for an economically sustainable fodder production.

Importance of green fodder

- Natural diet for animals.
- Improves fat percentage in milk.
- Rich in beta carotene and helps in synthesis of vitamin A.
- Vitamin A has greater impact on reproduction.

Current status of green fodder production in the country and the state

Category	India (Million hectares)	Tamil Nadu (Million hectares)
Total geographical area	328.7	13.00
Fodder crops	8.3	0.17
Green fodder deficit	60 – 65%	42.6%

Water conserving hydroponic technology is a state of the art technology that has revolutionised the fodder production system during the past decades across the globe. There is no doubt that it will play a major role in reducing the green fodder demand and supply gap in our country as well as state.

What is hydroponics?

The word hydroponics has been derived from the Greek word 'water working'. Hydro means 'water' and ponic means 'working' and it is a technology of growing plants without soil, but in water or nutrient rich solution for a short duration in an environmentally controlled houses or machine.

What is a fodder?

"Fodder" refers particularly to food given to the animals (including plants cut and carried to them), rather than that which they forage for themselves in pasture and grazing land. It includes hay, straw, silage, compressed and pelleted feeds, oils and mixed rations, and also sprouted grains and legumes.

What is hydroponic fodder?

Fodder grown using hydroponics technology.

Hydroponic green fodder - why?

Saves water

Consumes 98% less water than conventional method and the used water is recycled.

Water sprinkler system – Hydroponic machine

Reduced growth time

Takes only 8 days duration to develop from seed to fodder while it took 45 days for a conventional fodder to grow. Enhanced nutritive value – as the fodder contains the seed along with the fodder, it has higher crude protein content than conventional green fodder.

Ready to feed - 8th day hydroponic maize fodder

Marginal land usage

Up to 1000 kg green fodder can be produced from 480 square feet area daily which is equivalent to conventional fodder (Co4) produced in 25 acres of cultivable land. Use 99% less land than conventional production method.

Hydroponic machine (1000 kg capacity) Vs Land (25 acres)

Constant supply

Fodder can be produced round the year irrespective of the failure of monsoon, land availability, natural calamities, labour shortage. Promotes sustainable agriculture and livestock production.

Requires minimal man power and time

- Only 2 -3 hours of work daily, doesn't involve technical work.
- Farmer can do the work without difficulty.

Completely natural and organic

Fodder is grown completely natural without the use of any pesticides.

Optimal production cost

- ✪ Production cost is optimal when compared to conventional fodder production.
- ✪ Cost of production is 2.50 INR / kg of hydroponic maize fodder.
- ✪ Hydroponic machine (1000 kg capacity) consumes only 40 units of current per day.

Reduce feed cost

As the fodder contains more crude protein that conventional fodder it reduces the feed cost spent on the concentrate feed to half.

Concentrate Feed

Minimal equipment usage

Reduce the need for equipment and fuel used to plant, grow, harvest, transport, and store feed.

Nutritious fodder

- Hydroponic fodder along with seed and root (sprout mat) are highly edible and are rich in protein (10 – 17%).
- Ideal nutrients enriched fodder for livestock.

Do the livestock really like it?

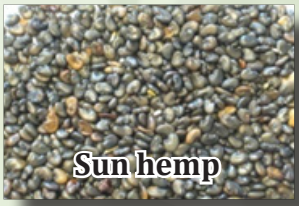
- The answer is 'yes'.
- Palatability of hydroponic green fodder was excellent among farm animals as it is succulent and delicious.
- Palatability trial showed greater response among farm animals like Cattle, Buffalo, Sheep, Goat, Pigs, Rabbit, Chicken and Turkey.

What can be grown as a fodder?

Yellow Maize, Cowpea, Horse gram, Sun hemp, Ragi, Bajra, Foxtail millet and Jowar has been grown successfully and received good response from the livestock as a fodder.


Yellow maize


Horse gram


Sun hemp


Foxtail millet


Ragi


Bajra


Jowar


Cowpea

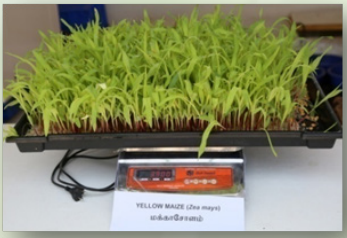
Varagu (Kodo millet)

Kuthiraivaali
(Sanwa millet)

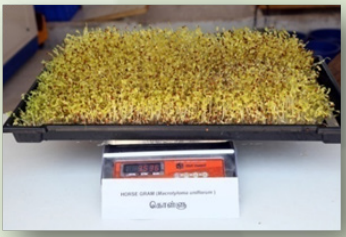
Saamai (Little millet)

Moth bean

Hydroponic green fodders



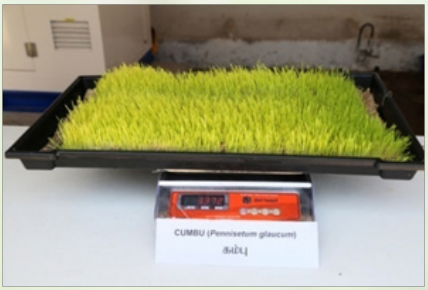
Yellow maize



Horse gram

Jowar

Hydroponic green fodders



Bajra

Ragi

Sun hemp

Cowpea

Foxtail millet

Hydroponic green fodders

Moth bean

Kuthiraivaali (Sanwa millet)

Varagu (Kodo millet)

Saamai (Little millet)

What are the requirements for hydroponic fodder production?

- 480 square feet area for production of 1000 kg of green fodder daily.
- Hydroponic machine.
- Uninterrupted power supply.
- Clean water.
- Seeds with good germination capacity.
- Good sanitation.
- Two labours.

How to produce?

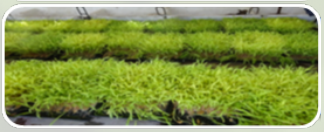
Soaking of seeds in water (20 hours)

Sprouting of seeds (24 hours)

Traying

Racking in the machine

Shifting of trays to next level daily



Fully grown fodder on 8th day

Growth stages of hydroponic maize fodder

Day 0

Day 1

Day 2

Day 3

Day 4

Day 5

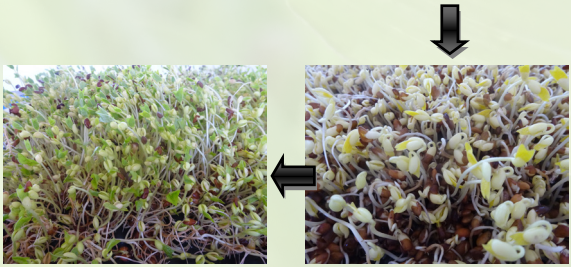
Day 6

Day 7

Day 8

Growth stages of hydroponic horse gram fodder

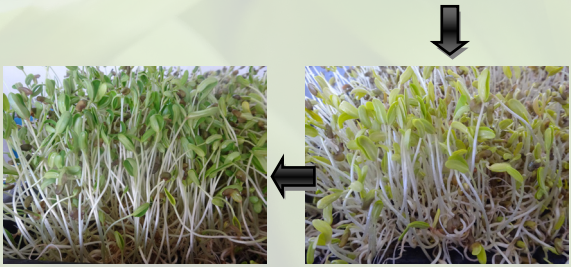
Day 0 Day 1 Day 2



Day 4 Day 3

Growth stages of hydroponic sun hemp fodder

Day 0 Day 1 Day 2



Day 4 Day 3

Growth stages of hydroponic jowar fodder

Day 0

Day 1

Day 2

Day 3

Day 4

Day 5

Day 6

Day 7

Day 8

Nutritional composition of different stages of growth of hydroponic maize fodder

SI. No	Type of hydroponic fodder	Day of growth	Moisture %	% Dry matter basis				
				CP	CF	EE	TA	NFE
1.	Maize (Purchased seed)	8	76.75	10.55	5.51	4.62	1.80	77.52
2	Maize Farm produced seed)	8	82.79	17.55	7.81	5.29	3.49	65.86
3.	Maize (Purchased seed)	7	70.92	9.83	5.78	3.62	1.98	78.79
4.	Maize (Purchased seed)	6	66.38	9.37	4.54	3.56	1.94	80.59
5.	Maize (Purchased seed)	5	61.49	9.41	3.40	4.23	1.51	81.45
6.	Maize (Purchased seed)	4	59.55	9.26	2.93	3.83	1.45	82.53
7.	Maize (Purchased seed)	3	49.43	9.22	2.37	4.34	1.38	82.69
8.	Maize (Purchased seed)	2	37.31	8.79	2.21	4.10	1.36	83.54
9.	Maize (Purchased seed)	1	39.26	8.72	2.50	3.92	1.43	83.43

Proximate analysis was done as per methods of AOAC, 2000.

Nutritional composition of different hydroponic fodder

Sl. No	Type of hydroponic fodder	Day of growth	Moisture %	% Dry matter basis				
				CP	CF	EE	TA	NFE
1.	**Maize**	8	76.75	10.55	5.51	4.62	1.80	77.52
2.	**Horse gram**	4	90.18	30.26	13.00	2.06	5.43	49.25
3.	**Sun hemp**	4	77.07	38.73	13.11	4.64	4.48	39.04
4.	**Cowpea**	4	77.93	27.84	6.51	1.93	4.88	58.84
5.	**Bajra**	4	74.80	9.22	4.16	4.57	1.49	80.56
6.	**Ragi**	4	87.86	10.62	8.80	2.52	2.95	75.11
7.	**Foxtail millet**	4	75.08	14.69	12.11	5.38	3.59	64.23
8.	**Jowar**	8	90.06	13.27	13.39	4.99	2.98	65.37
9.	**Moth bean**	8	94.37	38.83	18.91	2.63	6.61	33.02
10.	**Saamai (Little millet)**	8	83.60	13.46	15.74	4.75	8.11	57.94
11.	**Varagu (Kodo millet)**	8	80.97	8.87	15.21	3.15	4.08	68.69
12.	**Kuthiraivaali (Sanwa millet)**	8	86.40	10.70	19.61	4.39	11.60	53.70

Proximate analysis was done as per methods of AOAC, 2000.

Production details for different types of fodder

SI. No	Type of fodder	Seed : fodder production ratio (Kg.)
1	Maize	1.3 : 6.0
2	Cowpea	0.75 : 5.0
3	Horse gram	0.75 : 4.5
4	Ragi	1.0 : 3.5
5	Sun hemp	0.50 : 5.0
6	Bajra	1.0 : 3.0
7	Jowar	1.0 : 3.7
8	Foxtail millet	1.0 : 4.5
9	Moth bean	0.5 : 6.75
10	Kuthiraivaali (Sanwa millet)	1 : 8.6
11	Varagu (Kodo millet)	1 : 5.9
12	Saamai (Little millet)	1 : 5.9

Growth rate of hydroponic maize fodder

SI.No	Day of growth	Root length (cm)	Shoot length (cm)	No. of leaves/ plant
1	1	0.6±0.21	1.3±0.15	-
2	2	3.3±0.18	2.2±0.16	-
3	3	10.1±0.22	9.9±0.24	2
4	4	12.5 ±0.15	14.5±0.36	2
5	5	13.1±0.31	22.3±0.27	3
6	6	13.9±0.18	25.2±0.19	3
7	7	14.5±0.33	27.3±0.27	3
8	8	17.5±0.26	36.0±0.42	4

Maize fodder from Day 1 to Day 8

Growth rate of hydroponic horse gram fodder

SI. No	Day of growth	Root length (cm)	Shoot length (cm)	No. of leaves/plant
1	1	1.5±0.22	-	-
2	2	3.1±0.35	-	-
3	3	4.9±0.19	8.9±0.52	2
4	4	8.3±0.34	11.5±0.48	2

Horse gram fodder from Day 1 to Day 4

Growth rate of hydroponic sun hemp fodder

SI. No	Day of growth	Root length (cm)	Shoot length (cm)	No. of leaves/plant
1	1	_	1.1±0.37	_
2	2	2.4+0.12	5.3±0.26	2
3	3	5.8+0.26	12.5±0.18	2
4	4	10.2+0.25	16.1±0.26	2

Sun hemp fodder from Day 1 to Day 4

Growth rate of hydroponic jowar fodder

SI. No	Day of growth	Root length (cm)	Shoot length (cm)	No. of leaves/ plant
1	1	0.1±0.22	0.2±0.43	_
2	2	4.1±0.32	1.9±0.26	1
3	3	8.5±0.39	6.9±0.37	1
4	4	11.1±0.44	8.8±0.19	2
5	5	14.9±0.36	11.6±0.28	2
6	6	16.6±0.38	15.1±0.31	2
7	7	17.9±0.22	19.5±0.46	2
8	8	20.3±0.35	20.1±0.28	2

Jowar fodder from Day 1 to Day 8

Biomass of different hydroponic fodder

SI. No	Type of hydroponic fodder	Root biomass (%)	Shoot biomass (%)
1.	Yellow maize	70±0.52	30±0.49
2.	Horse gram	40±0.48	60±0.52
3.	Sun hemp	20±0.63	80±0.61
4.	Jowar	60±0.39	40±0.38

Sun hemp

Jowar

Horse gram

Yellow maize

Does it enhance livestock productivity?

Yes it is. The following are the benefits of feeding hydroponic fodder to livestock.

Young ones

- Faster weight gain.
- Good carcass quality.
- Lower feed cost per kg of weight gain.
- Improved health with low veterinary cost.

Adults

- Increased fertility – large litters.
- Low feed cost.
- High conception rate.

Lactating Animals

- Heavier, longer lactations.
- High milk yield.
- High fat percentage.
- Low feed costs.
- Increase in milk revenue.
- Increased fertility – fewer replacements.
- Improved herd health & longevity.
- Reduced culls.

Poultry

- Faster weight gain.
- Good carcass quality.
- Lower feed cost per kg of weight gain.
- Improved heath, low veterinary cost.
- More and higher quality eggs.

Protocol for fodder production

1. Seed storage and preparation

- Dry the seeds under direct sunlight one day prior to seed washing.
- Remove broken seeds and dirt's from the seeds.
- Store seeds in a dry and safe place.

Drying seeds under sunlight

2. Seed washing

- Take good quality seeds in a washing chamber.
- Add water.
- Wash the seeds with proper scrubbing by hand.
- Keep for settling for 5 minutes.
- Remove the light weight floating seeds.
- Drain out water and again add water.
- Stir manually by wooden stick for 5 minutes, keep settling for 5 minutes.
- Drain water.
- Repeat the above steps till, dirt and dead seeds are removed completely.

Stirring

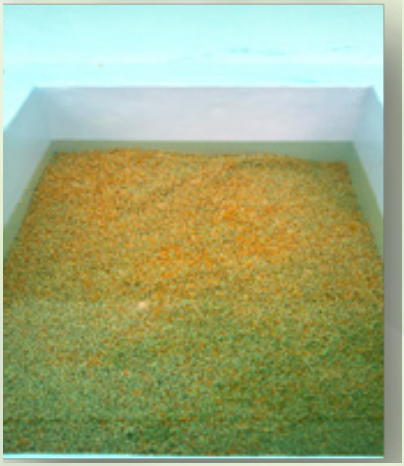
3. Seed cleaning

- Prepare 0.1% cleaning solution in a plastic chamber as given in the table below.
- Add washed seeds to this 0.1% cleaning solution.
- Stir manually by wooden stick for about 5 minutes.
- Keep for 1 HOUR.
- Drain the cleaning solution.

Seeds added to cleaning solution

4. Seed soaking

- Prepare stimulant Solution in the soaking chamber as per quantity given in the table below.
- Add seeds from the above steps to the soaking chamber.
- Close the lid and keep for soaking for number of hours as given in the table below for the given seeds.
- After soaking for the given hours, drain the stimulant solution.



Soaking seeds in the soaking chamber

5. Seed germination

- Cover/ place the "After soaking seeds" with the clean dry fumigated gunny bag.
- Keep the seeds loaded gunny bags away from direct sunlight.
- Keep the lid open & keep for germination for number of hours as mentioned for the given seed in the table below.
- Sprinkle water on gunny bag every 2-3 hours so that the gunny bag remains wet.
- After given hours, remove the seeds from gunny bag take weight.

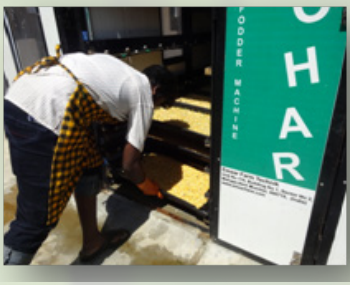
- About 35 to 40% increase in weight happen with about 90+% seed germination.

Seed germination – Gunny bags

6. Loading seeds in trays and racking

- Ensure that the trays are clean, washed with cleaning solution & are free from any dust / dirt etc.
- Transfer "after germination seeds" on the trays equally and put them in the sprout section (lower section where the height between two rows is around 5 inches) of machine
- Trays should be distributed evenly on both sides of the alley.

Sprouted seed loaded tray



Loading tray into the machine

7. Shifting of trays

- Shift trays to next level daily so that it move one step ahead in the growth cycle.
- Take the last tray out from every row and put it back on the front side of the same row.
- Ensure that all trays are moved one position every day
- Ensure that all trays receive sufficient water.
- If left side of the tray (in any tray) shows more growth then the right side (or vice-versa) then rotates the tray such that left side comes to the right side and right side of the tray goes to the left side.

8. Harvesting (Day 9)

- Trays on the 8th day rack are ready for harvest on the next day.
- Take out of the fodder mat from trays to feed livestock.
- Wash the trays in clean water and then in cleaning solution before reusing it for the next cycle.

Machine specific solution, water and seed quantity

Machine size (kg /day output)	Re-quired seed	Re-quired washing water (Liters)	Re-quired cleaning solution	Re-quired soaking solution	Re-quired trays for day	Re-quired cleaning solution daily in water tank
125	18	30	200 ml in 20 liters water	15 gm in 30 liters water	8	100
200	30	50	500 ml in 50 liters water	20 gm in 40 liters water	16	200
250	37	75	500 ml in 50 liters water	25 gm in 50 liters water	20	250
500	75	150	750 ml in 75 liters water	40 gm in 80 liters water	40	500
750	110	200	2000 ml in 200liters water	75 gm in 150 liters water	60	750
1000	150	300	2000 ml in 200 liters water	100 gm in 200 liter water	80	1 liter

Control panel automation settings

Parameters	Crop				
	Maize	Jowar	Barley	Wheat	Bajra
Seed washing time hrs	0.5	0.5	0.5	0.5	0.5
Seed cleaning time hrs (Cleaning solution)	1	1	1	1	1
Seed soaking time hrs (in 500 ppm stimulant solution)	20	12	10	6	15
Germination time hrs (in 100 ppm cleaning solution)	24	10	8	6	15
Temperature set ^{0}C	24 (± 2^{0}C)	23 (± 2^{0}C)	20 (± 3^{0}C)	20 (± 3^{0}C)	24 (± 3^{0}C)
Light on time hrs	9 hrs	10 hrs	10 hrs	10 hrs	10 hrs
Light off time hrs	15 hrs	14 hrs	14 hrs	14 hrs	14 hrs
Water on time minutes	4	3	3	3	4
Water off time hrs	3	6	6	6	5
Ozone on time minutes	30	30	30	30	30
Ozone off time minutes	30	30	30	30	30
UV light on time minutes	5	5	5	5	5
UV light off time hrs	23.55	23.55	23.55	23.55	23.55

- Above are the ideal conditions to grow different kinds of Fodder crops.
- Seeds quality and their germination rate are important elements in the success of the healthy fodder growth.
- Good agriculture practice involves clean machine, clean water and clean operating conditions. This helps in avoiding bacteria / fungus / pathogens growth.
- Parameters can be changed based on the observations.

Control panel

Ozone generator

UV light

Protocol for water tank maintenance

- Water sanitation: provide daily 5% cleaning solution dosing to external water tank to prevent from microbial / algae/ fungus growth.

Water tank cleaning:

- Change water in the external water tanks after every 3 days.
- Drain the tank completely.
- Let the tank dry.
- Clean the tank properly.
- Fill with fresh water.

Tank cleaning

Water filter cleaning

- Clean water filter thrice a day.
- Remove the cleaning lid on the filter.
- Clean the filter.
- Replace the filter.
- Turn on the pump to ensure that filter throws out water from the opening this way, filter will also throw out any accumulated dirt along with water.
- Close the lid.

Removal of filter

Washing of filter

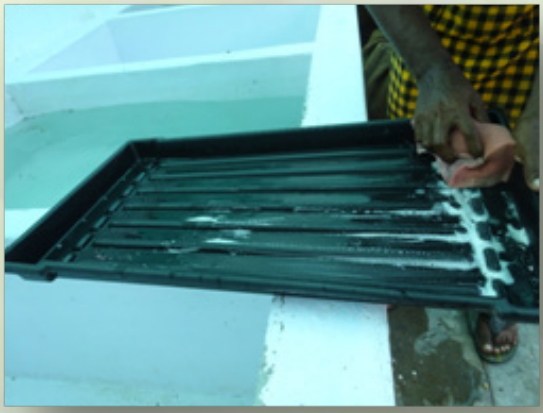
Cleaned filter

Reassembly of filter

Protocol for equipment maintenance

Tray cleaning:

- Clean the trays regularly after final fodder removal.
- After removal of final fodder, clean the tray with fresh water
- After cleaning the trays wipe the trays using 0.5% cleaning solution or disinfectants.



Cleaning of trays

Chamber cleaning

- Clean seed washing and soaking chamber, aluminum stool, gunny bag etc. regularly after every soaking and germination cycle.
- Clean the equipments with fresh water.
- After cleaning with fresh water, clean using 0.5% cleaning solution or disinfectants.

Protocol for machine maintenance

Machine cleaning

- For control of fungus / molds, sterilize the machine regularly twice in a month.
- Switch off power supply of the machine.
- Remove all trays out of the machine.
- Clean all inner surfaces of the machine e.g. aluminum pipes, tube light covers, drips, lateral pipe, PVC pipe etc use detergent solution and hard brush that can reach to all surfaces to remove any seeds, dirt material, algae or any possible fungus spore that could have grown due to high humidity inside the chamber
- Use jet cleaner pump (cold jet pressure pump) for the cleaning (pump pressure should be minimum 120-130 bar)
- Wipe the inner surfaces using 0.5 % cleaning solution or disinfectant.
- Keep the trays inside the machine & switch mains power supply on.
- If uncontrollable fungal growth noticed fumigation using Formalin (40 %) and Potassium permanganate can be done.

Lateral acid wash

- Acid wash the lateral pipes as whenever chocks in the drippers / sprinklers are observed or once in a month routinely.
- Take all the trays out of the machine
- Prepare 0.6% acid solution in the given machine wise quantity as below.
- Place the solution in the tub and attach it with the venturi tube.
- Start the water pump for 45 sec – 1 minute till water gets filled in the laterals and just start to come from the drippers.
- Stop the pump with the first drop of water from the last dripper.
- Repeat the above steps for 2 to 3 times.
- Open the end caps of laterals.
- Stop the venturi valves and flush the laterals with fresh water from tank for 6-8 minutes till all dirt get removed.
- Close the end caps again and put the trays back in the system.

Venturi for lateral wash

Acidified water being pumped through venturi

Machine specific ACID solution quantity for ACID wash

Machine size (kg / day / output	Required acid (0.6% solution)	Required water	Where to add the ACID
125	205 ml	12 liter	Filter
250	428 ml	25 liter	Filter
500	858 ml	50 liter	Ventury
750	1120 ml	70 liter	Ventury
1000	1542 ml	90 liter	Ventury

Protocol for unit area maintenance

- Have foot bath at the entrance of the unit.
- Fill the foot bath with disinfectants.
- Change the disinfectant daily.
- Follow separate way for the entry and exit for workers.
- Avoid stray animals' entry into the unit.
- Avoid rodents' entry into the unit as well as the seed storage room.
- Keep the area clean.
- Avoid frequent entry of visitors into the unit and the working area.

Footbath

Hygienic measures

- Personnel hygienic measures should be followed by the persons working in and around the machine.
- Follow separate ways for the entry of seed into the machine (seed inlet) and exit of full grown fodder out of the machine (fodder outlet).

Seed inlet

Fodder Outlet

- It is advisable to wear clean cloths, apron, caps and rubber gloves and separate chapels while carrying out work in the hydroponic machine.

Personnel hygiene

- Disinfect the apron, rubber gloves and chapels with disinfectant solutions before starting the work and entering into the machine.
- Do not use the same gloves for shifting trays that has been used for loading seeds as seeds may contain some fungal spores that would spoil the fodder production.
- Do not enter into seed storage room before working necessary.
- Only one person is advisable to work inside the machine to minimise the microbial load.
- Another person from outside the machine should assist the worker inside the machine in removing the grown fodder and in shifting the trays.

Only one person working inside the machine

Daily routine for workers

In the working area

Worker wearing cap and apron

- Wear apron and cap.
- Prepare disinfectant solution for foot bath and for washing tank, trays, chapels and rubber gloves.
- Fill the foot bath with disinfectants.
- Disinfect the chapels and rubber gloves in the solution and wear them.
- Check the sprouted seeds for any abnormalities.
- Load the sprouted seeds onto the trays for racking into the machine.
- Hand over the seed loaded trays to the person working inside the machine.
- Take the required quantity of seed for soaking from the seed storage room.
- Follow the protocol for soaking and sprouting seeds as discussed previously.
- If using gunny bags for sprouting, disinfect the gunny bags before and after use.
- Check the water tank for the quality of the recycling water and change if necessary.
- Take out and clean the water filter daily.
- Clean all the working area with disinfectant solution and finish the work.

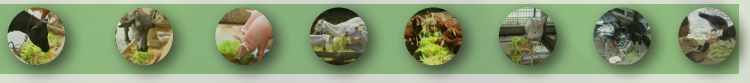
Working inside the machine

- Wear apron and cap.
- Disinfect the chapels and rubber gloves in the solution and wear them.
- Inspect the whole machine and fodder for any undesirable happenings.
- Remove the fully grown fodder from the machine through fodder outlet door.
- Shift the trays to next levels as discussed previously.
- Rack the seed loaded trays in the machine through seed inlet door.
- Clean the floor of the machine completely with some disinfectant solution.
- Clean the doors with disinfectant solution before closing the doors.
- Do not reopen the door unnecessarily.

Worker working inside the machine

Troubleshooting

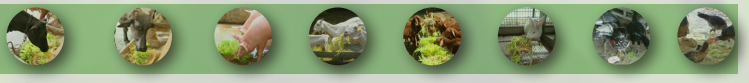
Poor germination	-	Check the seed quality.
	-	Buy seeds from farmers rather than seed shops.
	-	Buy seeds with less wastes and unbroken tips.
	-	Do not buy seeds stored for a prolonged duration.
	-	Check the moisture content of the seed (seed should have less than 12% moisture).
	-	Check the water quality.
	-	Do not over load the trays with high quantity of seeds.
	-	Avoid fluctuation of electric current.
Fungal attack	-	Check the fungal (Afflatoxin) level in the seeds. 1 ton of grain comes with 100 billion mould spores
	-	Check the sprouted seeds for fungal growth. Do not sprout the seeds in an air tight closed chambers. Sprouts and mould grow in a warm and wet environment.
	-	Check the machine fungal growth.
	-	Check for leakage of rain water into the machine.
	-	Check the recycling water in the tank.
	-	Clean the water tank periodically.
	-	Clean the machine twice a month.
	-	Clean the sprinklers.
		Follow hygienic measures.
	-	Check for water logging inside the machine.
	-	Check the water draining holes for any block.
	-	Check for clogging of sprinklers.



Bleaching of leaves	-	Check chlorine level in the water.
	-	Reduce chlorine level used for sanitation of water.
Drying of leaves	-	Check for the fluctuation in cooling system and the condition of AC.
Pouring of water over plants	-	Check the pipelines and sprinklers for clogging.
Stagnation of water inside the machine	-	Check the filters for clogging.
Poor water quality in the storage tank	-	Check the status of UV light.
	-	Check the water filters.

Check list for machine performance

- Condition of ozone
- Condition of UV light
- Sprinkler and drippers status
- Tube light status
- Condition of air conditioner and circulatory fans
- Temperature inside the machine
- Condition of fodder
- Cleanliness of water
- Cleanliness of machine
- Condition of blower fans
- Condition of exhaust fans
- Condition of water filters
- Seed and water quality
- Personnel hygiene
- Condition of water draining system.
- Due for water tank cleaning
- Due for lateral acid wash for pipelines
- Due for machine cleaning



Organic fungicidal treatments

These recipes were safe for animals.

Recipe: 1

- Mix 20 - 25 g of baking soda into 3.78 litres of water.
- Spray onto the seeds and infested plant parts.

Recipe: 2

- Mix 20 g of Potassium bicarbonate into 3.78 litres of water.
- Spray onto the seeds and infested plant parts.

Biological fungicide

- Selected strains of Bacillus subtillus are used as biological fungicide.
- It works both as a fungicide and a plant promoting rhizhophere bacteria.
- Mode of action:
  - Substrate competition for space and nutrients.
  - Mycoparacitism
  - Enzyme production.

Usage

- Mix 10 g of the wettable powder of Bacillus subtillus 1x 108 CFU/g in one liter of water.
- Spray over the infested plant parts.
- Can be re - sprayed at an interval of 8 – 9 days.

*Bacillus subtillus is approved for use as feed ingredient for animals by Association of American Feed Control Officials and The Canadian Food Inspection Agency. However, trials have been planned to study the actual effectiveness and the effect the above organism on animals.

Machine specification

Hydroponic machine consist of

- Growing chamber which consist of sprout section where the height between two rows is around 5 inches (day 1 to 4) and the growth section where the height between two rows is around 13 inches (day 5 to 8).
- Automated control system –Environment control system.
- Air cooling unit – Air conditioning unit with air blowers.
- Water recycling unit – UV light, filters and ozone.

Special features

- Daily electricity consumption – 35 -40 units.
- Water drainage in less than 3 minutes.
- Artificial light control for photosynthesis.
- Water sterilization control
- Water flow control
- Water recycling system
- Uniform air circulation through multiple circulatory fans.

1000 kg capacity hydroponic machine

Palatability trial

Sl. No	Animal	Type of hydroponic green fodder fed	Duration of study (Days)	Maximum intake / Animal/ Day
1	Cattle	Maize	7	15 Kg
2	Buffalo	Maize	7	15 Kg
3	Goat (Adult -Lactating)	Maize	7	2 Kg
4	Goat grower	Maize	7	1 kg
5	Goat grower	Horse gram	7	300 g
6	Goat grower	Sun hemp	7	250 g
7	Goat kid	Maize	7	0.5 Kg
8	Sheep (Adult)	Maize	7	1 Kg
9	Sheep grower	Maize	7	0.5 Kg
10	Pig – (Lactating)	Maize	7	2 Kg
11	Pregnant sow & gilt	Maize	7	1.5 Kg
12	Rabbit (Lactating)	Maize	7	150 g
13	Rabbit grower	Maize	7	100 g
14	Rabbit grower	Horse gram	7	100 g
15	Rabbit grower	Sun hemp	7	150 g
16	Turkey (Adult)	Maize	7	200 g
17	Desi chicken (Adult)	Maize	7	50 g
18	J. Quail (Grower)	Foxtail millet	15	50 g

Feeding trial

Effect of hydroponic maize fodder with replacement of 50 %, 100%, CO4 grass on milk production in dairy cattle

Type of feed	Treatment 1	Treatment 2	Treatment 3
	Control	50% replacement of CO4 grass	100% replacement of CO4 grass
CO4 grass	20 kg	10 kg	0
Hydroponic maize fodder	0	5.8 kg	11.6 kg

Parameters studied

- Milk yield and quality prior to treatment.
- Milk yield and quality during treatment.

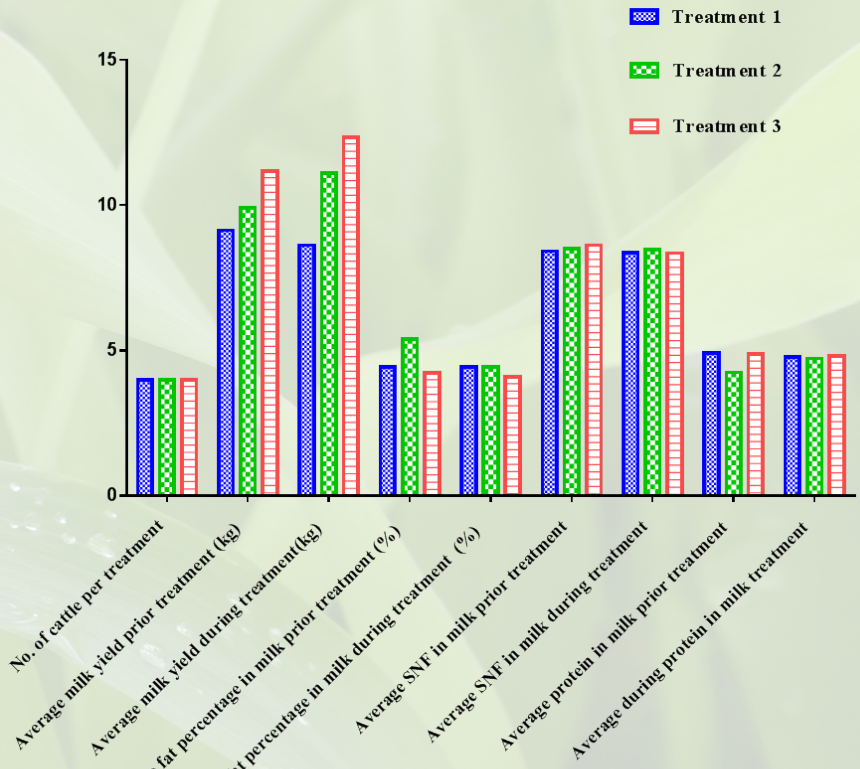
Result

Significance between treatments

Attributes	Treatment 1	Treatment 2	Treatment 3
No. of cattle per treatment	4	4	4
Average milk yield prior treatment (kg)	9.14 ± 0.54^{a}	9.90 ± 0.70^{a}	11.18 ± 0.60^{a}
Average milk yield during treatment (kg)	8.62 ± 0.54^{a}	11.11 ± 0.52^{a}	12.34 ± 0.70^{a}
Average fat percentage in milk prior treatment (%)	4.43 ± 0.38^{a}	5.40 ± 0.40^{a}	4.23 ± 0.47^{a}
Average fat percentage in milk during treatment (%)	4.43 ± 0.24^{a}	4.43 ± 0.30^{a}	4.09 ± 0.22^{a}
Average SNF in milk prior treatment	8.42 ± 0.31^{a}	8.50 ± 0.35^{a}	8.62 ± 0.17^{a}
Average SNF in milk during treatment	8.37 ± 0.18^{a}	8.47 ± 0.17^{a}	8.35 ± 0.12^{a}
Average protein in milk prior treatment	4.91 ± 0.45^{a}	4.25 ± 0.48^{a}	4.87 ± 0.49^{a}
Average during protein in milk treatment	4.77 ± 0.22^{a}	4.72 ± 0.23^{a}	4.80 ± 0.21^{a}
Total feed intake /head/day (kg) (DM basis)	10.22±0.48 a	8.15±0.23 a	8.10±0.36 a

Means with different superscript in the same row differ significantly ($P < 0.05$)

Effect of hydroponic maize fodder with 50% and 100% replacement of CO4 grass on the milk yield and quality in dairy cattle



Production parameters significance in the same group before and during treatment

Attributes	Prior treatment	During treatment
Treatment 1	4	4
Average milk yield (kg)	9.14±0.54[a]	8.62±0.54[a]
Average fat percentage in milk (%)	4.43±0.38[a]	4.43±0.24[a]
Average SNF in milk	8.42±0.31[a]	8.37±0.18[a]
Average protein in milk	4.91±0.45[a]	4.72±0.23[a]
Treatment 2	8.42±0.31[a]	8.50±0.35[a]
Average milk yield (kg)	9.90±0.70[a]	11.11±0.52[a]
Average fat percentage in milk (%)	5.40±0.40[a]	4.43±0.30[a]
Average SNF in milk	8.50±0.35[a]	8.47±0.17[a]
Average protein in milk	4.25±0.48[a]	4.72±0.23[a]
Treatment 3	1.19±1.57[a]	0.73±0.14[a]
Average milk yield (kg)	11.18±0.60[a]	12.34±0.70[a]
Average fat percentage in milk (%)	4.23±0.47[a]	4.09±0.22[a]
Average SNF in milk	8.62±0.17[a]	8.35±0.12[a]
Average protein in milk	4.87±0.49[a]	4.80±0.21[a]

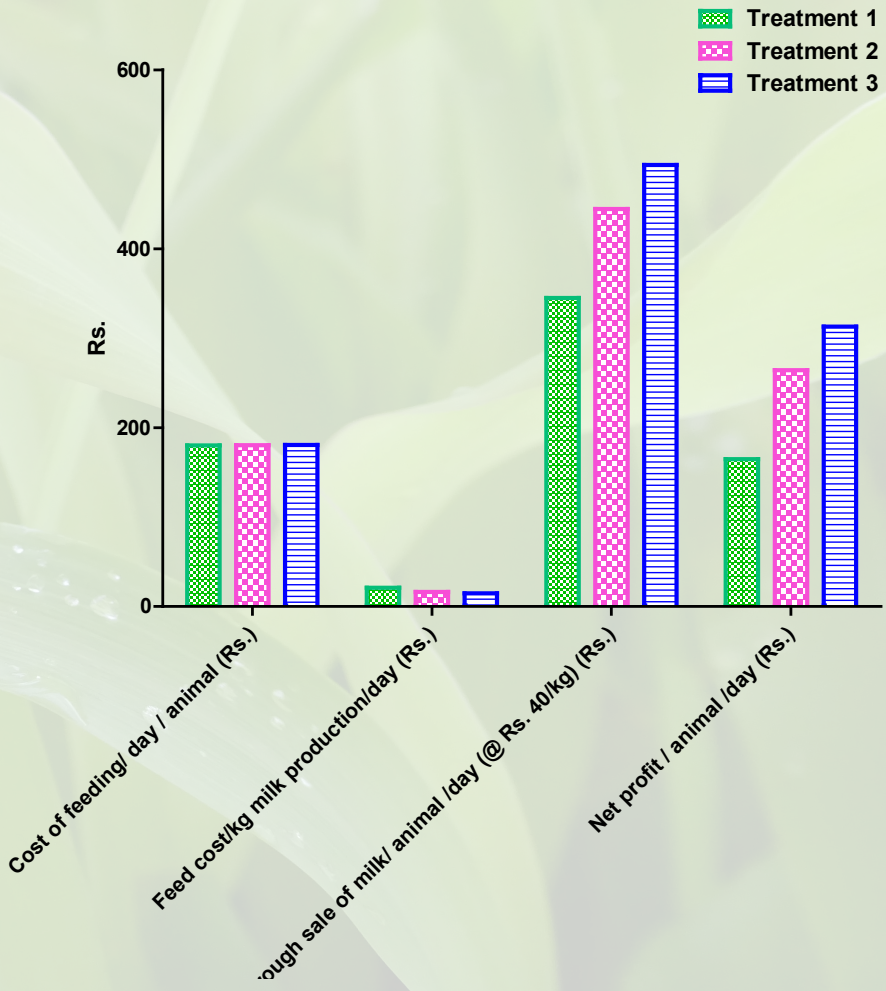
Means with same superscript in the same row do not differ significantly (P > 0.05)

Economics of feeding

Sl. No.	Attributes	Treatment 1	Treatment 2	Treatment 3
1.	Cost of feeding/ day / animal (Rs.)	180±0.32[a]	180.3±0.25[a]	180.6±0.19[a]
2.	Feed cost/kg milk production/day (Rs.)	20.88±0.42[c]	16.23±0.47[b]	14.6±0.51[a]
3.	Income through sale of milk/ animal /day (@ Rs. 40/kg) (Rs.)	344.8±0.36[a]	444.4±0.54[b]	493.6±0.46[c]
4.	Net profit / animal /day (Rs.)	164.8±0.39[a]	264.1±0.51[b]	313.0±0.28[c]

Means with different superscript in the same row differ significantly (P < 0.01)

Economics of feeding



Salient findings

- Hydroponic maize fodder is an alternate to conventional green fodder as both of them have similar effect on milk yield and quality

Effect of hydroponic horse gram fodder with replacement of concentrate mixture in growth performance of goat kids

Type of feed	Treatment 1	Treatment 2
	Control	50% replacement of concentrate
Concentrate	150 g	75 g
Hydroponic horse gram fodder	0	379.2 g

Production parameters studied

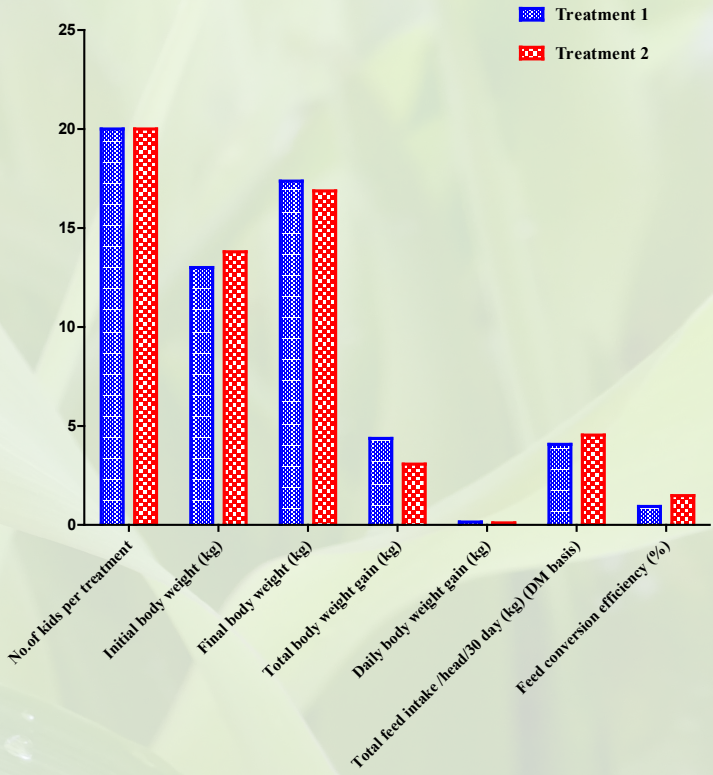
- Daily weight gain
- Feed efficiency
- Feed consumption

Result

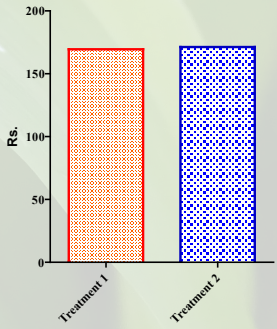
Attributes	Treatment 1	Treatment 2
No. of kids per treatment	20	20
Initial body weight (kg)	13 ± 0.25^{a}	13.8 ± 0.33^{a}
Final body weight (kg)	17.37 ± 0.39^{a}	16.87 ± 0.39^{a}
Total body weight gain (kg)	4.37 ± 0.37^{a}	3.07 ± 0.38^{a}
Daily body weight gain (kg)	0.15 ± 0.43^{a}	0.10 ± 0.32^{a}
Total feed intake /head/30 day (kg) (DM basis)	4.07 ± 0.58^{a}	4.54 ± 0.43^{a}
Feed conversion efficiency (%)	0.93 ± 0.21^{a}	1.48 ± 0.31^{a}
Cost of feeding for 30 days (Rs.)/animal	169.5 ± 0.49^{a}	171.33 ± 0.52^{a}

Means with same superscript in the same row do not differ significantly ($P > 0.05$)

Effect of feeding hydroponic horse gram fodder with 50% replacement of concentrate in the growth rate of Tellicherry kids



Cost of feeding/animal/30 days



Salient findings

- Hydroponic horse gram fodder can be used as an alternate to concentrate in kids.

Effect of hydroponic sun hemp fodder with replacement of concentrate mixture in growth performance of goat kids

Type of feed	Treatment 1	Treatment 2
	Control	50% replacement of concentrate
Concentrate	150 g	75 g
Hydroponic sun hemp fodder	0	128.78 g

Production parameters studied

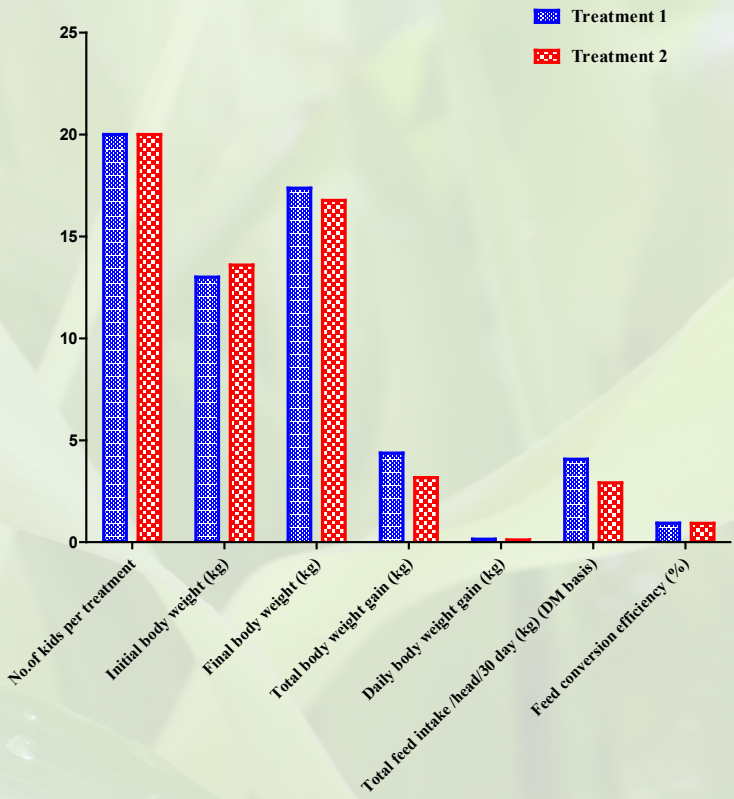
- Daily weight gain
- Feed efficiency
- Feed consumption

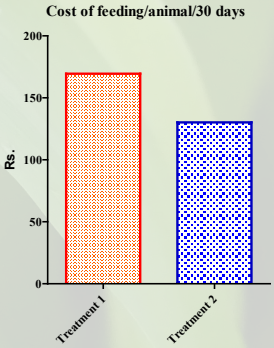
Attributes	Treatment 1	Treatment 2
No. of kids per treatment	20	20
Initial body weight (kg)	13 ± 0.25^{a}	13.6 ± 0.29^{a}
Final body weight (kg)	17.37 ± 0.39^{a}	16.77 ± 0.36^{a}
Total body weight gain (kg)	4.37 ± 0.37^{a}	$3.17 + 0.41^{a}$
Daily body weight gain (kg)	0.15 ± 0.43^{a}	0.11 ± 0.38^{a}
Total feed intake /head/30 day (kg) (DM basis)	4.07 ± 0.58^{a}	2.91 ± 0.23^{a}
Feed conversion efficiency (%)	0.93 ± 0.21^{a}	0.92 ± 0.31^{a}
Cost of feeding for 30 days (Rs.)/ animal	169.5 ± 0.49^{b}	130.23 ± 0.68^{a}

Means with same superscript in the same row do not differ significantly ($P > 0.05$)

Means with different superscript in the same row differ significantly ($P < 0.01$)

Effect of feeding hydroponic sun hemp fodder with 50% replacement of concentrate in the growth rate of Tellicherry kids





Salient findings

- Hydroponic sun hemp fodder can be used as an alternate to concentrate in kids.

Effect of hydroponic maize fodder with replacement of concentrate mixture in growth performance in rabbits – grower

Type of feed	Treatment 1	Treatment 2	Treatment 3
	Control	25% replacement of concentrate	50% replacement of concentrate
Concentrate	50 g	37.5 g	25 g
Hydroponic maize fodder	0	76.78 g	153.56 g

Production parameters studied

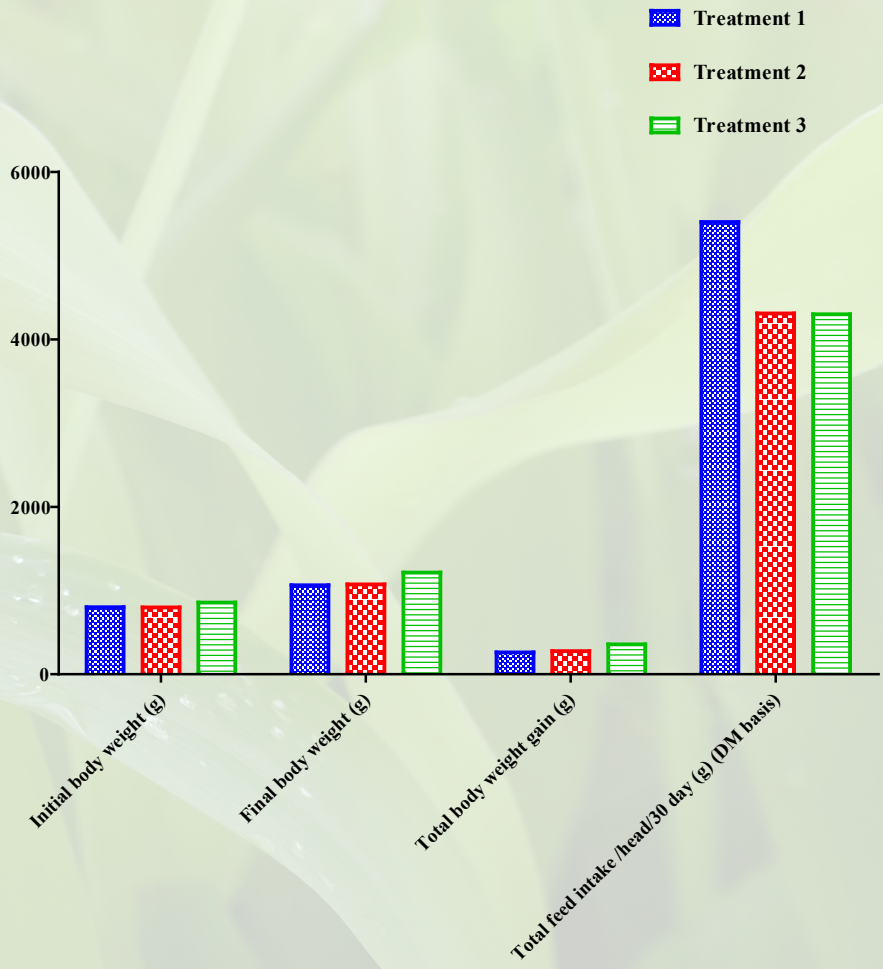
- Daily weight gain
- Daily feeding intake
- Feed efficiency

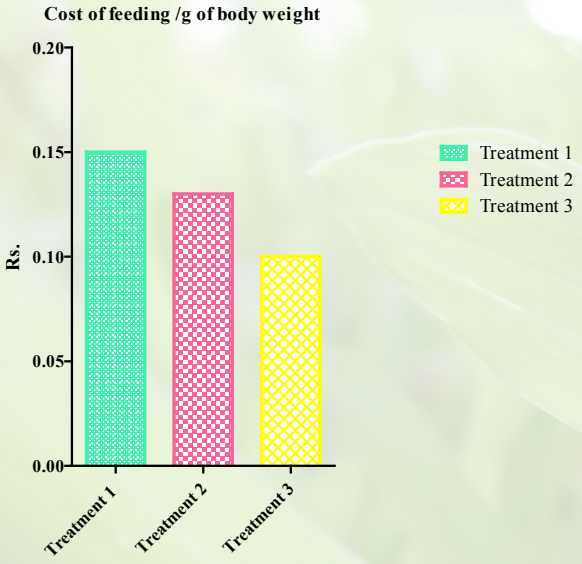
Results

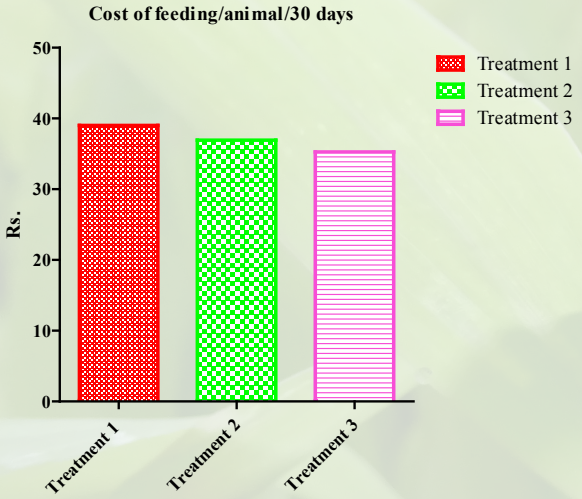
Attributes	Treatment 1	Treatment 2	Treatment 3
No. of bunnies per treatment	4	4	4
Initial body weight (g)	800±9.21^{a}	797.5±4.87^{a}	857.5±6.61^{a}
Final body weight (g)	1062±5.18^{a}	1073±7.39^{a}	1214.5±5.19^{a}
Total body weight gain (g)	262±10.57^{a}	275.5±7.18^{a}	357±5.55^{a}
Daily body weight gain (g)	8.73±0.46^{a}	9.18±0.52^{a}	11.90±0.58^{a}
Total feed intake /head/30 day (g) (DM basis)	5400±0.43^{a}	4310±0.38^{a}	4300±0.29^{a}
Feed conversion efficiency (%)	20.61±0.21^{a}	15.64±0.19^{a}	12.04±0.15^{a}
Economics of feeding			
Cost of feeding/animal/30 days	39±0.58^{a}	36.94±0.42^{a}	35.25+0.39^{a}
Cost of feeding / g body weight	0.15+0.58^{a}	0.13+0.42^{a}	0.10+0.39^{a}

Means with same superscript in the same row do not differ significantly (P > 0.05)

Effect of hydroponic maize fodder with 25% and 50% replacement of concentrate in growth performance of bunnies







Salient findings

- Hydroponic maize fodder can be used as an alternate to concentrate in bunnies.

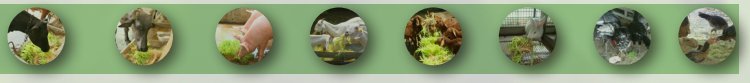
Cost of production of hydroponic fodders in commercial machine

Particulars	Amount (Rs)
Cost of maize seed	Rs. 14.50 Kg (Purchased from outside)
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (7 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic maize fodder	Rs. 2.10 (maize seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.70 (Labour cost) = Rs.3.0 per Kg

Particulars	Amount (Rs)
Cost of horse gram seed	Rs. 30 per Kg
Quantity of seed per tray	0.75 kg
Seed cost per tray	Rs. 22.5
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (5 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic horse gram fodder	Rs. (4.50 seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.90 (Labour cost) = Rs.5.6 per Kg

Particulars	Amount (Rs)
Cost of sun hemp seed	Rs. 30 per Kg
Quantity of seed per tray	0.50 kg
Seed cost per tray	Rs. 15
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (5 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic horse gram fodder	Rs. (3.00 seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.90 (Labour cost) = Rs.4.10 per Kg

Particulars	Amount (Rs)
Cost of bajra seed	Rs. 19 per Kg
Quantity of seed per tray	1 kg
Seed cost per tray	Rs. 19
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (3 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic bajra fodder	Rs. (6.33 seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.90 (Labour cost) = Rs.7.43 per Kg

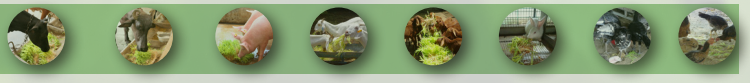


Particulars	Amount (Rs)
Cost of ragi seed	Rs. 26 Kg (Purchased from outside)
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (3.5Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic ragi fodder	Rs. 7.42 (seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.70 (Labour cost) = Rs.8.32 per Kg

Particulars	Amount (Rs)
Cost of foxtail millet seed	Rs. 37 per Kg
Quantity of seed per tray	1 kg
Seed cost per tray	Rs. 37
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (4.5 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic foxtail millet fodder	Rs. (8.22 seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.90 (Labour cost) = Rs.9.32 per Kg

Particulars	Amount (Rs)
Cost of jowar seed	Rs. 26 Kg (Purchased from outside)
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (3.7 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic jowar fodder	Rs. 7 (seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.70 (Labour cost)= Rs.7.90 per Kg

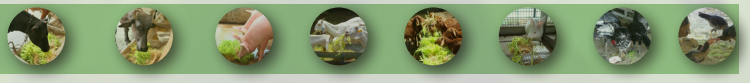
Particulars	Amount (Rs)
Cost of moth bean seed	Rs. 25 Kg (Purchased from outside)
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (6.75 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic jowar fodder	Rs. 1.85 (seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.70 (Labour cost)= Rs.2.75 per Kg



Particulars	Amount (Rs)
Cost of saamai seed	Rs. 25 Kg (Purchased from outside)
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (6 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic saamai fodder	Rs. 4.20 (seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.70 (Labour cost) = Rs.5.10 per Kg

Particulars	Amount (Rs)
Cost of varagu seed	Rs. 25 Kg (Purchased from outside)
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (6 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic varagu fodder	Rs. 4.20 (seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.70 (Labour cost) = Rs.5.10 per Kg

Particulars	Amount (Rs)
Cost of kuthiraivaali seed	Rs. 25 Kg (Purchased from outside)
Current consumption	40 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (4.3 Kg)	0.5 unit or Rs. 2 per tray
Labour cost for production of 1 tray	4.5
Cost of production of one Kg of Hydroponic kuthiraivaali fodder	Rs. 2.90(seed cost) + Rs. 0.20 (Current bill cost) + Rs. 0.70 (Labour cost)= Rs.3.80 per Kg



TANUVAS – URF - Low cost hydroponic device

- Hydroponic devices available commercially are meant for large scale production especially designed to meet the fodder requirement of medium to large scale livestock farms.
- These devices are very expensive, that a livestock farmer having 2- 5 animals and having no land source for green fodder production to feed their livestock cannot afford.
- In order to ameliorate this problem, a low cost hydroponic device has been designed at TANUVAS with a production capacity of 40 kg/day.
- This device is a semi automatic device in which the sprinklers switch has to be switched on manually every 2 hours during day time.
- The device is fitted with air cooler and exhaust fan which works throughout the day to maintain the ideal temperature of 25 – 28^{0}C.
- LED lights were provided inside the device which has to be turned on during night time for photosynthesis.

- Provided with side panels to allow sunlight during daytime for photosynthesis.
- The water used will be collected in a tank and recycled for period of 3 days after which the tank has to be refilled with fresh water.
- Water requirement is 100 litres / 3 days.
- The device consists of 8 rows with the holding capacity of 4 trays per row.
- Each tray can hold a seed rate of 1- 2.0 kg to produce hydroponic fodder ranges from 5 to 12 kg.
- Provided with wheels to move it to any desired location.
- Require only 25 sq.ft / machine.
- Different types of seeds the can be grown in to hydroponic fodder are maize, sun hump, horse gram, jowar and moth bean etc.,
- It is simple and rural friendly and can be maintained by the farmer itself.
- It can be purchased from University Research Farm, TANUVAS by placing order.
- Cost Rs.48,000/-

Cost of production

Particulars	Amount (Rs)
Cost of maize seed	Rs. 14.50 Kg (Purchased from outside)
Current consumption	2 units / day
Cost of one unit current consumption	Rs. 4 per unit
Cost of current for production of 1 tray (6 Kg)	0.5 unit or Rs. 2 per tray
Cost of production of one Kg of Hydroponic maize fodder	Rs. 2.10 (maize seed cost) + Rs. 0.20 (Current bill cost) = Rs.2.30 per Kg

For more information please contact

Postal Address

The Professor and Head
University Research Farm
Tamil Nadu Veterinary and Animal Sciences University
Madhavaram Milk Colony, Chennai - 600 051

Phone & Email

Phone : 044-2555 1571; e-mail : urf@tanuvas.org.in

DD in favour of

The Professor and Head, URF, Chennai - 51

For online transaction

Bank Name	:	Union Bank of India
Branch	:	Madhavaram
Account No.	:	332902010726941
IFSC code	:	UBIN0533297

Remarks :

- ✪ Low cost hydroponic device will be delivered about 40 days from the date of order
- ✪ Transportation arrangements should be made at your own cost