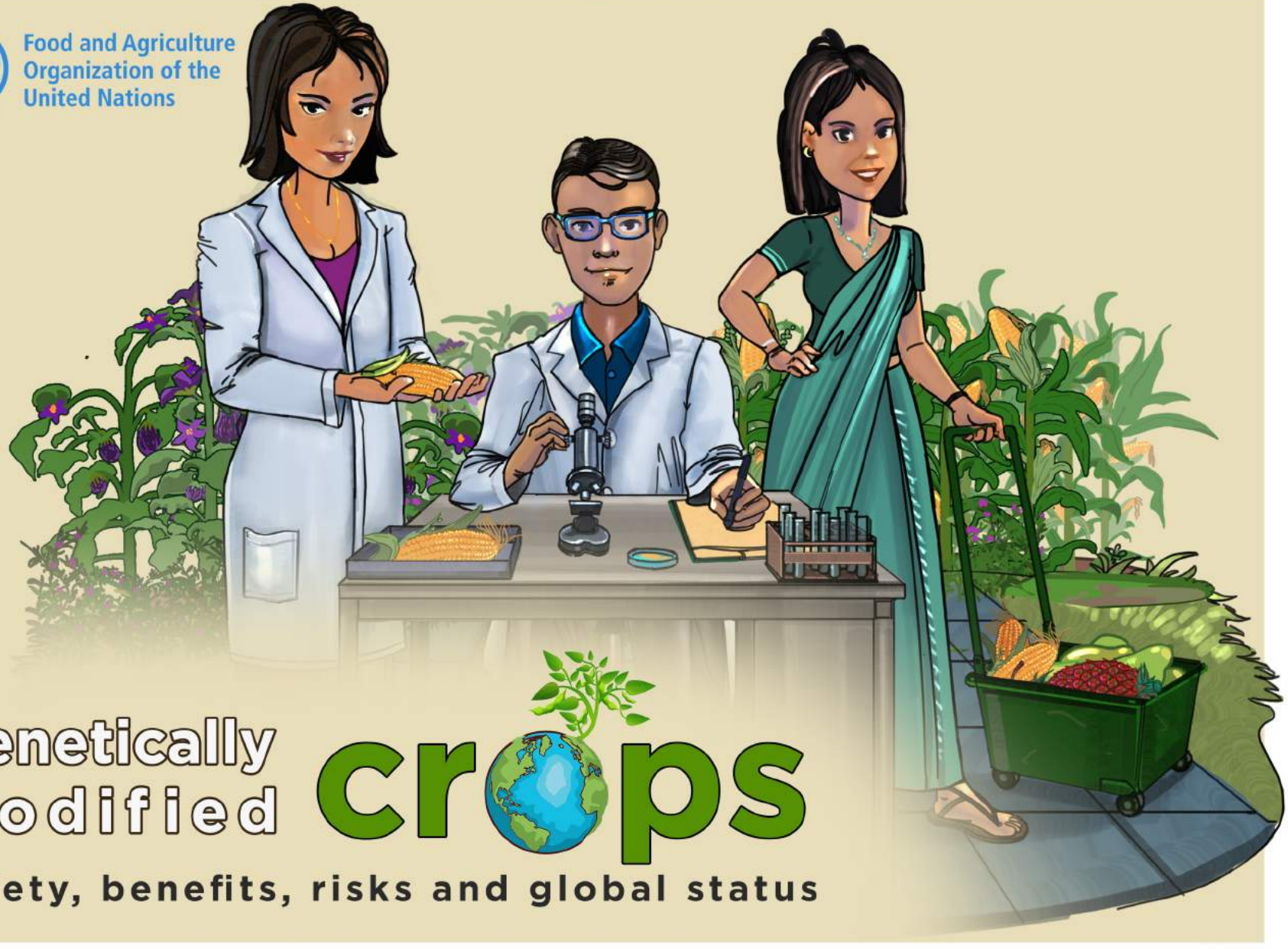
Food and Agriculture Organization of the United Nations



Genetically modified crops

Safety, benefits, risks and global status

FAO. 2022. *Genetically modified crops: Safety, benefits, risks and global status.* Colombo.

Introduction

When any fruits or vegetables look extraordinarily good such as sweeter, seedless, bigger or juicier, they are misconceived to be genetically modified (GM) crops. This set of flash cards provides factual information on all the approved and commercialised GM crops globally; their traits; benefits; and potential risks. The cards also provides the biosafety information on how the risks are assessed and managed.

Genetically modified (GM) crops

GM crops are crops that have gene(s) inserted from the same or unrelated organism using genetic engineering methods. The genes confer beneficial traits such as pest resistance, ability to grow in extreme and unfavorable conditions and increased nutrient levels among others.

Biosafety

Set of measures and actions that addresses the safety of genetically modified organisms (GMOs) to human, animal and environment. These are based on scientific evaluations.

Food and feed safety: For human and animals

All GM food crops undergo food and feed safety assessment to identify new or altered hazards associated with the food as a result of the genetic modification. If a new or altered hazard, nutritional or other food safety concern is identified, further investigation is undertaken to determine its relevance to human and animal health.

Risk assessment for food and feed safety

- Nutrition, anti-nutrition, allergens and toxins are compared between GM and non-GM varieties to assess whether there are any new risks. This is done by analysing the composition of the GM crops. This is called substantial equivalence.
- The inserted new gene(s) are studied to ensure they do not cause any unintended consequences.
- Tests are also conducted for allergens and any other compounds that may cause harm to humans and animals.

Risk management for food and feed safety

When any GM crops in research and development (R & D) stages show any potential risks or unintended effect on food and feed safety, the research is abandoned. According to World Health Organisation (WHO, 2014), “GM foods currently available on the international market have passed safety assessments and are not likely to present risks for human health. In addition, no effects on human health have been shown as a result of the consumption of such foods by the general population in the countries where they have been approved.”

Environment safety: conservation of biodiversity

Environment risk assessment (ERA) is carried out to identify, characterize and evaluate risks from the cultivation of GM crops to the environment. It requires a structured, reasoned and science-based approach and full understanding of the crop species, the introduced trait (gene) and interaction with the environment.

Contained, confined and open field trials are carried out to assess the following:

- Unintended effects to the environment (flora and fauna)
- Impact on non-living components – water, soil and air
- Impact on agricultural practices
- Changes in agronomy
  (height, root system, flowering, yield, grain size, seedling emergence among others)
- Cross pollination or gene flow
- Weediness
- Any other unintended changes such as new product in the environment.

Post-release monitoring is also carried out once the crops are approved and cultivated by farmers. Any unintended changes are observed and actions taken according to the scale of the risks.

Risk assessment for environment

i. Contained testing – refers to GM crops in a laboratory, a greenhouse and net house. Under contained conditions, there are physical barriers where there is no direct contact of viable GMOs with the environment.

ii. A confined field trial (CFT) is an experiment outside the laboratory.

a) It is of limited size, typically carried out on a small scale, often one hectare or less.
b) Usually carried out in experiment stations.
c) It is an experimental activity conducted to collect biosafety data.
d) The CFTs are conducted under conditions where the following do not take place:
   - Pollen- or seed-mediated dissemination of the experimental crop;
   - Persistence of the GM crop or its progeny in the environment, and
   - Introduction of the GM crop or crop products into the human food or livestock feed supply chain.
e) Access to the field site is restricted to authorized personnel. The site may be on a restricted-access government facility, such as an experimental station. Where necessary, a fence with a lockable gate may be installed to restrict access to the site.
f) The measures for confinement are set forth in detail in the terms and conditions of authorization of the confined trial, and must be strictly followed by the authorized party and trial personnel.
g) Both the regulatory authority and developer of the GM crop monitor the trial.

Risk management for environment

Existence of an environmental risk does not mean the GM crop cannot be approved. Risks are also common among non-GM crops where cross pollination, weediness and pest resistance occur. Conventional agricultural tools like chemical herbicides and pesticides have similar risks too.
Some risks can be managed. Here are some examples:

i. Insect developing resistance. This is addressed by inserting two or more genes for Bt proteins. By doing so, insects are exposed to more than one type of Bt protein and this slows down building of resistance. Another method is planting refuge crops (non-GM crops, a mix of GM and non-GM crops, or other crops) for pests to interbreed with those that feed on GM crops only and non-GM crops in the same area. Both measures slow down developing of resistance.
ii. Weediness: Post-harvest management by the destruction of weedy crops before flowering with the use of herbicides or by non-chemical methods. Stacking of more than one gene also slows down development of weediness in weeds and crops.
iii. Cross pollinating with non-GM varieties: Growing GM and non-GM relatives at different times to avoid crossing of pollens.
iv. Cross pollination with wild varieties: GM crops are not cultivated in regions rich with wild varieties of the same species.

GM crops

Traits, countries, benefits and potential risks

Herbicide tolerant crops

Trait

Herbicide tolerant crops are able to withstand a particular chemical herbicide. The herbicides only kill the weeds while not harming the crops. Crops are developed to withstand specific herbicides such as glyphosate and glufosinate.

Crops

Glyphosate tolerant: Cotton, Canola, Soybean, Maize, Sugarbeet, Alfalfa

Glufosinate tolerant: Cotton, Canola, Soybean, Maize, Sugarbeet

Countries

- Argentina
- Australia
- Bolivia (Plurinational State of)
- Brazil
- Canada
- Chile
- Colombia
- Costa Rica
- Honduras
- Mexico
- Paraguay
- Philippines
- South Africa
- United States of America
- Uruguay
- Viet Nam

Benefits

- Farmers replaced more toxic herbicides with glyphosate and glufosinate which have been studied extensively for their safety.
- Glyphosate and glufosinate are more economical and environment friendly.
- Effective weed control that increases yield.
- No-till (farmers do not plough the land before sowing) reduces carbon dioxide (CO_2) emission.
- No manual weeding reduces labour cost and time.

Potential risks

- Weeds may become resistant to the herbicide (weediness).
- Crops may become weedy and become invasive.
- Gene flow from herbicide tolerant crops to wild relatives or non GM-varieties may cause wild crops to acquire this trait.
- Allergens, toxicity, nutrition composition.

Insect resistant crops

Trait

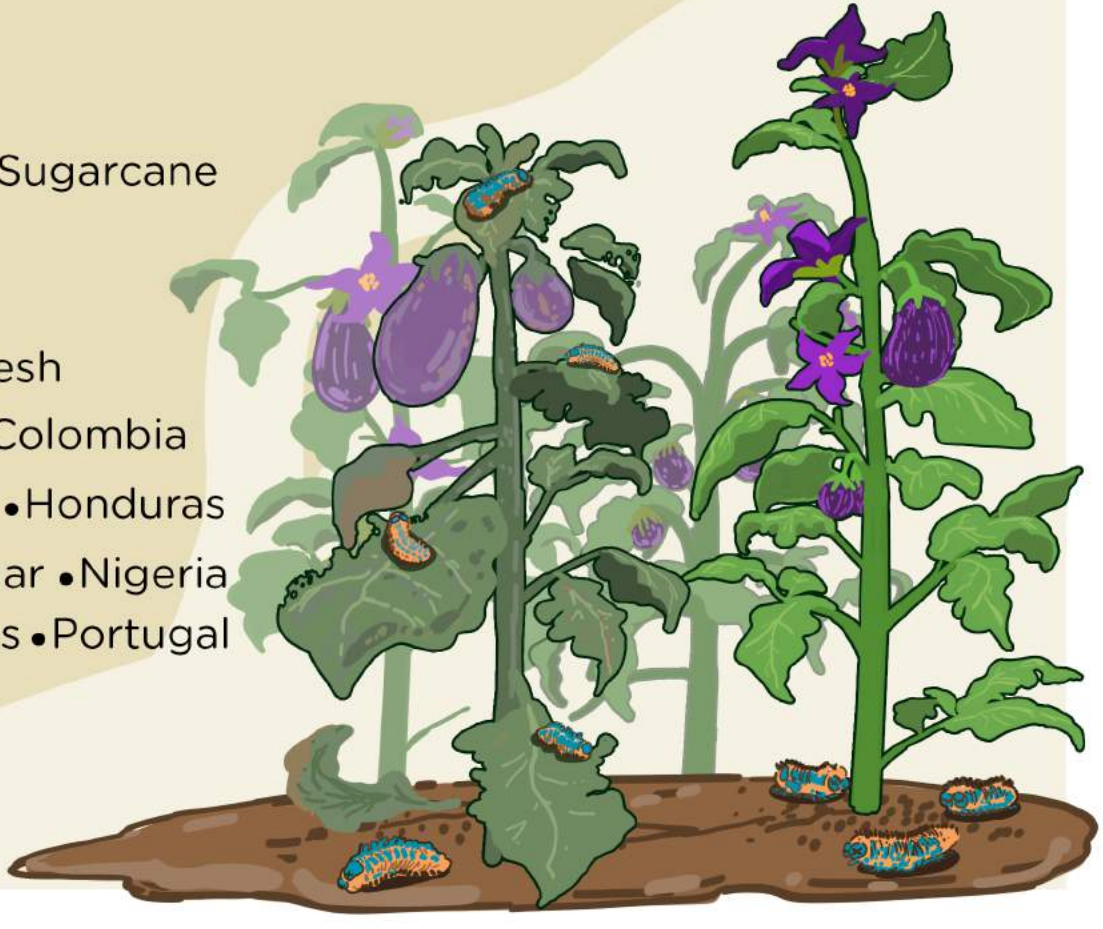
Borers are common pests for crops like cotton, maize, brinjal and soybean. These crop are developed to contain a bacterial gene (Bt) that produces a protein toxic to the borers.

Crops

Cotton, Soybean, Maize, Brinjal, Sugarcane

Countries

- Argentina
- Australia
- Bangladesh
- Brazil
- Canada
- Chile
- China
- Colombia
- Costa Rica
- Eswatini
- Ethiopia
- Honduras
- India
- Malawi
- Mexico
- Myanmar
- Nigeria
- Pakistan
- Paraguay
- Philippines
- Portugal
- South Africa
- Spain
- Sudan
- United States of America
- Uruguay
- Viet Nam



Benefits

- Reduced use of pesticides
- Increased yield and farmers income
- Reduced cost of production
- Reduced release of CO_2 due to less spraying
- Reduced need for labour and time
- Less chemical residues in our food
- Reduced health hazards with chemical pesticides

Potential risks

- Build-up of resistance in target pests.
- Allergens, toxicity, nutrition composition
- Cross pollination between the GM crop and related plant species
- Impacts on non-target species

Alfalfa with reduced lignin

Trait

Alfalfa is modified to have reduced level of lignin by reducing the expression of genes that is responsible for lignin production.

Crop

Alfalfa

Countries

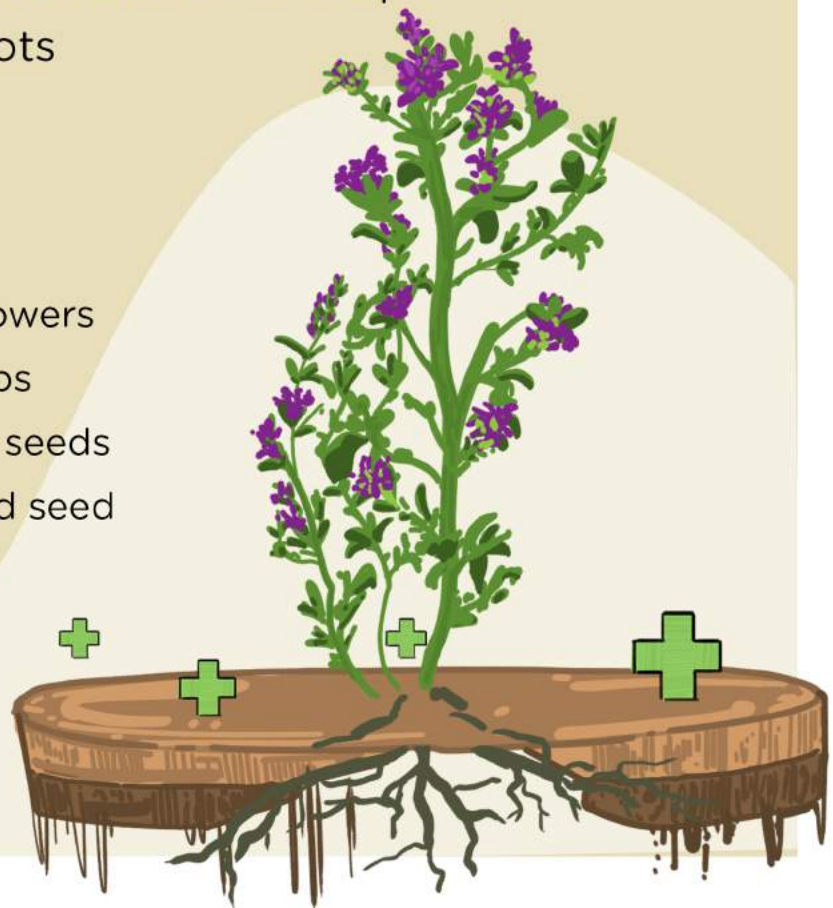
- Argentina
- Canada
- United States of America

Benefits

- Improves digestibility for livestock and improves milk production
- Harvesting can be delayed without compromising the quality. This reduces labour costs.
- Non-frequent harvest reduces damage to soil and other crops
- Increases carbohydrate reserves in the roots

Potential risks

- Cross pollination with non-GM varieties.
  This is reduced as farmers harvest before the flowers bloom and seeds are not dispersed. Mature crops also produce toxin in the soil that prevents new seeds from germinating. This prevents cross-pollinated seed from germinating.



Non-browning apples

Trait

Ability to resist browning after being cut. These GM apples were produced by reducing the activity of polyphenol oxidase, an enzyme that causes browning.

Crop

- Apple

Country

- United States of America

Benefits

- Flavour and nutritional values of apples are protected
- Less wastage since they stay fresh longer
- Foods made from apple such as yogurt, ice cream and smoothies do not require acid like lemon to stop oxidation that will curdle milk

Potential risks

- GM crops becoming invasive
- GM crops cross pollinating wild varieties
- Allergens, toxicity, nutrition composition

High oleic acid

Trait

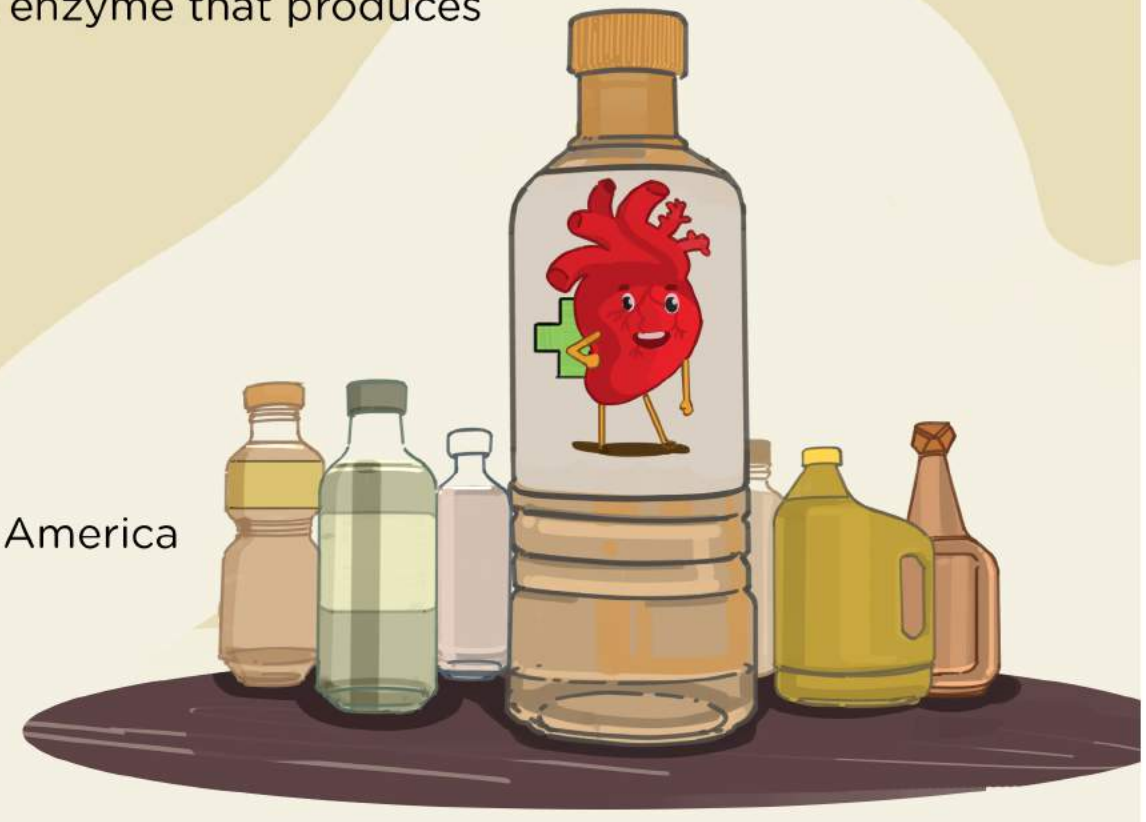
This soybean with high oleic acid and reduced linoleic acid was developed by suppressing the activity of an enzyme that produces linoleic acid.

Crops

- Soybean and Safflower

Countries

- Australia
- United States of America

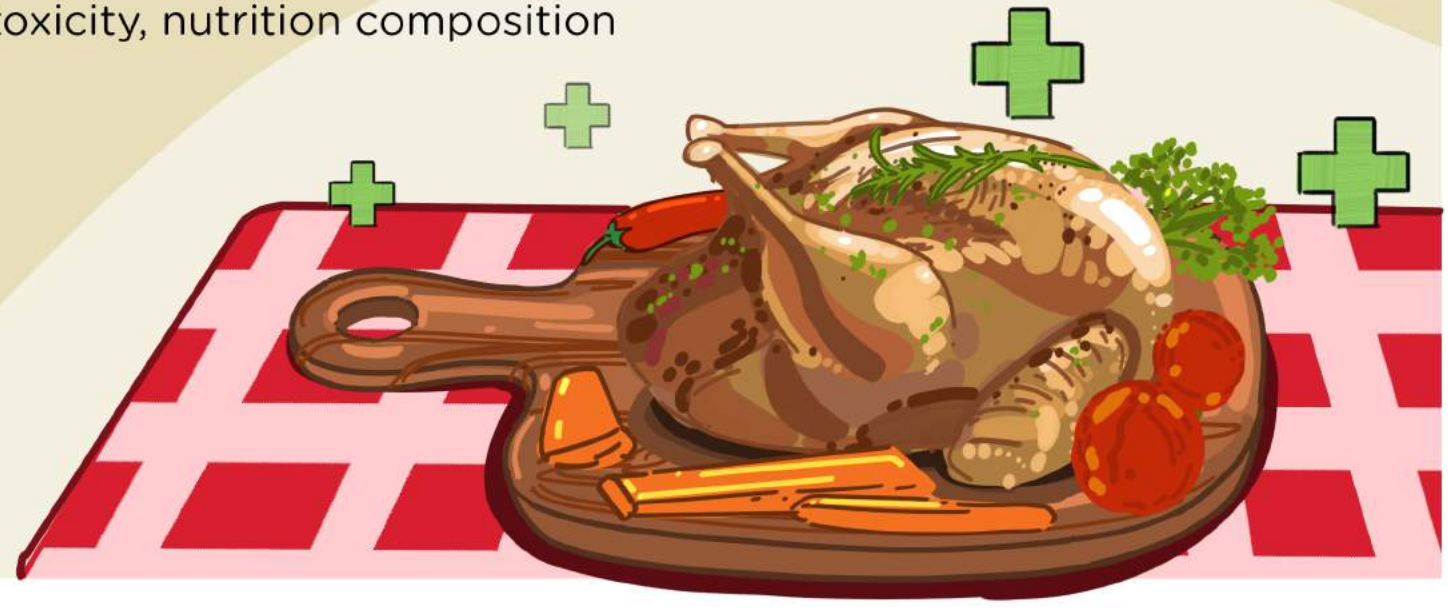


Benefits

- Improves shelf life of the oil
- Reduces the need for hydrogenation. This reduces cost and formation of trans fatty acid that is linked to many health problems

Potential risks

- GM crops becoming invasive
- GM crops cross pollinating wild varieties
- Allergens, toxicity, nutrition composition



Low level acrylamide

Trait

Potatoes are developed with reduced acrylamide that are known carcinogens.

Other traits in GM potatoes:

- Resistant to late blight disease, the most common potato disease
- Reduced starch to prevent shrinking and bruises that reduces waste in the food industry

Crop

- Potato

Countries

- United States of America
- Canada

Benefits

- Acrylamide is a known carcinogen and is formed when potatoes are deep fried. Reduced acrylamide is good for health
- Reduced black spot and bruises reduces wastage during storage
- Reduces use of chemicals to inhibit sprouting during storage
- Reduced pesticide to control late blight disease
- Enables potatoes to be stored in lower temperature that reduces wastage

Potential risks

- GM crops becoming invasive
- Allergens, toxicity, nutrition composition

Resistant to virus

Trait

Papaya that is resistant to papaya ringspot virus.
Squash resistant to mosaic and yellow mosaic viruses.

Crops

- Papaya
- Squash

Countries

- China
- United States of America

Benefits

- Reduced use of chemical pesticides
- Reduced cost of production
- Increased farmer income
- Lesser environmental impact due to lesser usage of chemicals

Potential risks

- GM crops becoming invasive
- GM crops cross pollinating wild varieties
- Allergens, toxicity, nutrition composition

Crop high in lycopene

Trait

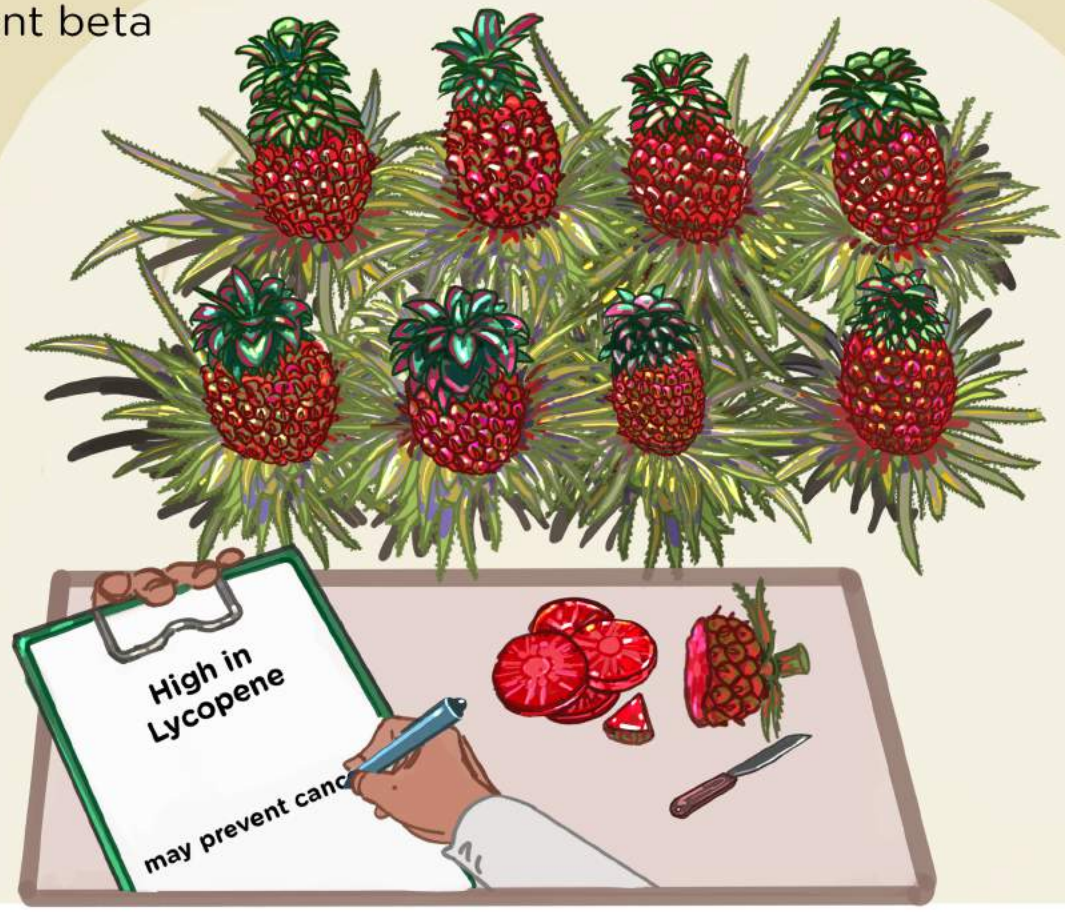
Produces more lycopene that is red in colour than the usual yellow pigment beta carotene.

Crop

- Pineapple

Country

- Costa Rica



Benefits

- Lycopene is an antioxidant that may prevent cancer

Potential risks

- Allergens, toxicity, nutrition composition

Drought tolerant crops

Trait

Crops that can grow well with very little water/rain/irrigation

Crops

- Sugarcane
- Maize

Countries

- United States of America
- Indonesia

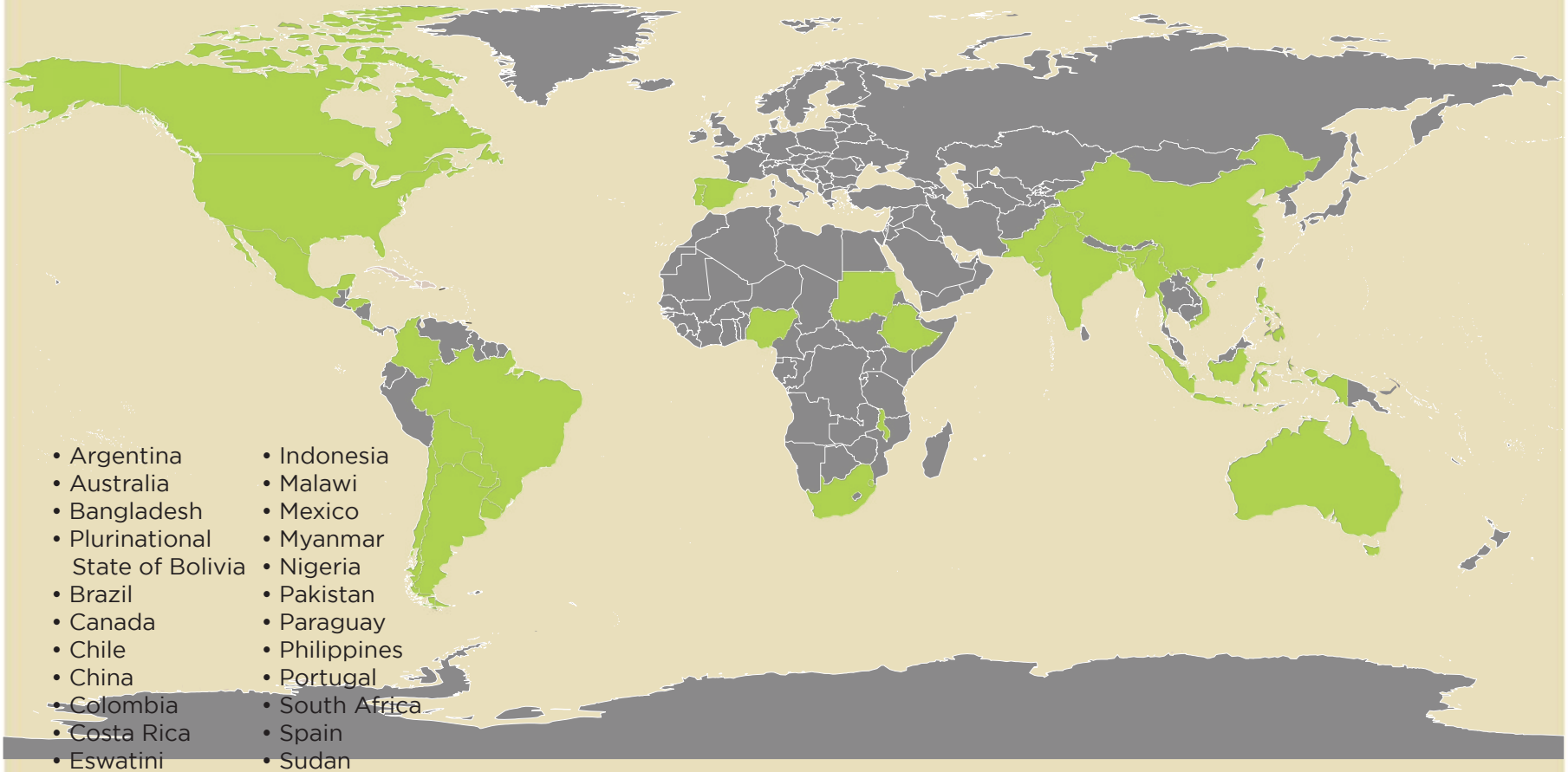
Benefits

- Less use of water and irrigation
- Dry land can be used for agriculture
- Higher farmer income

Potential risks

- GM crops becoming invasive
- Allergens, toxicity, nutrition composition

Where? GM crops are currently grown



- Argentina
- Australia
- Bangladesh
- Plurinational State of Bolivia
- Brazil
- Canada
- Chile
- China
- Colombia
- Costa Rica
- Eswatini
- Ethiopia
- Honduras
- India
- Indonesia
- Malawi
- Mexico
- Myanmar
- Nigeria
- Pakistan
- Paraguay
- Philippines
- Portugal
- South Africa
- Spain
- Sudan
- United States of America
- Uruguay
- Viet Nam

UN.2020. *Map of the World.* [https://www.un.org/geospatial.content/map-world] (Cited 3 January 2022), "Modified with the list of countries shaded"

This awareness material was developed through the project “Implementation of the National Biosafety Framework in Accordance with the Cartagena Protocol on Biosafety” implemented by the Food and Agriculture Organization of the United Nations and the Ministry of Environment, Sri Lanka with funding from the Global Environment Facility.

Information were sourced from the International Service for the Acquisition of Agri-biotech Applications (ISAAA) Brief No 55-2019, ISAAA brief 55 Executive Summary, and ISAAA’s GM Approval Database: https://www.isaaa.org/gmapprovaldatabase/default.asp (July 2021).

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