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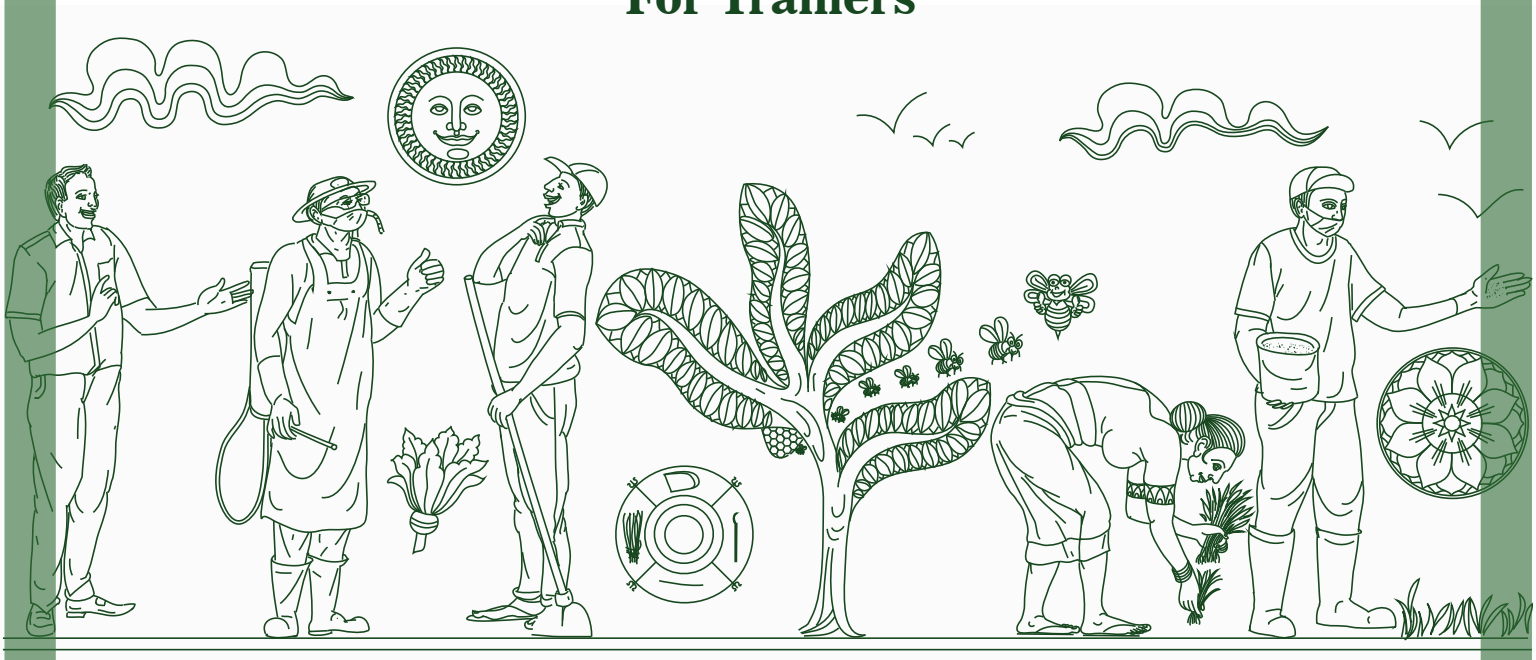
Safe and Appropriate Use of Pesticides and Fertilizers in Sri Lanka

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TRAINING TEXT BOOK

For Trainers



කෘෂිකර්ම දෙපාර්තමේන්තුව

Department of Agriculture

2025

This textbook has been prepared in accordance with the recommendations of the Department of Agriculture for the reference of trainers involved in the project for Promotion of Safe and Appropriate Use of Pesticides & Fertilizer in Sri Lanka, implemented with the support of the Japan International Cooperation Agency (JICA).

We hope this textbook may be used in future training on safe and appropriate use of pesticides & fertilizer by any interested party.

December 2025

Promotion of Safe and Appropriate Use of Pesticides and Fertilizer in Sri Lanka

Training Textbook

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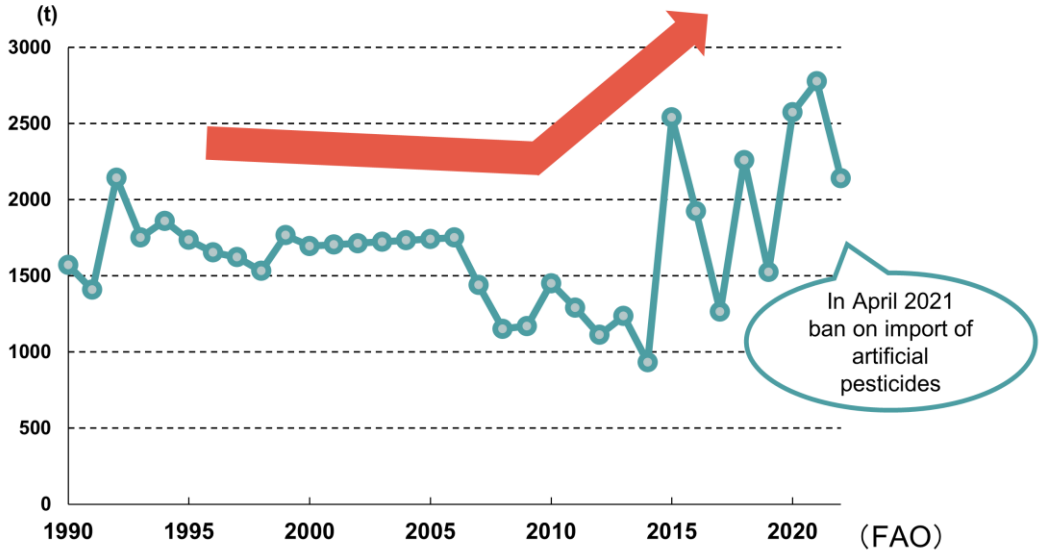
CHAPTER 1

The Influence of Pesticides & Fertilizer on the Environment and Humans

1.1. The situation of pesticides and fertilizer use in Sri Lanka
1.2. Negative effects of misuse application of pesticides and fertilizer
1.3. Direction to be taken in promoting Sri Lankan agricultural produce
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1.5. Direction to be taken in protecting environment

1.1 The situation of pesticides and fertilizer use in Sri Lanka

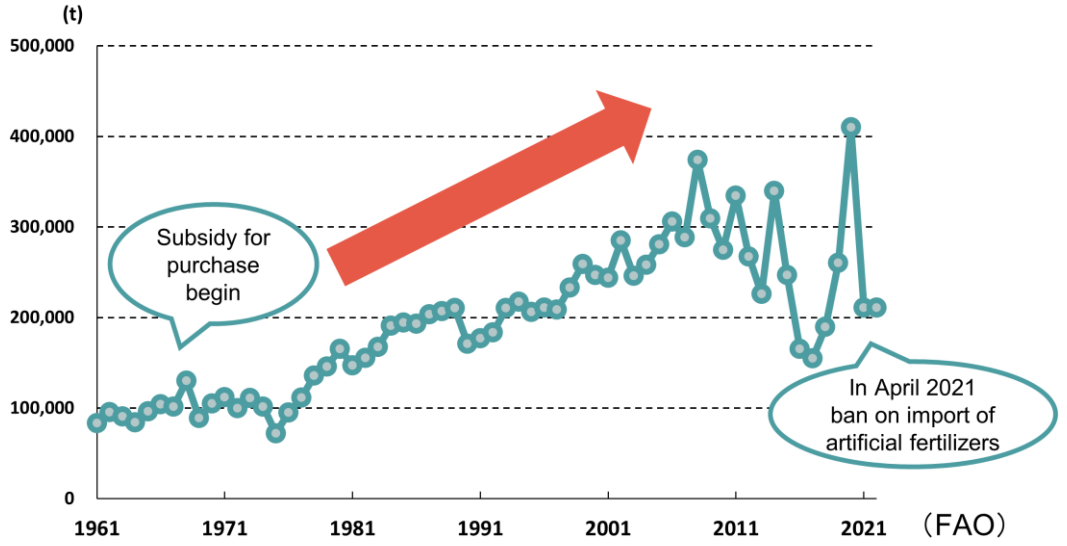
Pesticide Use (1990-2021)



Focus Point

Increasing pesticide use and unstable supply

Fertilizer Use (N, P_2O_5, K_2O) (1961-2021)



Focus Point

Increasing fertilizer use and unstable supply

The use of pesticides has increased around 1.5 times in the last 30 years.

Unstable Supply

- Since pesticide use is dependent on imports, the volume of imports is greatly affected by international pesticide markets.
- For example, in April 2021, imports of pesticides were banned as part of the organic farming policy, resulting in a significant decrease in pesticides used.

Negative Effects of Use

- The negative effects to the environment and health caused by the use of pesticides has become increasingly evident in recent years.
- Many pesticides have been banned, including about 10 in 2010, 5 in 2013, and a ban on the use of herbicide (glufosinate) in 2015, and similar restrictions are expected to continue in the future.

Fertilizer use has increased about three times since the 1960s.

Background of Increased Use

- The fertilizer subsidy program began in 1962, around the same time as the Green Revolution, to encourage farmers to switch to high-yielding varieties.
- The budget is said to account for 2-2.5% of the national expenditure now.

Unstable Supply

- Frequent adjustments to subsidies have caused fluctuations in fertilizer use.

  Use decreased during subsidy suspensions in 1990 and import bans in 2016-2017 and 2021.
- Like pesticide, fertilizers are heavily dependent on imports, and fertilizer use has fluctuated widely up and down over the past decade due to international fertilizer market prices.

  It was not possible to import fertilizers because the international market price had increased significantly, and emergency imports were implemented by the WB, ADB, and USAID.

Negative Effects of Use

- Environmental and health hazards due to fertilizer use are becoming evident.

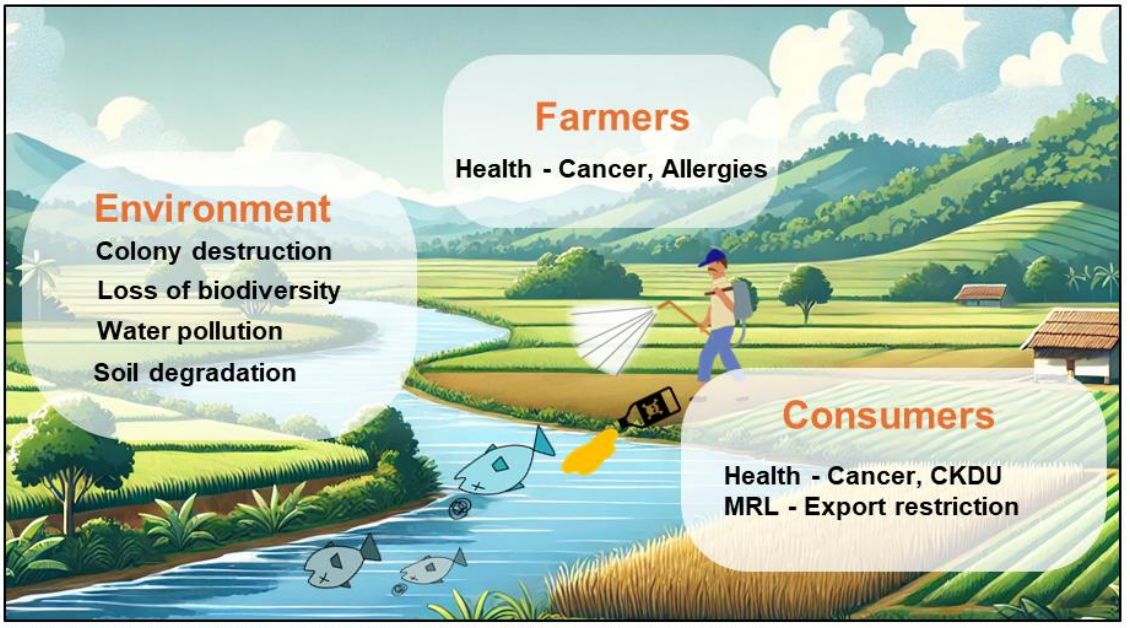
Future of Pesticide and Fertilizer Use

- The supply of fertilizers and pesticides has been unstable in recent years, and their impact on the surrounding environment and human health is drawing increasing attention.
- To ensure stable agricultural production while protecting health and the environment, the future goal of agriculture is expected to focus on stable yields with reduced use of fertilizers and pesticides.

1.2 Negative effects of misuse application of pesticides and fertilizers

Pesticides can remain for a long time and continue to cause negative effects

(1) Pesticide use

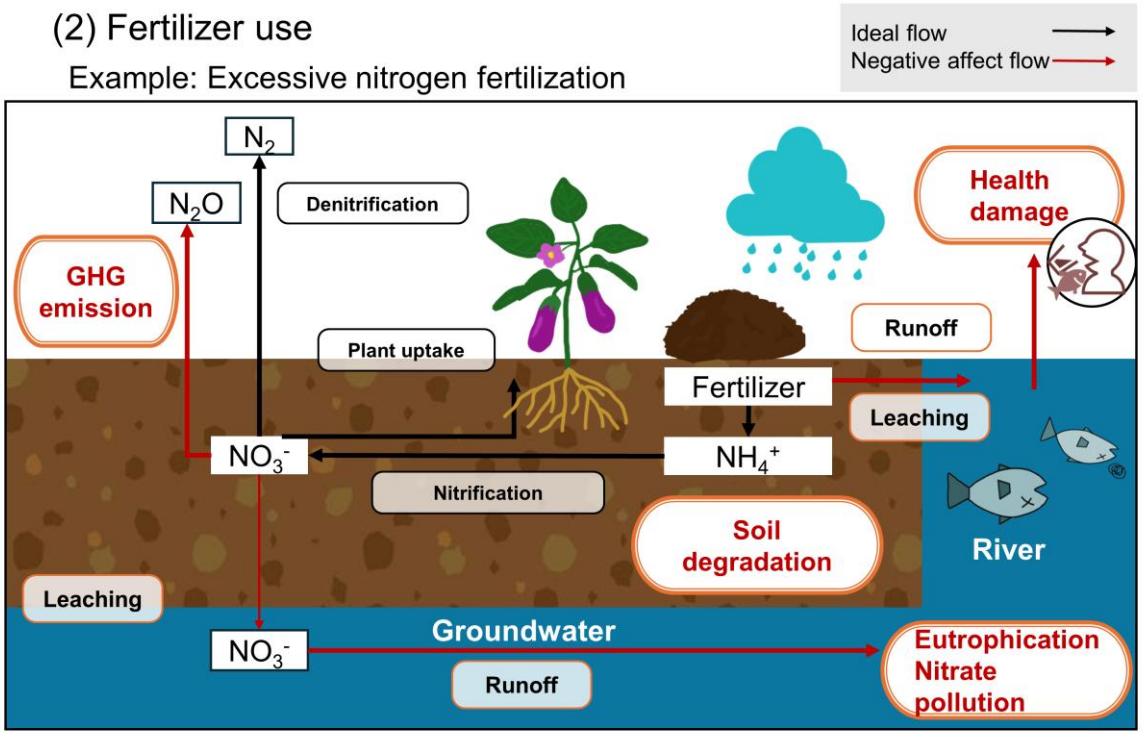


*MRL: Maxima Residue Level * CKDu: Chronic Kidney Disease of Unknown Etiology

Nutrients can easily leach out from farmland

(2) Fertilizer use

Example: Excessive nitrogen fertilization



The inappropriate use of pesticides is recognized as having negative effects on the surrounding environment and health.

Examples of Inappropriate Use

- Excessive use
- Discharging surplus pesticide formulation to waterways after spraying
- Washing of sprayers and other containers in the waterways
- Permitting erosion of pesticide treated soils and runoff of water over it

Specific Examples of Negative Effects

Impacts on the Environment: Pollution from pesticides running off into nearby rivers and soil, and the components in the pesticides affect the hormones of animals and plants, inhibiting their activity and impacting non-target species.

Impacts on Farmers: Health damage such as allergies and cancer due to exposure to pesticides.

Impacts on Consumers: Health damage such as chronic kidney disease due to the ingestion of heavy metals contained in chemical fertilizers through drinking water and agricultural products.

There have been some cases food products have been refused export due to pesticide residues exceeding legal limits.

Nutrients in fertilizer are not always absorbed by plants as soon as they are supplied to the soil. Each nutrient has a form that is easier or harder for plants to absorb.

Runoff to the Environment

- **Nitrogen:** Plant absorb nitrogen in the form of nitrate nitrogen. However, nitrate nitrogen is not retained by soil and can easily leach into groundwater and rivers.
- **Phosphorus:** Similarly, plant-absorbable form is prone to leaching into the environment.

Of the fertilizers applied, 65% of nitrogen and about half of phosphorus are said to be leaked into the environment.

Effect on Environment

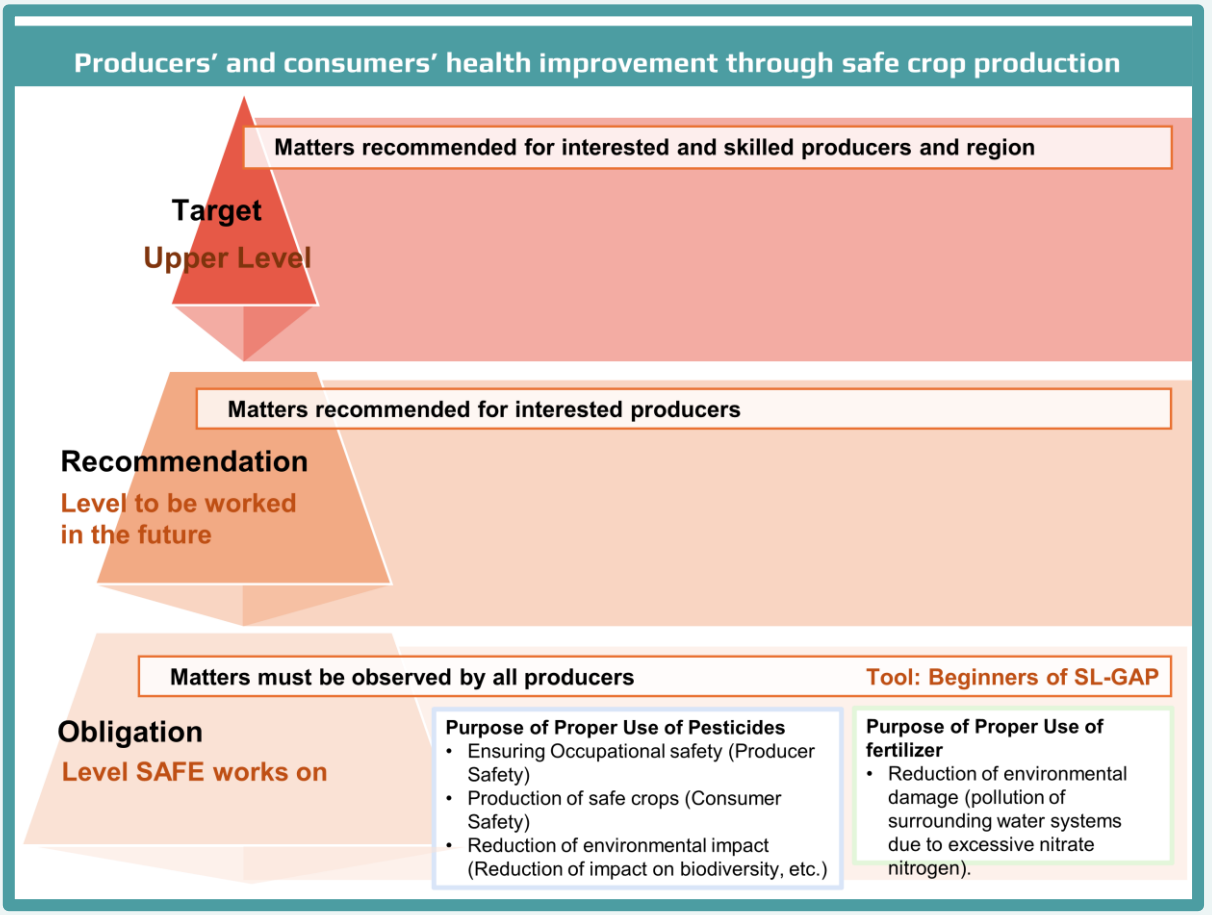
- Nitrate-nitrogen and phosphorus that runoff into rivers causes eutrophication and water pollution. Ingestion of water containing nitrate-nitrogen is also hazardous to health.
- The denitrification process of nitrate-nitrogen also produces N_2O, which has a greenhouse effect about 300 times greater than that of carbon dioxide.

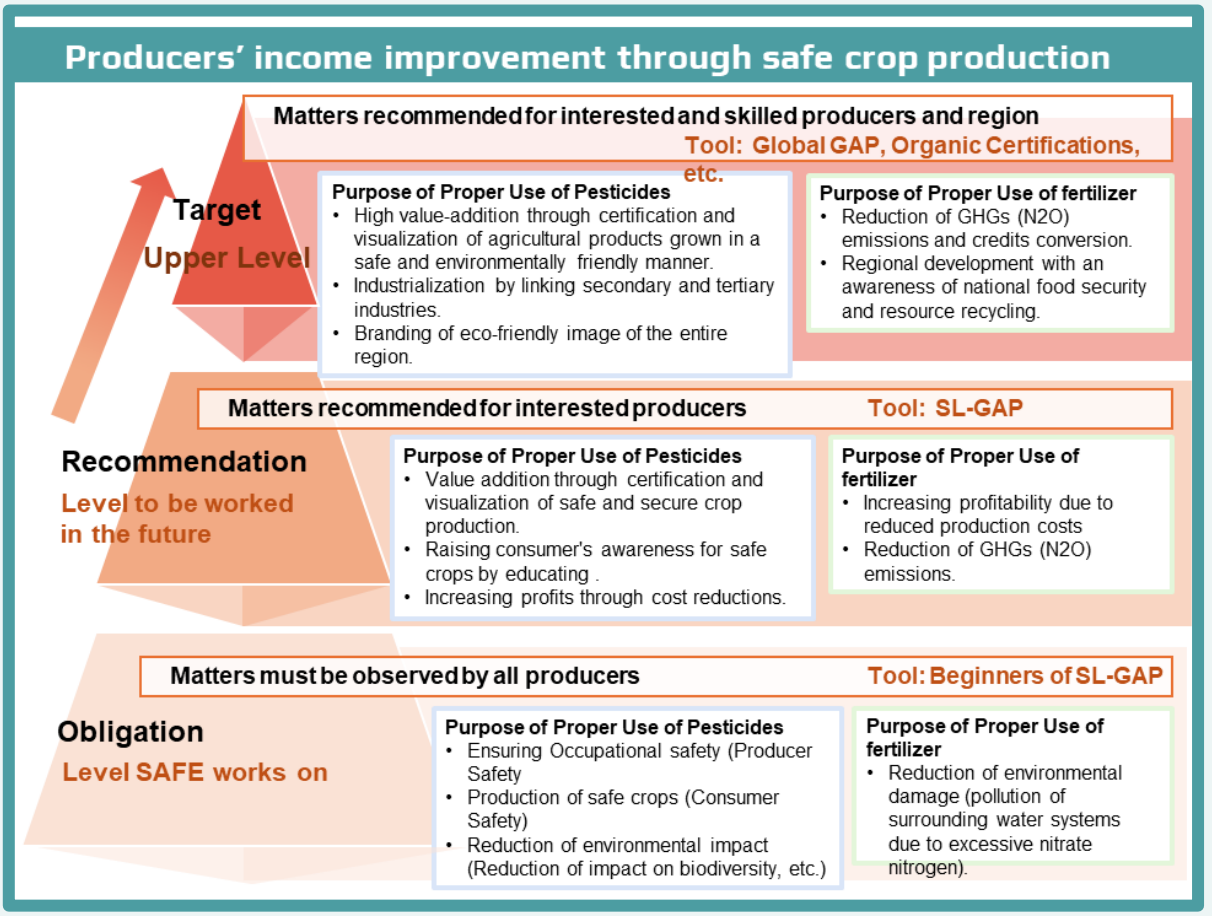
Effect on Health

- Drinking water that contains a lot of nitrate-nitrogen can cause health problems such as blue baby disease.

As described above, although the dynamics of pesticides and fertilizers are different, it is clear that their usages have a variety of negative effects on the environment and health.

1.3 Direction to be taken in promoting Sri Lankan agricultural produce





The production of safe crops can be divided into three levels.

Level that the SAFE Project Works on

This project addresses the minimum required level, which must be observed by all producers.

Purpose of Proper Use of Pesticides:

- Occupational Safety (Producer Safety)
- Production of safe crops (consumer safety)
- Reduction of environmental impact (reduction of impact on biodiversity, etc.)

Purpose of Proper Use of Fertilizer:

- Reduce environmental damage (pollution of surrounding water systems due to excessive nitrate nitrogen).

Level to be Worked in the Future

After this project is completed, it is hoped that the next level of "recommended" content will be promoted to interested producers.

Purpose of Proper Use of Pesticides:

- Value addition through certification and visualization of safe and secure crop production.
- Raising consumer awareness for safe crops.
- Increase profits through cost reductions.

Purpose of Proper Use of Fertilizer:

- Increase profitability due to reduced production cost.
- Reduction of GHGs (N_2O) emissions.

Upper Level

Furthermore, for those who have the skills as well as the interest, there is a higher level of safe crop production.

Purpose of Proper Use of Pesticides:

- High value-added through certification and visualization of agricultural products grown in a safe and environmentally friendly manner.
- Sixth industrialization by linking secondary and tertiary industries.
- Branding of an eco-friendly image for the entire region.

Purpose of Proper Use of Fertilizer:

- Reduction of GHGs (N_2O) emissions and credits conversion.
- Regional development with an awareness of national food security and resource recycling.

1.4 Direction to be taken in protecting farmers' health

Examples of health damage by pesticides





(ROP)

Allergic

- Asthma - Skin, eye and nose irritation

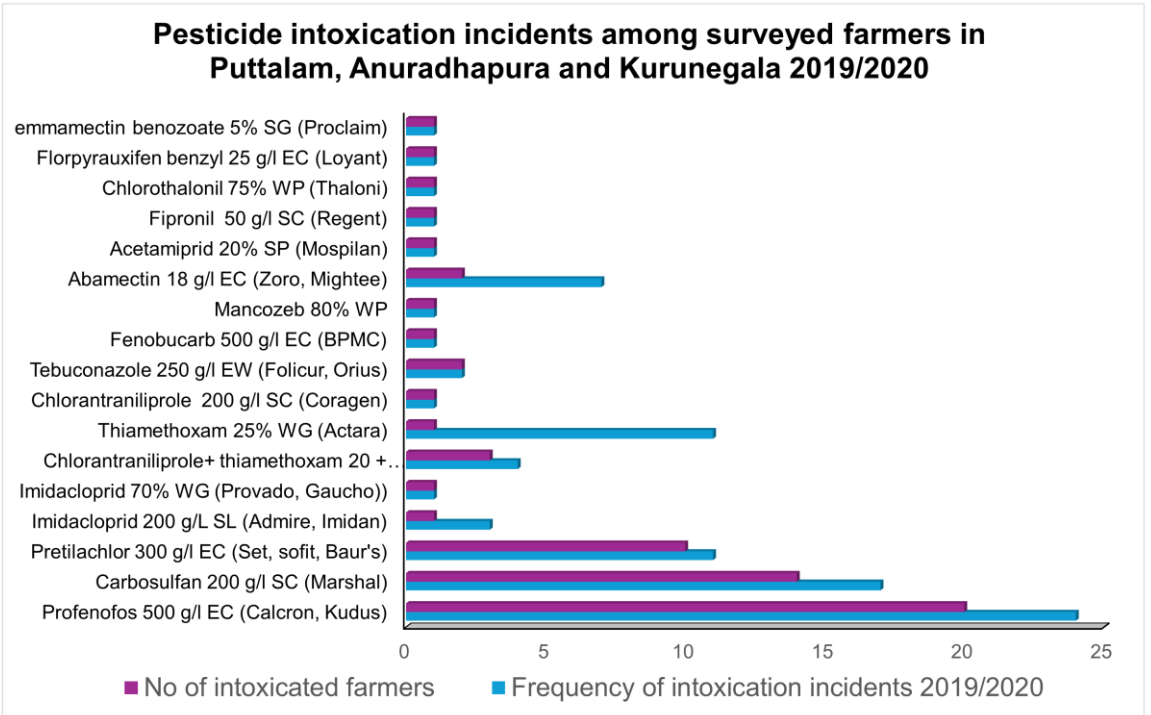
Acute effect

- Serious diseases – Death

Chronic effect

- Chronic Kidney Disease of Unknown Etiology (CKDu)
- Cancer - Reproductive problems et al.

Examples of health damage by pesticides



Health damages caused by pesticides is beginning to be seen as a crucial problem in Sri Lanka.

The Current Situation

A study mentions that 48% of farmers have experienced illness due to pesticide exposure at least once in a season.

Types of Health Damages

The health damages can be divided into three categories:

- **Allergic:** Asthma, skin irritation, eye irritation, and nose irritation
- **Acute**: Serious diseases, Death
- **Chronic:** Chronic Kidney Disease of Unknown Etiology (CKDu), cancer, reproductive problems

CKDu: A Major Issue in Sri Lanka

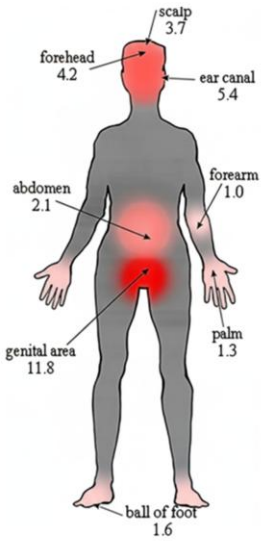
- In Sri Lanka, CKDu is a significant concern, particularly in agricultural areas. Even focusing only on CKDu, it is reported that as many as 30,000 patients were affected per year in 2015 (Planning Phase Project Implementation Report).
- The exact cause of CKDu has yet to be determined, but the disease is prevalent in farming regions.

- The Pesticides that caused poisoning incidences by occupational exposure – farmer survey 2019-2020 office of the Registrar of Pesticides.

1.4 Direction to be taken in protecting farmers' health

Safety First: Absorption and toxicity of pesticides

Dermal Contact



Relative absorption rates, as compared to the forearm (1.0)

WHO – Acute toxicity (and for a limited number pesticides also chronic toxicity)

	Hazard class				
	Class Ia *Extremely hazardous*	Class Ib *Highly hazardous*	Class II *Moderately hazardous*	Class III *Slightly hazardous*	Class U *Unlikely to present acute hazard in normal use*
Hazard symbol				*No symbol*	*No symbol*
Signal word	Very toxic	Toxic	Harmful	Caution	*No signal word*
Colour band	PMS red 199 C	PMS red 199 C	PMS Yellow C	PMS Blue 293 C	PMS Green 347

(Green < Blue< Yellow < Red)

Safety First: The right outfit for pesticide application



(DOA)



(DOA)

Focus Point

Small changes like using personal protective equipment (PPEs) can greatly reduce health hazards.

- Relative absorption rates of different places of the body, as compared to the forearm (1.0)

- According to the World Health Organization classification, pesticides are classified considering their mammalian toxicity level (Ia, Ib, III, IV/). Accordingly different colours are given to each hazard class.

Green<Blue<Yellow<Red

Increasing toxicity to mammals

- For every pesticide product a colour band has been assigned depending on the toxicity of the product.

Measures to Prevent Health Damage

The measures vary depending on the type of damage (Allergic, Acute, Chronic), but allergic and acute damages that occur during agricultural work can be prevented by changing the clothing worn when spraying pesticides.

Current State of Wearing When Spraying Pesticides

- Pesticide spraying is often done in the clothing shown on the left.
- A study revealed that only 11% of respondents were using protective clothing properly.
- According to a JICA planning phase survey, nearly half of the respondents reported taking some measures, but most were limited to wearing gloves and hats.

Measures to Prevent Health Damage Caused by Pesticides

- By wearing Personal Protective Equipment (PPE), like the one shown on the right, when spraying pesticides, it is possible to prevent exposure to pesticides.
- In 2016, the DOA issued instructions under the name "Stewardship Initiatives and Mandatory Requirement for Personal Protective Equipment in Sri Lanka". However, PPE use has not been popular in Sri Lanka.
- It is necessary to prevent health damage to farmers by disseminating and promoting these technologies.
- Spraying while considering the wind direction is also effective.

1.5 Direction to be taken in protecting environment

Examples of environmental damages by pesticides and fertilizer



(Nitrogen Policy Report)

Effects on environment

- Eutrophication
- Water pollution
- Soil degradation

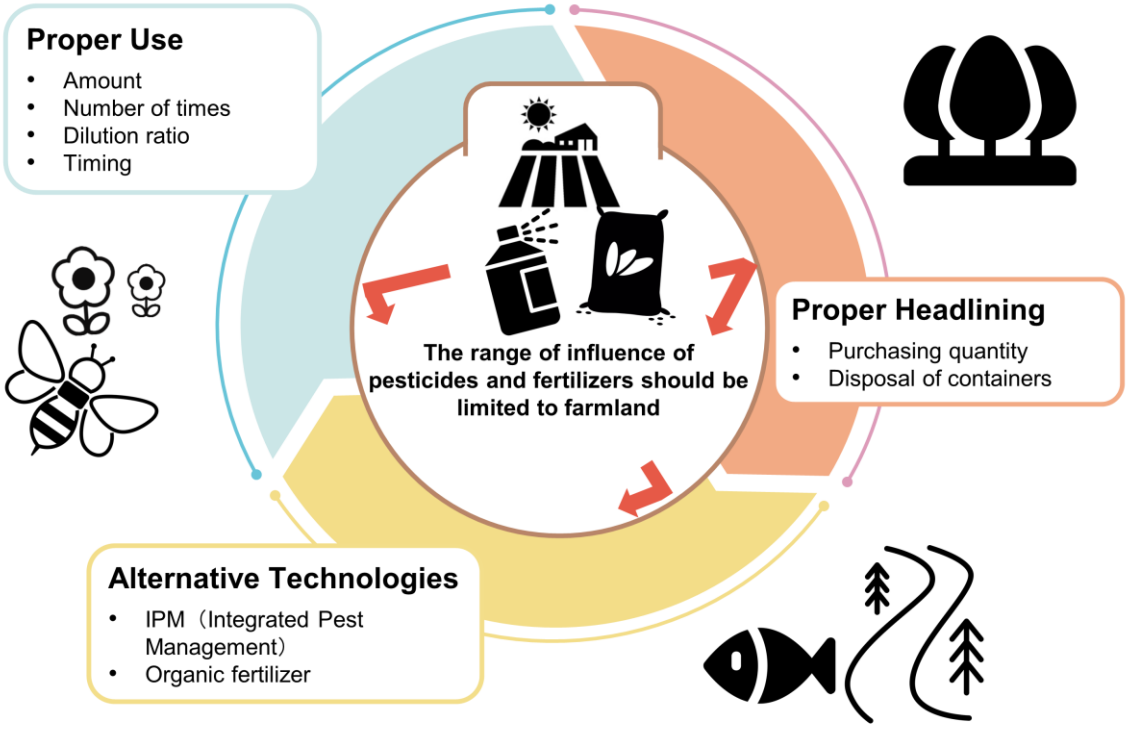


(DOA)

Effects on non-target animals and plants

- Colony destruction
- Decline in biodiversity

Measures to prevent fertilizer and pesticide runoff from farmland



The environmental effects of the use of pesticides and fertilizer is a problem not only in Sri Lanka but also around the world.

Effects are divided into two types, effects on the environment and effects on non-target animals and plants.

Effects on the Environment

Runoff of nutrients can lead to eutrophication of rivers, water pollution and soil degradation.

Effects on Non-Target Animals and Plants

In addition to the direct adverse effects of pesticide ingredients on non-target animals and plants, there are also indirect effects caused by environmental deterioration.

Examples in Sri Lanka

- **Destruction of honeybee colonies**: the destruction of honeybee colonies by pesticide ingredients is a direct impact of pesticide use that is considered problematic.
- **Mass fish deaths**: In rivers where eutrophication has occurred, fish have died in large numbers due to a lack of oxygen in many areas.

It is necessary to prevent pesticides and fertilizer from flowing out of farmland through "proper use", "proper handling", and the "use of alternative technologies".

Proper Use

- Currently, many farmers think that the more pesticides and fertilizer they use, the better and they use them more frequently than recommended on the package.
- Even if you use smaller amount than now, maximum effectiveness can be achieved for any crop by following the appropriate application amount, frequency, dilution ratio and application timing

Proper Handling

- Currently, Some farmers wash containers in rivers after use or flush the remaining waste down the drain.
- Farmer need to know how to properly dispose of the product after use and should purchase only the amount needed.

Use of Alternative Technologies

- The introduction of IPM (Integrated Pest Management) and organic fertilizers helps reduce the use of chemical fertilizers and pesticides.
- Sri Lanka’s National Agriculture Policy (2007) already highlights the use of IPM to reduce pesticides and fertilizers through integrated pest management.

By utilizing these measures in an integrated manner, it is possible to use pesticides and fertilizers without affecting the surrounding environment of farmland.

Exercise



- How would you explain to a farmer the importance of the appropriate use of **pesticides** when you found him spraying pesticides without PPE?
- How would you explain to a farmer the importance of appropriate use of **fertilizer** when you found him applying the fertilizer as much as possible?

Memo :

CHAPTER 2

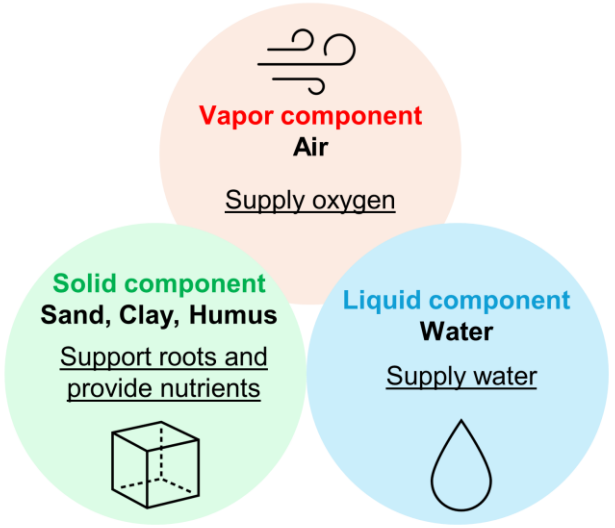
Soil Management and Fertilizer Use

2.1. Role of soil, fertilizer and soil management
2.2. Fertilizer needs and essential nutrients
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2.4. Fertilizer application based on soil testing
2.5. Fertilizer application in protected agriculture

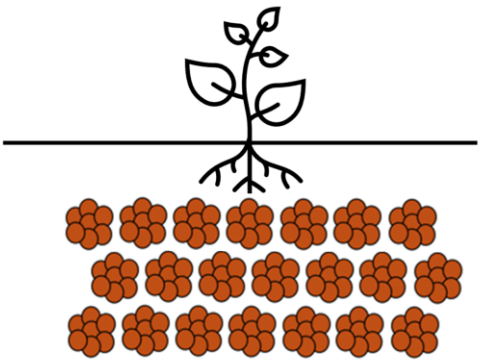
2.1 Role of soil, fertilizer and soil management

Importance of the three component balance and aggregate structure

The three component balance



Aggregate structure



Adequate water retention and oxygen supply due to large and small gaps.

Focus point

Aggregate structure can be formed by high-quality organic matter

Properties that contribute to the soil's ability to support crops

Physical: drainage, water retention, aeration etc.

Focus point

Soft soil, good water retention and drainage

Chemical: pH, nutrient composition, CEC, EC, etc.

Focus point

Optimum nutrient supply at appropriate pH

Biological: organic matter decomposition, disease control, microbe converting nutrients to crop available form etc.

Focus point

Moderate organic matter & active macro & micro-organisms

Plants spread their roots in the soil to absorb water and nutrients. When roots spread widely in the soil, they can absorb nutrients from a broader area, promoting healthy growth of the aboveground parts. This also contributes to enhancing the resistance of plants to pests and diseases.

Good soil for crops provides enough space for roots to expand and ensures sufficient supply of oxygen, water, and nutrients. The spaces in the soil are categorized into three phases:

Solid component: The main body of the soil

- A higher proportion of the solid component makes the soil harder.
- Typically, a solid component ratio of 40-50% is considered ideal for soil.

Liquid component: The spaces in the soil that contain water

- A desirable liquid component ratio for crops is about 25-30%.

Vapor component: The spaces in the soil that contain gas

- A desirable vapor component ratio for crops is also about 25%.

The balance of the three components (vapor, liquid and solid) is an important indicator of the physical condition of the soil, including its hardness, aeration and water retention.

The physical properties, the biological properties and the chemical properties of the soil interact with each other to create soil that is well-suited for crop growth.

Physical properties: Thickness of the soil layer, water retention capacity, drainage ability, and resistance to wind and water erosion.

Thick, soft soil layers with excellent water retention and drainage are optimal for crop growth.

Chemical properties: Nutrient retention and availability, soil pH, oxidation and reduction potential, fertilizer composition etc.

The pH should be within an appropriate range, and the soil must contain a moderate amount of essential nutrients.

Biological properties: Capacity for organic matter decomposition, nitrogen fixation ability, resistance to pests and diseases, and the ability of microorganisms to break down harmful substances.

Soil with a moderate level of organic matter and active microorganisms is ideal.

Drainage (aeration) is neither too good nor too bad

- Poor drainage: root damage and disease outbreaks.
- Too good drainage (easy to dry out): fewer useful micro-organisms and small animals, disease easily occurs.

Improvement of soil through organic matter

Incorporating organic matter into the field improves soil in the following ways:

- Organic matter acts like glue, binding soil sand and clay particles together, and promotes soil aggregation.
- Aggregated soil forms both large and small pores.
- Large pores allow excess water to drain, improving drainage, while small pores retain water, enhancing water-holding capacity.
- As a result, the field achieves both good drainage and water retention.

2.1 Role of soil, fertilizer and soil management

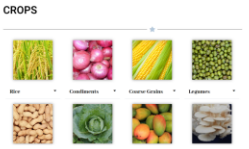
Suitable pH for Different Crops

pH	Vegetable
6.5 - 7.5	Beet (6.3 - 7.3)
6.0 - 7.5	Radish
6.0 - 7.0	Gotukola, Mukunuwenna, Kang Kung, Cauliflower (6.0 - 6.8)
6.0 - 6.5	Cabbage
5.5 - 7.5	Tomato, Pumpkin, Cucumber, Snake Gourd, Luffa, Bitter Gourd, Kekiri
5.5 - 7.0	Capsicum (5.5 - 6.8), Yard Long Bean (5.6 - 7.0)
5.5 - 6.5	Bean, Potato (5.5 - 6.6), Kiri Ala
5.5 - 6.0	Brinjal (5.5 - 5.8), Ela Batu (5.5 - 5.8), Knol khol (around 5.5)
5.0 - 6.0	Cassava, Leeks

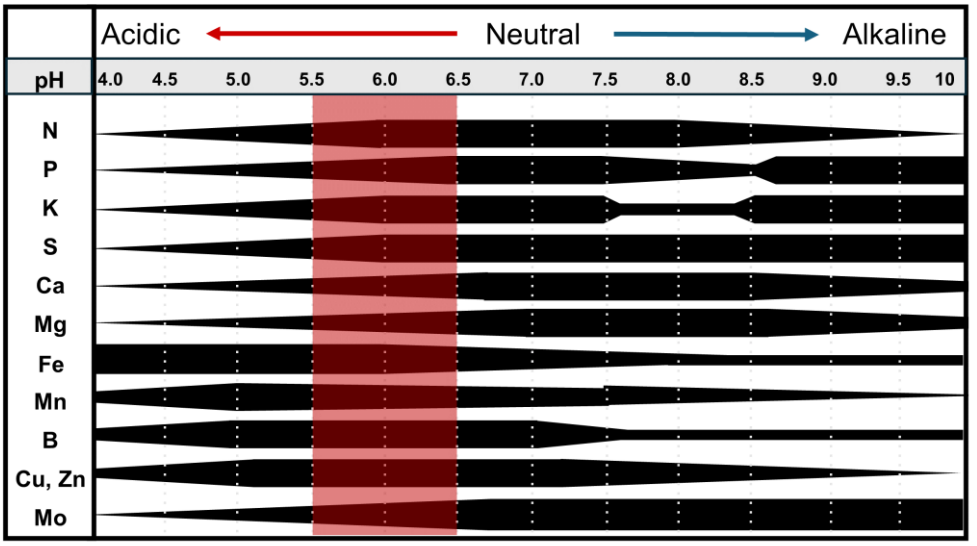
Focus point

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விவசாயத் திணைக்களம்
Department of Agriculture

The DOA (Department of Agriculture) provides cultivation information, including pH requirements, for each crop.



pH and Nutrient Solubility in Fertilizer



Focus point

- ✓ Absorption efficiency is different in nutrient and pH
- ✓ Slight acidic pH (5.5-6.5) is the best condition for absorbing almost all nutrient.

Appropriate Soil pH

- pH indicates the acidity of the soil and is measured on a scale from 0 to 14.
- A pH of 7 is neutral, values below 7 indicate acidity, and values above 7 indicate alkalinity.
- The optimal pH varies depending on the crop. Please refer to the table on the left for the recommended pH levels for each vegetable as suggested by the DoA (Department of Agriculture).
- Some crops, such as tea and blueberries, prefer acidic soils with a pH of around 5 (not included in the table), but the majority of crops thrive in slightly acidic soils with a pH around 6.0.
- In Sri Lanka, where rainfall is abundant and rain is mildly acidic, most soils are acidic, with a natural pH range of 4.4 to 5.5.
- Conducting soil testing to determine the current pH is crucial.

The solubility of nutrients in the soil changes depending on the soil's pH. The diagram on the left illustrates the solubility of fertilizer nutrients in soil, showing that nutrient availability is poor at both low and high pH levels.

Problems with acidic soil

- Micronutrients such as manganese, iron, copper, zinc, as well as aluminum, dissolve excessively in water on the acidic soil, negatively impacting crops.
- Aluminum and iron bind with phosphate, hindering its absorption by crops, which reduces the effectiveness of phosphate fertilizers in acidic soils.
- When soil pH drops below 5.5, the activity of soil bacteria and filamentous fungi decreases, resulting in organic matter in the soil not decomposing effectively and failing to benefit crops.

Diseases common in acidic soil

- Root-knot disease (affecting crops like cabbage and "*komatsuna*")
- Tomato wilt (causing root death)
- White silk disease (attacking stem bases in Rutaceae)

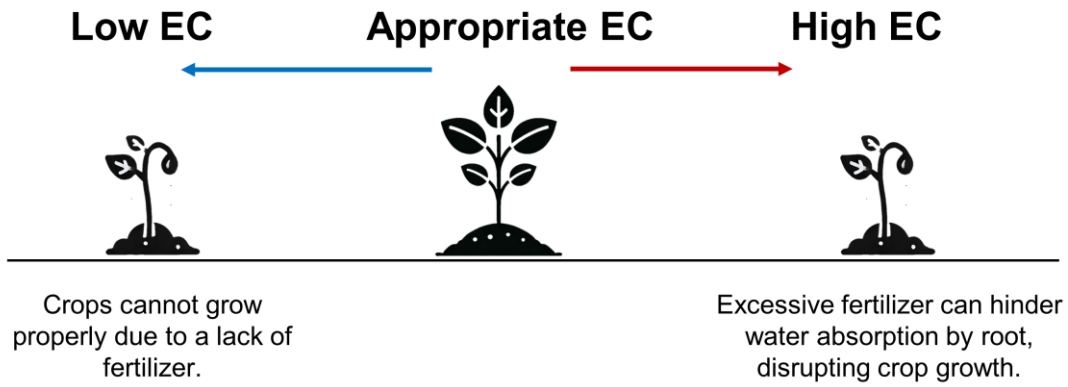
Diseases common in alkaline soil

- Potato scab and sweet potato wilt (caused by actinomycetes)
- Lettuce big vein
- Epiphyte root disease (caused by soil-borne viruses)

2.1 Role of soil, fertilizer and soil management

EC (Electrical Conductivity)

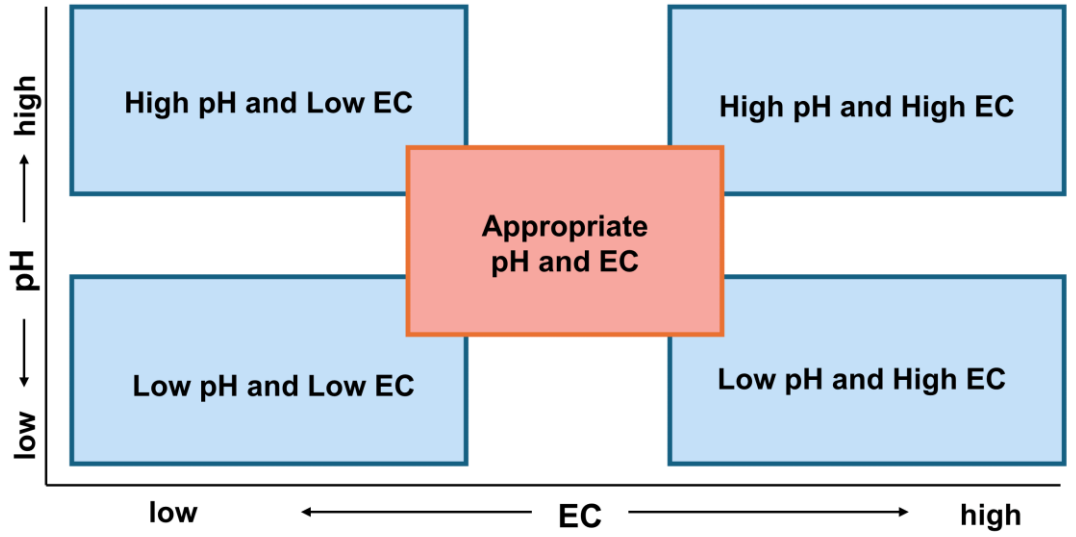
EC Indicates the total amount of water-soluble salts in the soil



Focus point

The optimal EC range varies depending on the crop.

The balance between pH and EC for soil nutrient status



Focus point

- ✓ Regular measurement of pH and EC
- ✓ Appropriate solution according to result

EC (Electrical Conductivity) is an indicator used to understand the soil salinity, particularly the residual levels of nitrogen fertilizer.

- The higher the nutrient concentration, the more easily the soil solution conducts electricity, resulting in a higher EC value.
- A higher EC value does not necessarily mean better conditions. If EC is too high (indicating a high soil salinity), it can hinder water absorption by plant roots, potentially causing crops to wither.
- When EC is high, fertilizer application should be reduced.
- The tolerance of crops to high soil salinity varies. Generally, crops like Chinese cabbage and spinach are more resistant to salt stress, while strawberries and green beans are more susceptible.

High pH and Low EC

Main Cause: Fertilizer and compost were not applied, while excessive amounts of lime were used.

Main Countermeasure: Use sulfate-based fertilizers such as ammonium sulfate or potassium sulfate.

Low pH and Low EC

Main Cause: Fertilizer and lime are deficient.

Main Countermeasure: Actively apply compost and fertilizers to improve EC, and use lime to raise the pH.

High pH and High EC

Main Cause: Excessive fertilizer and lime were used.

Main Countermeasure: Flood the area temporarily, then drain the water to flush out the excess fertilizer and lime

Low pH and High EC

Main Cause: Fertilizer is overapplied

Main Countermeasure: Apply plenty of water to remove the excess nitrogen. Avoid using lime to raise pH, as it may increase not only pH but also EC.

Focus points

- The optimal pH and EC levels vary depending on the crop.
- It is important to conduct a soil analysis to understand the properties of the field.
- Based on the results, take appropriate actions to adjust the EC and pH levels.

2.2 Fertilizer needs and essential nutrients

Macronutrients

Macronutrients	Responses
N (Nitrogen)	✓ Improves root, stem and leaf development ✓ Excessive application can cause weakness and encourage pests and diseases
P (Phosphorus)	✓ Flowering and fruiting ✓ Important nutrient for early growth
K (Potassium)	✓ Promotes flowering and fruiting ✓ Strengthens roots and stems ✓ Increases resistance to disease and cold
Ca (Calcium)	✓ Strengthens disease resistance ✓ Promotes root development ✓ Increases pathogen resistance
Mg (Magnesium)	✓ Root fertilizer; deficiency after K is associated with poor root growth
S (Sulfur)	✓ As much as P is required, and if deficient, it becomes soft and yellowing from the lower leaves.

Micronutrients

Micronutrients	Responses
Fe (Iron)	✓ Essential for chlorophyll (photosynthesis)
Mn (Mangan)	✓ Nitrate assimilation
Zn (Zinc)	✓ Plays a role in nucleic acid & protein synthesis
Cu (Copper)	✓ Promotes formation of vitamins A in plants
Cl (Chlorine)	✓ Plays a role in opening and closing stomata
Mo (Molybdenum)	✓ Necessary for protein assimilation and nitrogen fixation
Ni (Nickel)	✓ Components of urea-degrading enzymes. Protein synthesis
B (Boron)	✓ Similar to Ca, deficiency results in disturbance of root elongation

Essential elements are indispensable for plant growth and their deficiency can regulate or halt plant development. There are 17 such essential elements, which are broadly classified into macronutrients and micronutrients based on the quantity required by plants.

Macronutrients

- Macronutrients include nine elements: C, H, O, N, P, K, Ca, Mg and S.
- C, H and O are supplied from carbon dioxide (CO_2) and oxygen (O_2) in the atmosphere, as well as water (H_2O) in the soil, so they do not need to be applied as fertilizers.
- N, P, and K are often deficient in soil and applying them as fertilizers is highly effective. For this reason, they are also referred to as the "three primary nutrients" in fertilizers.

N (Nitrogen):

Promotes the growth of stems and leaves, making them greener, hence referred to as a "leaf fertilizer." Excessive application causes crops to become weak and overly elongated, increasing susceptibility to pests and diseases. High levels of N can lead to Ca deficiency.

P (Phosphorus):

Primarily supports flowering and fruiting, known as a "flower fertilizer" or "fruit fertilizer." When P binds with Al or Fe in the soil, it becomes less absorbable by roots. Excess P inhibits the absorption of Mn, Zn and Fe, potentially causing physiological disorders.

K (Potassium):

Mainly promotes flowering and fruiting as well as root development, referred to as a "root fertilizer." Excessive K can induce deficiencies in Mg and Ca.

Ca (Calcium):

Essential for meristematic tissues, particularly for root development. Overapplication of lime ($CaCO_3$) suppresses the absorption of Mg, K and P by plants.

Mg (Magnesium):

A key component of chlorophyll and many enzymes, playing a critical role in metabolic processes. Excess Mg inhibits the absorption of K and Ca.

S (Sulfur):

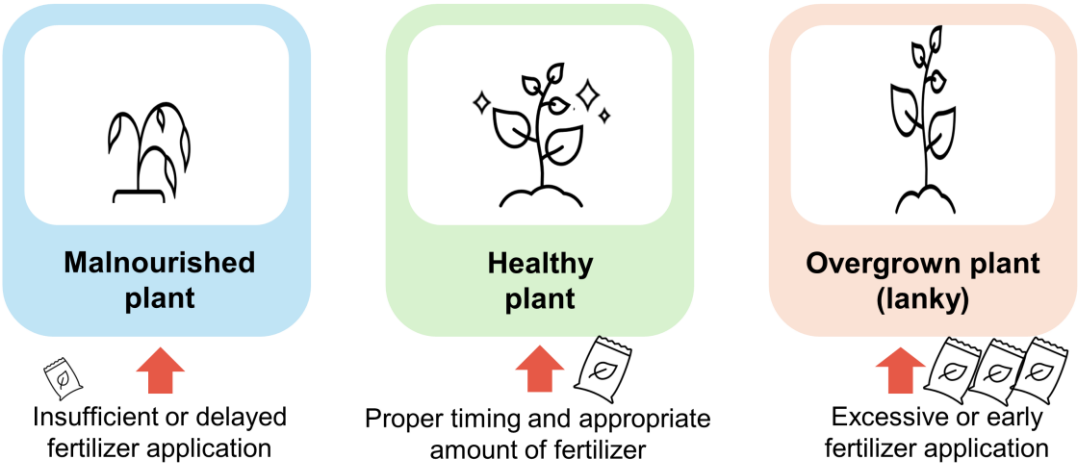
Involved in protein synthesis and metabolism. A deficiency in S weakens crops.

Micronutrients

- Micronutrients include eight elements: Fe, Mn, Zn, Cu, Cl, Mo, Ni, B
- Micronutrients are typically present in the soil and do not require supplementation through fertilizers.
- However, B and Zn are easily deficient and may be supplemented with fertilizers.
- Deficiency of B or Zn increases the permeability of cell membranes, allowing nutrients such as amino acids and sugars to escape from roots and leaves, triggering various pathogens and making them more susceptible to infection.

2.2 Fertilizer needs and essential nutrients

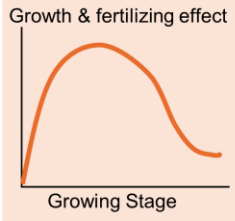
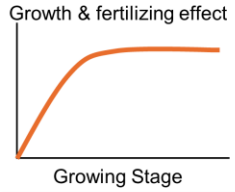
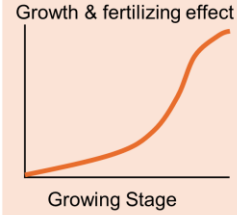
Application of right amount of fertilizer at right time to build a strong plant



Focus point

- ✓ Loss of fertilizer and reduced vigor leads to disease
- ✓ Smooth fertilizer application without running out of fertilizer by considering the type of fertilizer for each vegetable crop
- ✓ Fostering a resistant plant
- ✓ Increase fertilizer use efficiency

Fertilizer effectiveness by crop types

Type		Crops	Fertilizer application
Start dash type Require the fertilizer at beginning		Spinach, Lettuce	✓ Mainly basal dressing ✓ No N fertilizer required in the second half of the year
		Cabbage, Chinese cabbage, Cauliflower, Onion	✓ Mainly basal dressing ✓ Applied until mid-growth ✓ Moderate in the second half
Constant type Require the fertilizer constantly		Cucumbers, tomatoes, peppers, brinjal, spring onions, green beans, carrots, celery	✓ Use delayed-release fertilizer as basal dressing for long-lasting effects ✓ Apply top dressing frequently
Last spurt type Require the fertilizer at final stage		Asparagus, pea beans, strawberries	✓ Apply minimum basal dressing ✓ Earlier application of top dressing.
		Pumpkins, watermelons, melons, radishes	✓ Apply minimum basal dressing ✓ Apply top dressing in the mid- to late-period to regulate growth

Importance of Fertilization

- Proper fertilization management is essential for cultivating crops with resistance to pests and diseases.
- If fertilization is insufficient, crops will not grow adequately, resulting in low yields.
- On the other hand, excessive fertilization can lead to susceptibility to diseases and a decline in quality.
- When fertilizing, it is necessary to consider the amount, timing and type of fertilizer (quick-release or slow-release.

Timing of Fertilizer Application

The timing of fertilizer application varies depending on the crop. Fertilization timing can be broadly categorized into three types: Start dash type, Constant type, and Last spurt type.

Start Dash Type

This category includes crops that primarily apply basal fertilization.

- These crops have a short growth period and are typically harvested for their stems and leaves and crops in which stems and leaves grow first, followed by the enlargement of underground parts such as tubers.
- Spinach: All fertilization is applied as basal fertilizer, and top dressing is generally not conducted.
- Cabbage: Primarily relies on basal fertilization using slow-release fertilizers. Top dressing is mainly applied during the early and middle growth stages, while it is minimized in the later stages.

Constant Type

This category includes crops that require both basal fertilization and frequent top dressing in relatively large amounts.

- Crops with long growth periods that are harvested gradually, such as eggplants and cucumbers are this type.
- Basal fertilizers for these crops should be slow-release fertilizers.

Last Spurt Type

This category includes vegetables that benefit from reduced fertilization in the early stages of growth and increased top dressing during later stages.

- Asparagus: Reducing basal fertilization and applying top dressing early can promote healthy growth.
- Pumpkin: Minimize basal fertilization and apply top dressing from the middle to the later stages of growth. Excessive fertilization during the early growth period may result in large stems and leaves but poor fruit setting and size development.

2.3 Types and roles of fertilizer

Fertilizer classification according to raw material

Chemical fertilizer
Made from natural raw materials such as air or ores and chemically treated

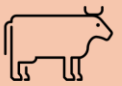


Mono fertilizer
Containing only one type of NPK

Compound fertilizer
Containing two or more nutrients

1. **Chemical compound fertilizer**
   Chemically combining two or more nutrients in a mono fertilizer grain
2. **Mixed compound fertilizer**
   Simply mixing several mono fertilizer
3. **Liquid fertilizer**
   Fertilizer in liquid form containing nutrients

Organic fertilizer
Made from animal or plant organic matter such as rice bran or oil meal



Plant-based organic fertilizer
- Oil meal
- Rice bran
- Rice hulls

etc.

Animal-based organic fertilizer
- Fish meal
- Bone meal
- Compost

etc.

Fertilizer classification in Sri Lanka

Fertilizer	Natural fertilizer	Mineral fertilizer	✓ Gypsum ✓ Dolomite ✓ Rock phosphate
		Organic fertilizer	✓ Manure & compost ✓ Animal excretes ✓ Plant wastes
	Synthetic/Chemical fertilizer	Nitrogenous fertilizer	✓ Urea ✓ Potassium Nitrate ✓ Ammonium sulphate
		Phosphatic fertilizer	✓ TSP ✓ DAP ✓ SSP
		Potassic fertilizer	✓ MOP ✓ SOP ✓ Potassium nitrate
		Other fertilizer	✓ NPK mixtures ✓ MN mixtures

Chemical fertilizers and organic fertilizers are two of the various classifications of fertilizers, classified according to their raw materials.

Chemical Fertilizers

- Inorganic fertilizers made from natural raw materials such as air and ores and chemically treated.
- Fertilizers containing only one type of N, P or K are called ‘mono fertilizer.’
- Fertilizers containing two or more nutrients are called ‘compound fertilizers.’
- Compound fertilizers that are manufactured by chemically combining two or more of the three elements in a mono fertilizer grain are called chemical compound fertilizers.
- Fertilizers made by simply mixing several mono fertilizers are called mixed fertilizers.

Organic Fertilizers

- Fertilizers made from animal or plant organic matter, such as rice bran or oil meal.
- Organic fertilizers are classified into two types: plant-based fertilizers such as oil meal and animal-based fertilizers such as fish meal.

Natural Fertilizers

Classified into mineral fertilizer and organic fertilizer.

- Mineral fertilizer: Gypsum, dolomite, rock phosphate, etc.
- Organic fertilizer: Manure & compost, animal excretes, plant wastes, etc.

Chemical Fertilizers

Classified into nitrogenous fertilizer, phosphatic fertilizer, potassic fertilizer, and other fertilizers.

- Nitrogenous fertilizer: Urea, potassium nitrate, ammonium sulphate, etc.
- Phosphatic fertilizer: TSP, DAP, SSP, etc.
- Potassic fertilizer: MOP, SOP, Potassium nitrate, etc.
- Other fertilizer: NPK mixtures, Micro Nutrient (MN) mixtures, etc.

2.3 Types and roles of fertilizer

Difference between chemical and organic fertilizers

	Chemical fertilizers	Organic fertilizers
Material	Inorganic materials	Organic materials
Manufacturing method	Chemical synthesis	Fermentation and maturity
Effect	Mostly early	Mostly slowly
Price	Reasonable per nutrients	Expensive per nutrients
Distribution	✓ Easy to distribute due to small quantity ✓ Stable quality and supply	✓ Difficult to distribute du to large quantity ✓ Quality is variable and must be adjusted for stable supply
Characteristics	✓ Easy to adjust the amount of fertilizer applied and directly compensate for shortages. ✓ Relatively reasonable	✓ Contribute to soil aggregation, improve soil physical water retention, aeration) and biological (microbial effect) properties. ✓ Include minor nutrients

Focus point

✓ Do not overuse chemical fertilizers just because they are easy to use
✓ It is better to understand the characteristics and use both well

Differences between Organic Fertilizer and Chemical Fertilizer

- Chemical Fertilizers: Dissolve quickly in the soil, allowing nutrients to be rapidly absorbed by plant roots. However, slow-release chemical fertilizers are also available on the market.
- Organic Fertilizers: Require decomposition by microorganisms before nutrients become available, resulting in slower but longer-lasting effects.

Effects of Fertilizers on Farmland

- Excessive use of fertilizers without compost application significantly reduces soil fertility over time.
- Excessive application of N fertilizers causes the pH to drop due to the accumulation of nitric acid, leading to soil degradation.
- Excessive application of urea causes a decrease in microbial diversity and generation of N_2O and ammonia gas in the field.
- Excessive application of ammonium sulfate ($(NH_4)_2SO_4$) in anaerobic paddy fields generates hydrogen sulfide gas.

2.4 Fertilizer application based on soil testing

Soil testing

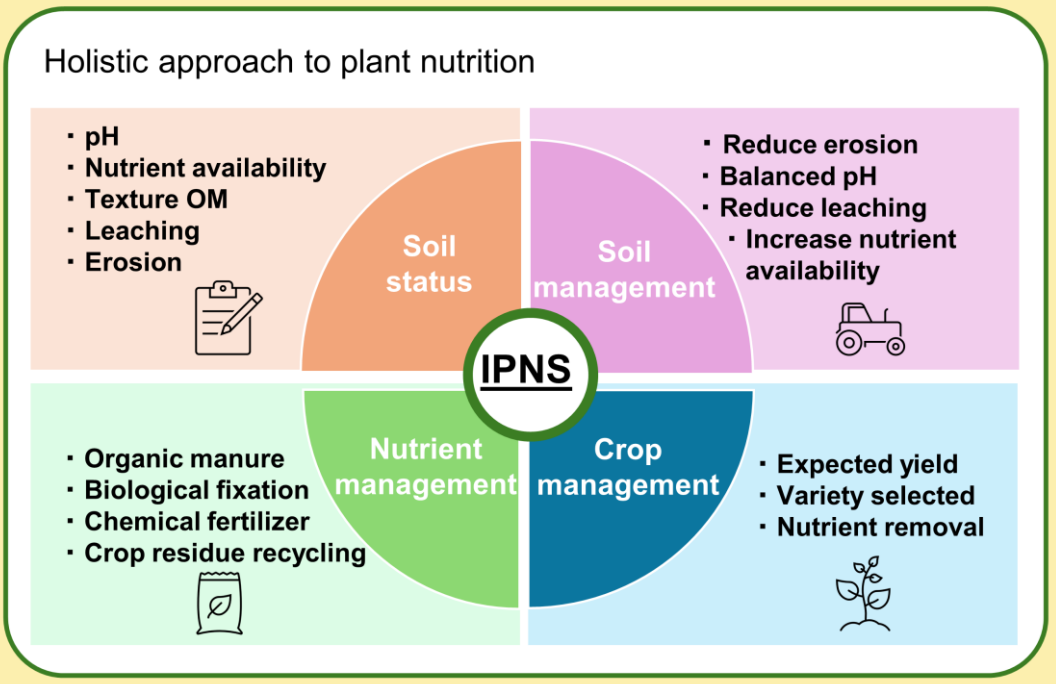
Process	Contents
1. Basic Testing	Make a composite soil sample and grasp the characteristics - Physical : Soil texture
2. Soil Improvement Testing	Make the prescription, considering physical and chemical - Physical : Soil moisture, WHC, compaction - Chemical : CEC, EC, pH, available phosphorus - Nutrient content: How to use soil test kit Test different factors in the soil
3. Fertilization Testing	Make a fertilization design for each crops (design the amount and timing of fertilization to balance chemical fertilizer and organic fertilizer)

$$\text{Fertilizer amount} = \left(\text{Nutrient requirements} - \text{Nutrients in the soils}\right) \div \frac{\text{Utilization rate}}{100}$$

*Note: Fertilizer amount is the amount of fertilizer to be applied in one crop

*Note: Utilization rate is N: 40-60%, P: 5-15%, K: 40-70%

Integrated Plant Nutrition System (IPNS)



IPNS contributes to safe food production and environmental protection

Nutrients in Soil

- The natural supply of nutrients from the soil and their utilization rates vary by soil type and region.
- The amount of nutrients remaining in the soil after harvest varies with the crop.

Nutrient Utilization

- Fertilizer design based on soil testing can help determine the amount of nutrients needed and prevent over-fertilization.
- The amount of fertilizer applied should be calculated based on the utilization ratio, since not all nutrients are available for use.
- If compost is used, its nutrient content should also be taken into account.
- The amount of fertilizer applied is the amount of nutrients required per cropping season, but the timing of fertilizer application should also be considered, as each vegetable category has a different fertilizer effect type.
- Excessive amounts of N and P in particularly can cause problems.

The Integrated Plant Nutrition System (IPNS) is a holistic approach to plant nutrition that combines nutrients from both inorganic and organic sources to maintain soil fertility, enhance crop productivity and ensure ecological compatibility, social acceptability and economic viability.

Soil Condition:

Focuses on monitoring soil properties such as pH, nutrient availability, organic matter (OM), leaching and erosion to assess and maintain soil health.

Soil Management:

Implements practices to reduce erosion, balance soil pH, minimize nutrient leaching and enhance nutrient availability for sustainable farming.

Nutrient Management:

Emphasizes the combined use of organic manure, biological nitrogen fixation, chemical fertilizers and crop residue recycling to optimize nutrient supply and minimize waste.

Crop Management:

Set harvest targets and select crop varieties accordingly. Additionally, remove weeds to prevent them from depleting nutrients.

This integrated approach ensures that plant nutrition is balanced and environmentally sustainable, contributing to long-term agricultural success.

2.4 Fertilizer application based on soil diagnosis

Fertilizer recommendation

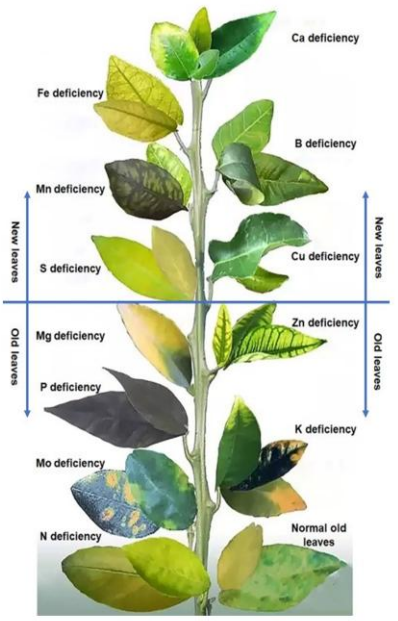
1. Chemical Fertilizer - kg/ha

Crops	N	P	K	Application Times
Cabbage	150	125	90	4 times
Potato	150	125	150	3 times
Tomato	90	150	80	3 times
Beans	80	75	80	2 times
Brinjal	140	150	100	3 times

2. **Lime:** 1-2 t/ha
3. **Organic manure (poultry and cattle manure or compost):** 10 t/ha

- ✓ Fertilizer should not be applied at once, but in the **right amount at the right time**!
- ✓ It should be applied after creating good soil by adding organic fertilizers and liming!

Deficiency Symptoms



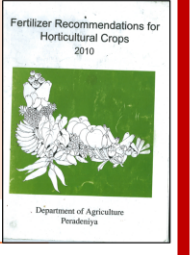
https://shining.homes/plant-deficiency-diagnosis

See Fertilizer Recommendations for Horticultural Crops 2010 (DoA) for more details

Fertilizer recommendation

Types	Crops
Low Country Vegetables	✓ Bitter gourd, Snake gourd & Luffa ✓ Brinjal ✓ Cooking banana ✓ Cucumber, Pumpkin, Gherkin & Squash ✓ Okra ✓ Thumbakarawila ✓ Thibbatu ✓ Vegetable cowpea ✓ Winged bean ✓ Leafy vegetables
Up Country Vegetables	✓ Bean (Bush bean) ✓ Bean (Pole bean) ✓ Beet root ✓ Cabbage & Cauliflower ✓ Carrot ✓ Capsicum ✓ Knol khol ✓ Leek ✓ Lettuce ✓ Radish ✓ Tomato ✓ Mixed cropping system (Leek + Beet) ✓ Mixed cropping system (Leek + Carrot) ✓ Organic vegetable production

Types	Crops
Potato	✓ Potato
Root & Tuber crops	✓ Cassava ✓ Dioscoria ✓ Ginger ✓ Innala ✓ Kiriala ✓ Sweet Potato ✓ Turmeric
Fruit Crops	✓ Apple & Peach ✓ Avocado ✓ Banana ✓ Citrus ✓ Durian ✓ Grapes ✓ Guava ✓ Jak ✓ Mango ✓ Mangosteen ✓ Papaya ✓ Passion fruit ✓ Pears ✓ Pineapple ✓ Pomegranate ✓ Rambutan ✓ Strawberry
Floricultural crops	✓ Aster



See Fertilizer Recommendations for Horticultural Crops 2010 (DoA) for more details

Lime and Organic Manure Application

- Lime application should be done 2 weeks before planting and mix well into the soil.
- Lime and chemical fertilizer should not be applied together.
- Application of any organic manure at the rate of 10 t/ha is beneficial.
- Poultry manure should not exceed 10 t/ha and should be applied 3-5 days before planting and the keeping the soil moist.
- If poultry manure is used continuously, liming can be omitted.
- Integrated use of organic manure and chemical fertilizers is more effective than using either alone.

Chemical Fertilizer Application

- Basal N, P and K should be applied and incorporated into soil at least 1-2 days before planting.
- Ensure the soil remains sufficiently moist after fertilizer application.

Foliar Fertilizer Use

- Foliar fertilizer application is advisable only when deficiency symptoms are observed.

Fertilizer Recommendations for Horticultural Crops

This manual, created by the Department of Agriculture (DOA), provides fertilizer guidelines for over 50 crops.

It is important to refer to this Recommendation and apply the right amount of fertilizer at the right time to ensure that nutrients are available to the crops without waste.

The contents included in this manual are as follows:

- Includes chemical fertilizer application rates, plant spacing and soil preparation methods.
- Details the timing and quantity of chemical fertilizers to be applied.

2.5 Fertilizer application in protected agriculture

Fertilizer recommendation - Protected Agriculture ①

For crops grown on **soil media**

Crop	Basal Fertilizer / per plant (A day before planting)	Fertilizer at the time of growth (g/plant – once a week)					
		Up to 3 weeks		4 to 7 weeks		Ahead	
Bell pepper, Tomato, Curry chili, Green chili or Chili	8 g of TSP and 4 g of slow-releasing granule fertilizer containing all micro nutrients	Urea 1.0	MOP 0.75	Urea 1.5	MOP 1.0	Urea 1.5	MOP 1.5
		Up to 2 weeks		3 to 6 weeks		Ahead	
Salad cucumber	5 g of TSP and 3 g slow-releasing granule fertilizer containing all micro nutrients	Urea 1.0	MOP 0.75	Urea 1.0	MOP 1.0	Urea 1.5	MOP 1.5

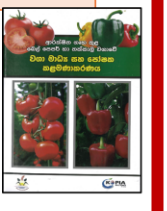


See greenhouse cultivation manual and videos for details of Fertilizer application in protected agriculture

Fertilizer recommendation - Protected Agriculture ②

For crops grown on **coir dust media**

Crop	Quantity of Albert fertilizer to be applied – g/day per plant (The amount of water to be used for applying the fertilizer in ml)						
	1st week	2nd week	3-4 weeks	5-6 weeks	7-8 weeks	9-10 weeks	Ahead
Bell pepper	0.25 (250)	0.375 (250)	0.50 (400)	0.75 (500)	1.00 (750)	1.25 (750)	1.50 (1000)
Curry chili	0.25 (250)	0.375 (250)	0.50 (400)	0.75 (500)	1.00 (750)	1.25 (750)	1.50 (1000)
Green chili	0.25 (250)	0.375 (250)	0.50 (400)	0.75 (500)	1.00 (750)	1.25 (750)	1.25 (1000)
Tomato	0.25 (250)	0.50 (250)	0.75 (400)	1.00 (500)	1.25 (750)	1.50 (750)	2.00 (1000)
Salad cucumber	1 week	2 week	3 week	4 week	5-6 weeks	Ahead	
	0.25 (250)	0.50 (250)	0.75 (400)	1.00 (500)	1.50 (750)	2.00 (1000)	



See greenhouse cultivation manual and videos for details of Fertilizer application in protected agriculture

In open fields, a significant proportion of the fertilizer applied is washed off by rainfall down through the soil and into the surrounding soil, groundwater and rivers. However, in the protected agriculture, due to the lack of rainfall and low irrigation compared to evapotranspiration, a significant proportion of the fertilizer remaining unabsorbed by the crop remains on or near the soil surface and accumulates as salts. Therefore, in protected agriculture different fertilizer management is required than the open field.

Fertilizer Management for Soil Media in Protected Agriculture

- Commonly used open-field fertilizers such as urea, triple superphosphate (TSP), and muriate of potash (MOP) can also be applied in a soiled medium in a protected house.
- TSP should be applied entirely to the media before planting, while urea and MOP can be applied in parts in several cases.
- Water should be applied first and fertilizer should be added only after surface water has completely drained.
- Fertilizer should be placed 2-3 inches away from plant roots, mixed into the soil and covered. Irrigation should be avoided immediately after fertilizer application.
- About 1 gram of Albert or Kodi mix fertilizer should be dissolved in water & applied per plant once a week.
- High micronutrient utilization efficiency can be achieved by slowly releasing the micronutrients that remain in the media for a long term.

Fertilizer Management for Coir Dust Media in Protected Agriculture

- A well-water-soluble fertilizer mixture containing all essential plant nutrients should be used. Albert mixture or Kodi mix fertilizer is recommended for this purpose.
- Fertilizer should be applied daily, with the amount increasing as the plant grows, as shown in the table.
- The recommended quantities are based on weather conditions and may vary depending on weather factors.
- Fertilizing the crops begins at 7.30-8.00 am and continues until 1.00 pm It is best to keep the volume applied in parts at a maximum value between 10.00 am and 12.00 noon.
- The Electrical Conductivity (EC) should always be kept below 2 ds/m and the pH close to 6.5.
- It is best to mix 2 grams of fertilizer per liter of water when processing the amount of fertilizer, since the electrical conductivity and pH value at the time of Albert fertilizer 2 g/l are close to 2 ds/m and 6.5 respectively.

Exercise 

- What are the advantages and disadvantages of organic fertilizers?
- I have been consulted by a farmer who says he/she has been applying a lot of chemical fertilizers, but the yields are not increasing. What advice would you give him/her? Please explain the procedure clearly.

Memo :

CHAPTER 3

Pest Management and Pesticide Use

3.1. Basics of pest control
3.2. Integrated Pest Management (IPM)
3.3. Type of pests and their control methods
3.4. Type of diseases and their control methods
3.5. Physical control of pests and diseases
3.6. Biological control of pests and diseases
3.7. Cultural control of pests and diseases
3.8. Chemical control of pests and diseases
3.9. DoA recommended pesticides application

3.1 Basics of pest control

Why are Crops Vulnerable to Pests and Diseases?

Reason 1

Lack of biodiversity in agricultural land

- Single crop cultivation
- Lack of natural enemies
- Pest dominance



Reason 2

Degradation of self-defense due to breeding

- Non-toxicity of plants due to breeding
- Reduction of negative substances such as bitterness, astringency, etc.



Reason 3

High nutritional value of crops

- High protein and sugar content
- Vigorous growth of pests that have eaten them

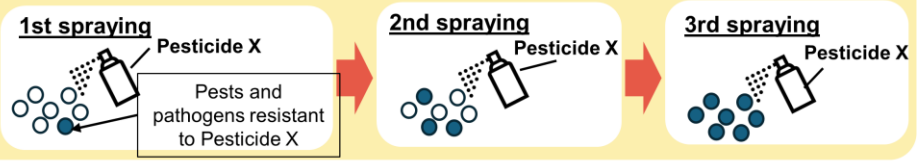


Why is the Number of Pesticide-Resistant Pests Increasing?



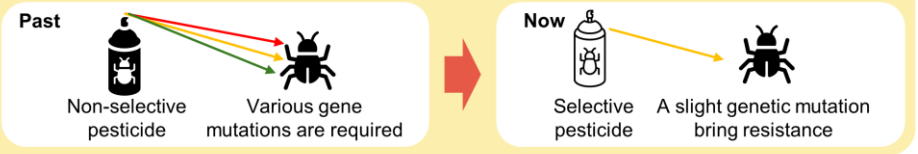
Reason 1

Increase in resistant pests and pathogens



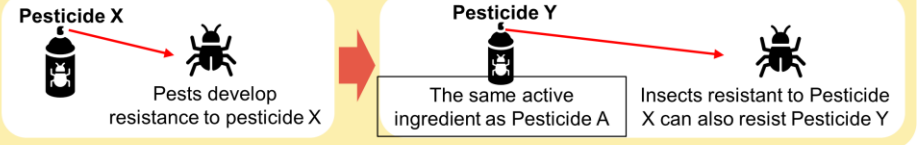
Reason 2

Increase in selective pesticides



Reason 3

Increase in cross resistance



Crops are vulnerable to pests and diseases due to the following reasons:

Lack of biodiversity in agricultural land

- In natural ecosystems, diverse organisms maintain complex food chain relationships, creating a stable interrelationship.
- In contrast, agricultural ecosystems feature simplified flora, often consisting of a single crop variety at the same development stage.
- Consequently, the insects and micro-organisms present also become limited to species that feed on these crops.
- Without natural enemies in such an environment, pests can easily proliferate and spread their influence.

Degraded self-defense through breeding

- Natural defense substances, such as pungency, bitterness, astringency, and acridity, help repel herbivores.
- However, breeding for cultivated varieties has prioritized high yields, non-toxicity, and good taste, making them more attractive to pests.
- Cultivated varieties have weaker self-defense mechanisms compared to wild species.

Nutritional value of crops

- Nutrient-rich crops with less bitterness or other repellent substances are also appealing to pests, promoting their growth when consumed.
- Additionally, pests feeding on such crops become more fertile, leading to a significant increase in their population in the next generation.
- Micro-organisms that cause crop diseases also often attack soft, nutrient-rich crops.

Pesticides are used to eliminate pests, but the increase in pesticide-resistant pests and pathogens has become a significant issue. Such pesticide resistance primarily develops due to the following three factors.

Increase in pesticide-resistant pests

- Some pests and pathogens possess genes that confer resistance to insecticides and fungicides.
- Repeated use of the same pesticide selects for these resistant individuals, allowing them to survive and multiply, gradually dominating the population and rendering the pesticide ineffective.
- As a result, pests and pathogens that are unaffected by the pesticide can proliferate.

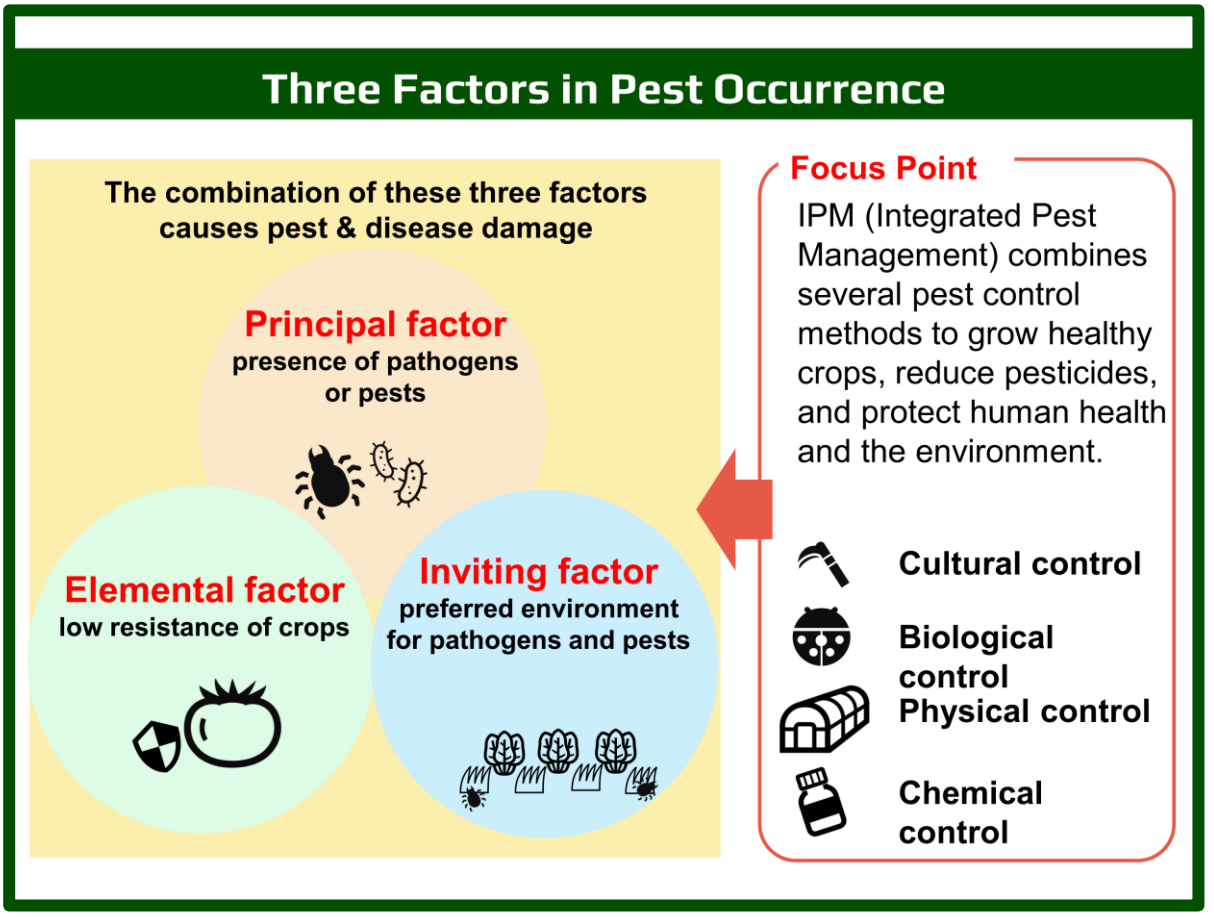
Increase in selective pesticides

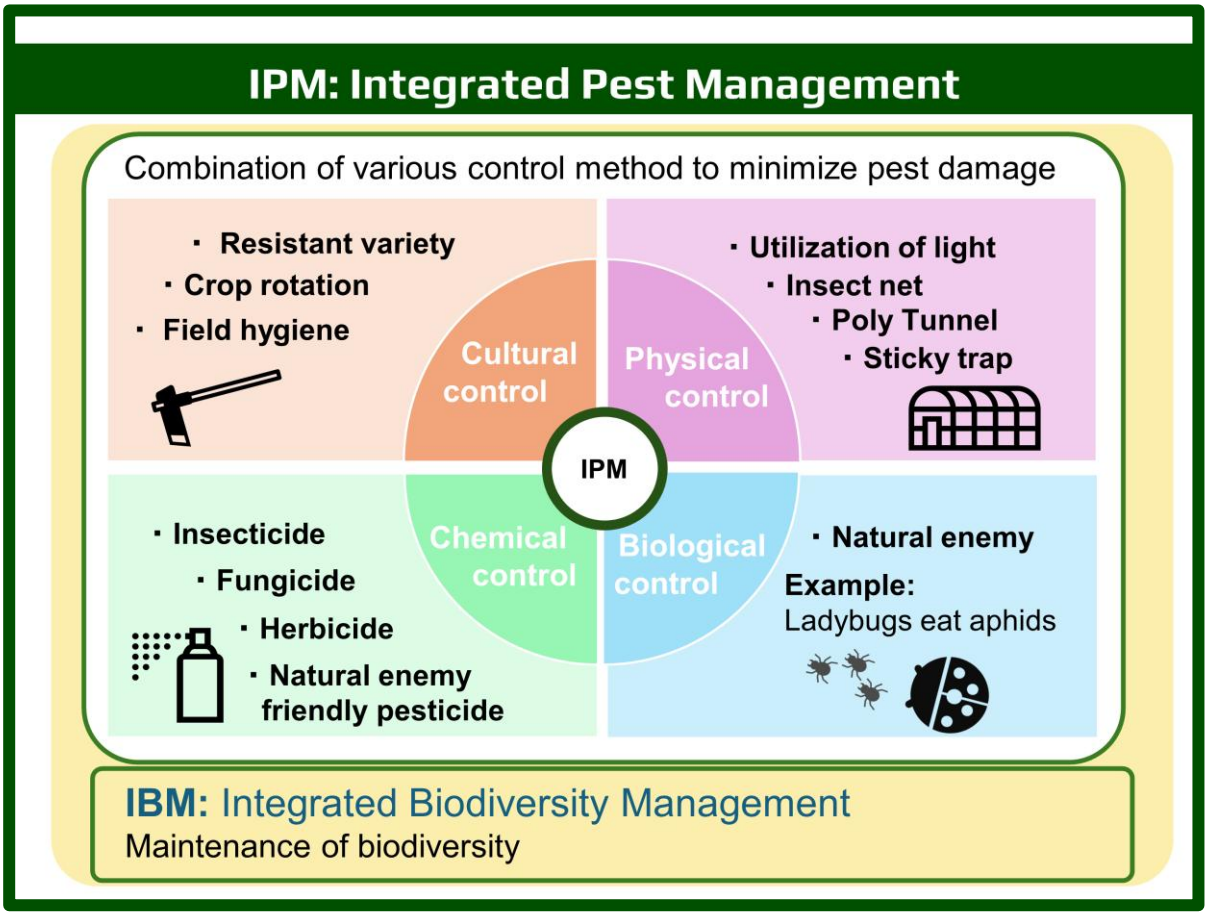
- Considering pesticide safety and environmental concerns, many modern pesticides are designed to target specific parts of particular pests and pathogens.
- However, because they act on specific sites, even minor genetic mutations can result in resistance, leading to a rapid increase in resistant pests and pathogens.

Increase in cross-resistance

- Pests that develop resistance to one pesticide may also resist others with the same mode of action, even those never used before.
- As new agrochemicals are continuously developed, it is crucial to understand their modes of action and apply them strategically in agriculture.

3.2 Integrated Pest Management (IPM)





There are three factors that determine the occurrence of pest and diseases;

- **Principal factor:** Presence of pathogens or pests.
- **Elemental factor**: Vulnerability of crops to pests and diseases.
- **Inviting factor**: Favorable environment for pest outbreaks.

Comprehensive Pest Management

- Effective pest control involves addressing all three factors, not just the principal one.
- While chemical pesticides target the principal factor, other methods are essential to reduce elemental and inviting factors.
- Combining of chemical, cultural, biological, and physical methods is essential for effective pest and disease control.
- Avoiding reliance solely on chemical control helps suppress the proliferation of pesticide-resistant pests and pathogens.

IPM is the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations.

It combines biological, chemical, physical and crop specific (cultural) management strategies and practices to grow healthy crops and minimize the use of pesticides, reducing or minimizing risks posed by pesticides to human health and the environment for sustainable pest management.

IPM was introduced as the most appropriate pest control strategy in Sri Lanka's 1995 agriculture policy. The DOA plays a key role in promoting IPM programs through research, training, and technology transfer via nationwide extension services.

Cultural control

- Crop Rotation: Alternate the cultivation of different crops.
- Resistant varieties: Use varieties that are less susceptible to pests and diseases.
- Field hygiene: Remove old branches, leaves, and weeds. Use clean equipment. Monitor fields regularly for early pest and disease detection.

Physical control

- Insect Nets: Use nets to prevent pests from entering fields.
- Utilization of Light: Deter pests with light that they dislike.

Biological control

- Natural Enemies: Utilize predatory insects, parasitic wasps, and beneficial microorganisms.

Chemical control

- Pesticide: Pests do not need to be eradicated but should be maintained at levels that do not cause economic damage.
- Pesticides should be selective, targeting pests while being safe for natural enemies, rather than non-selective ones.

IBM (Integrated Biodiversity Management)

- Recently, the importance of IBM, which evolved from IPM, has come to be recognized.
- IBM aims to create an environment suitable for crop cultivation while ensuring biodiversity, including managing pests, natural enemies, and other insects.

3.3 Types of pests and their control methods

The main insects acting as pests - 1

Type		Characteristic	Damage	Damage part
Thrips		Adults are 1~2mm and difficult to find because hide in leaf folding. Both larvae and adults suck the juice to scrape the soft parts of the plant, and the leaves lose color or fall with white spots-virus vectors.	Sap-sucking	Stems and leaves
Stink bug*2		There are several types. Adult insects are difficult to control because they fly in groups. They put the sucking marks.	Sap-sucking	Grain
Aphids		Taxonomically, it is a member of the stink bug family, but only the males can fly or jump. They suck nutrients in groups and inhibit growth. Vectors of viral diseases such as mosaic disease.	Sap-sucking	Stems and leaves
Butterflies & moths		Butterflies & moths larvae include hairless caterpillars and hairy caterpillars; they are predatory pests that feed on leaves and flowers. For control, it is better to cut off the leaves and branches and dispose of them.	Feeding damage	Leaves, flowers
Beetles*3		Adults feed on leaves and flowers in the aboveground part, and larvae eat roots in the soil. Adults can fly around, so control is troublesome.	Feeding damage	Leaves, flowers, roots
Whiteflies		The larvae are less than 1 mm in size, suck nutrients from the leaves and their excrement causes sooty mold. Adults are about 1 mm in size and have white wings	Sap-sucking	Stems and leaves

The main insects acting as pests -2

Varieties	Characteristic	Damage	Damage part
Mite 	Small pest less than 1 mm in size, inhabit leaf undersides and extract nutrients, causing white spots, yellowing, and leaf drop. It matures into an adult approximately 10 days after hatching, allowing for rapid reproduction and widespread damage in a short period of time. Examples: spider mites, dust mites, rust mites.	Sap-sucking	Stems, leaves and fruits
Nematode*6 	The body is thread-like and about 1 mm. Moves by twisting its body like a snake. It is often colorless and transparent, making it difficult to find. The density increases due to continuous cropping, and once it occurs, it is difficult to completely get rid of it with pesticides. Symptoms like wilting and withering as seen in pathogenic bacterial infections. The infection is often spread through contaminated seedlings, soil and water, etc.	Sap-sucking	Roots

Measures

The basis of pest control is early detection through frequent observation.

- Prevention by an environment that does not attract pests.
  Carefully observe the presence of pests, plant abnormalities, and deal with them at an early stage.

Damage of pests

When symptoms such as wilting or discoloration occur, it is important to identify whether the cause is a pathogen or a pest and to take appropriate measures accordingly.

If leaves or other parts of the plant are chewed, it is immediately clear that pests are responsible. However, even tissue discoloration or poor growth can also be caused by pests.

Types of pests

Sucking pests:

- Damage: Extract plant sap, weakening the plant.
- Examples: Mites, aphids, and other small-sized pests.

Chewing pests:

- Damage: Cause severe harm by puncturing, feeding on, or devouring plant tissues.
- Examples: Caterpillars.

Not all insects found on plants are harmful. Some may be beneficial insects that help control pest populations or contribute to the plant ecosystem. It is important to correctly identify pests before taking control measures.

To mitigate the damage caused by these pests, consider implementing the following measures.

Optimize the growing environment

- Strong, healthy plants are more resistant to minor pest attacks.
- To create a pest-resistant growing environment, ensure plants receive adequate sunlight and maintain good ventilation.

Preventive measures

- Use tools such as insect nets and mulch to prevent pest invasion and control weeds.
- Encourage and increase the population of natural enemies like ladybugs, which prey on pests such as aphids.
- For early infestations, remove pests manually.
- If the infestation becomes too severe for manual removal, consider using insecticides.
- However, as pesticides can also harm beneficial insects, carefully plan their application method and timing.

Reference

1. Stink bug: https://www.dallasnews.com/arts-entertainment/2018/10/15/how-to-tell-the-difference-between-good-stink-bugs-and-bad-stink-bugs/
2. Beetle: https://www.inaturalist.org/photos/18009671
3. Nematode: https://plantwiseplusknowledgebank.org/doi/full/10.1079/pwkb.species.43900

3.4 Types of diseases and their control methods

Three Main Types of Pathogens

Size of Pathogens: Large → Small

Filamentous Fungi

- Cause the majority of plant diseases damage.
- Commonly referred to as mold.
  Thrive in warm and humid environments.
  When it rains, spores are easily scattered, and diseases are likely to occur.
  Examples: powdery mildew, downy mildew



Powdery mildew caused by Filamentous Fungi

Bacteria

- Proliferate through cell divisions.
  Infections spread quickly, and the damage tends to be large.
  In paddy fields, unlike in upland fields, bacteria are more abundant than filamentous fungi.
  Actinomycetes are also taxonomically bacteria, but they have similar characteristics to filamentous fungi.
  Examples: soft rot (Chinese cabbage, carrot), wilt (tomato, eggplant)



Bacterial Wilt on Brinjal

Virus

- Pathogens that have no cells and are not considered living organisms.
- Viral diseases cannot be controlled by pesticides.
- Control measures focus on preventing pests such as aphids, which transmit viruses
- Examples：Mosaic disease（Cucumber, Tabacco, Tomato and so on）



Tomato brown rugose fruit virus

Infection Pathways

Pathway		
Air-borne infection 	• Mainly filamentous fungi that form spores Spores are scattered by the wind and adhere to plants It can be scattered from thousands of miles away	Common Rust, Powdery mildew, Rice Blast
Soil-borne infection 	• Filamentous fungi, bacteria and viruses in the soil infect the roots Repeated cultivation increases the density of pathogenicity and causes repeated cultivation damage They invade from the root surface, when favorable plant's root grow	Soft rot (bacteria), Common Scab (actinomycete), Root rot (Filamentous fungus), Bacterial wilt (bacteria), Dwarf disease (Filamentous fungus), Club root (Filamentous fungus)
Seed-borne infection 	• Pathogenic bacteria lurk in the seeds and infect the seedlings • Virus transmitted through bulbs • Bacteria and filamentous fungus also	
Infection by vector 	• Insects such as aphids, thrips, and leafhoppers transmit the virus	

Measures

Grow a sturdy plant body in a suitable environment and eliminate the conditions favored by pathogenic bacteria
- ✔ Good sunlight, ventilation, and drainage
- ✔ Avoid repeated cultivation by crop rotation and mixed cropping

Paddy fields and farmlands host a variety of microorganisms essential for plant growth and ecological balance. However, a small percentage of these microorganisms are harmful, causing diseases that lead to poor growth or even plant death.

Microorganisms, in descending order of size, include bacteria, actinomycetes, filamentous fungi (e.g., molds and mushrooms), algae and protozoa (e.g., amoebas). Viruses, though not classified as microorganisms, also inhabit soil and act as pathogens.

Approximately 70% of soil microorganisms by weight are filamentous fungi, while about 25% consist of bacteria and actinomycetes.

Filamentous fungi

- About 80% of plant diseases are caused by filamentous fungi.

Bacteria

- Multiply through cell division, spreading infections quickly.
- Actinomycetes are similar to bacteria in cell size and structure, but they develop mycelium and form spores, resembling filamentous fungi.

Viruses

- Viruses, which can only be observed under an electron microscope, invade an organism's system and multiply as if they were living organisms.
- Many viruses are transmitted by sap-sucking insects. In some cases, they are spread via human hands or farm machinery during agricultural work.

Four paths of infection are listed, including Air-borne infection, Soil-borne infection, Seed-borne infection and Infection by vector.

Control Measures

- Each plant requires a specific environment for optimal growth, and hardy plants grown in such conditions are less likely to become infected by diseases.
- It is essential to cultivate plants in their suitable environments while simultaneously eliminating conditions that favor pathogens as much as possible.

Utilize sunlight and proper spacing

- Sunlight promotes photosynthesis, which strengthens plants.
- Avoid dense planting and ensure adequate spacing between plants. Prune and thin plants to improve ventilation and reduce humidity, which inhibits pathogen growth.

Improve soil drainage

- Poor drainage weakens root respiration and supports pathogen proliferation.
- Soil-borne pathogens spread through water, making measures such as drainage channels and high ridges essential.

Target the soil when watering

- Watering should target the soil rather than the plants themselves.

Avoid continuous cultivation

- Continuous cultivation of the same plant or plant family in the same location can imbalance in the soil ecosystem and nutrients, leading to poor plant growth and disease.

3.5 Physical control of pests and diseases

Effective Farming Practices ①

Rain-shelter cultivation



- Blocks out strong sunlight, stabilizes soil moisture and prevents disease.
- Suitable for crops native to dry regions with low rainfall, such as tomatoes.

Mulching



- Use for different purposes, as there are various types and effects, such as preventing soil from sprinkling up.

Type	Effect	Disadvantages and countermeasures
Black	Increases soil temperature to promote growth and prevent weed growth	Drying out the ground increases spider mites and aphids, therefore change to straw etc. in hot weather
Transparent	Increased soil temperature to promote growth, solar disinfection to control weeds and soil pests	
Silver & white	Sparkling, insect repellent effect	Natural enemies are also repelled

Use of covering materials



- Covering materials such as insect nets, non-woven fabrics and cheese cloth are easy ways to reduce pesticide use.
- Note that each method of application has its own benefits and points to consider.
- Timing of application is also important.

Effective Farming Practices ②

Use of UV-cut material



- Effective in fighting pests and diseases requiring UV light in greenhouse cultivation
- Often has a positive effect on crops by blocking UV rays.
- UV cut-off rate depending on the application situation and the applied crop.

Use of light and color



- Yellow LED lights is effective in repelling noctuid moths that have acquired pesticide resistance.

See Guidance for test results and details on how to use yellow lights

- Yellow sticky sheets for trapping aphids, whiteflies etc. Choose the color, etc. according to the application, as blue attracts other pests, etc.

See Guidance for test results of sticky traps and details on how to use

Use of heat



- Bacterial wilt, Southern blight and Wilt disease are diseases transmitted through the soil and require soil disinfection.
- Conventional chemicals are banned or have limited effectiveness and present many challenges.
- Disinfection methods include solar disinfection, hot water disinfection and baked soil disinfection.

Physical control methods are one method of pest management that does not rely on chemical pesticides.

Rain-shelter cultivation

- Tomatoes originate from arid regions and tend to crack fruits when they absorb excess rainwater. Additionally, high humidity increases the risk of disease infection, making rain shelters an effective method to protect them.
- Rain covers help reduce solar radiation, prevent sunburn damage, so they are used for crops such as spinach, cucumbers, peppers, lettuce, and celery.

Mulching

- Using mulch can promote crop germination and growth, suppress weeds, and repel pests, but as shown in the table, it can also have negative effects.
- Using straw mulch to prevent soil temperature from rising is and effective methods.

Use of covering materials

- Effective on vegetables vulnerable to pests such as cabbage and Chinese cabbage.
- Non-woven fabrics protect crops from pests and have heat-retaining effect.
- Cheese cloths protects crops from pests and has shading and cooling effect.
- Can be used as tunnels (A method of covering plants in which covering material is applied over the tops of poles.)
- The finer the mesh of the insect net, the more likely it is to prevent the entry of smaller pests, but it also reduces air ventilation.
- Covering should be done immediately after sowing or at the same time as planting, and before the white flies and aphids have established habitation.
- Covering after solar soil disinfestation is recommended to prevent pests in the soil.

Use of UV-cut films

- UV light cuts prevent grey mold, a common greenhouse issue, and virus transmission by thrips, as thrips avoid UV-free spaces.
- These cuts benefit crops like spinach, chives, cucumbers and early-stage tomatoes. However, improper UV reduction can be harmful, so the optimal cut rate should be selected based on the crop and application conditions.

Use of light and color

- Noctuid moths fly and lay eggs at night, so they can be prevented by using yellow LED lights to create the illusion of daytime.
- Yellow lights are only effective against adult moths and are less effective if larvae or eggs are already present.
- The disadvantage is that stink bugs, beetles and cicadas are attracted to yellow lights.
- Sticky traps - Yellow: Attracts and captures whiteflies, aphids, yellow tea thrips and diamond back moth; Blue: Attracts and captures western flower thrips, melon thrips and cabbage butterfly.

Use of heat

- Solar disinfection: Effective for shallow soil areas.
- Hot water disinfection: Effective for small soil areas.
- Burnt-soil disinfection: Effective for seedling beds.

3.6 Biological control of pests and diseases

Natural Enemies

The world of insects is also based on a food chain of "eating and being eaten."



By effectively utilizing natural enemies of pests, it is possible to reduce pest population.

Create a suitable environment for natural enemies.

- Choose pesticides that are effective against pests but have minimal impact on natural enemies.

Natural Enemies – Bio Pesticides ①

Bio-Control of Root-Knot Nematodes

Control nematodes with mycelium and metabolites



Nemato-Catcher

Contents

Pseudomonas / Bacillus bacteria sp.



TRICHO-COMPOST

Contents

Trichoderma fungus
+
compost fertilizer



TRICHO-LEACH

Contents

Trichoderma fungus
+
Organic liquid fertilizer



Biological control or biocontrol, is a sustainable method of managing pests by utilizing their natural enemies such as predators, parasitoids, pathogens and competitors to reduce pest populations.

Utilization of indigenous natural enemies

- Indigenous natural enemies are local organisms that help control pests.
- To make the most of their benefits, it's important to create a habitat that supports their growth and activity.
- Example
  - Planting hairy vetch or crimson clover around farm fields can attract beneficial insects like ladybugs, which eat aphids.
  - These plants provide a welcoming environment that encourages these helpful predators to thrive.

HORDI has developed bio-pesticides to control several pests :

1. Bio Control of Root knot nematode:

Nemato-Catcher

- Organic nematicide
- Contains *Pseudomonas / Bacillus* bacteria sp.
- Produce metabolites that are harmful to nematodes.
- Incorporate 2.5 g into the planting hole one week before planting.

TRICHO-COMPOST

- Basically an organic fertilizer
- Contains *Trichoderma* fungus
- Produce metabolites that are harmful to nematodes.
- Incorporate to soil as compost fertilizer.

TRICHO-LEACH

- Basically an organic liquid fertilizer
- Contains *Trichoderma* fungus
- Drench the soil.
- Can be used as inoculum to produce TRICHO-COMPOST.

3.6 Biological control of pests and diseases

Natural Enemies – Bio Pesticides ②

Bio-Control of Whitefly

Adult predators lay eggs in the larval stages of whiteflies.



WHITE FLY HUNTER

Contents

Encarsia guadeloupae





EMIE CHIPS

Contents

Eretmocerus eremicus





Natural Enemies – Bio Pesticides ③

Bio-Control of Aphids

The adult of predator lays eggs in aphids.



Bio-Control of Diamond Back Moth

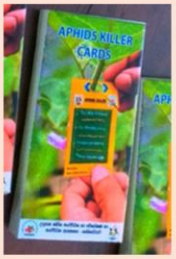
The adult of predator lays eggs in DBM larvae.



APHID KILLER CARDS

Contents

Aphidius ervi





DBM Destructor

Contents

Cotesia plutellae





2. Bio Control of White fly

WHITE FLY HUNTER

- Parasitoid - *Encarsia guadeloupae*
- Adult females lay eggs during the 2nd and 3rd larval stages of whiteflies.
- Pupae of the parasitoid are pasted on cards.
- Introduce the parasitoid into the field every 2 weeks.
- 20 cards per acre

EMIE CHIPS

- Parasitoid– *Eretmocerus eremicus*
- Adult females lay eggs during the 2nd and 3rd larval stages of whiteflies.
- Pupae of parasitoids are pasted on cards.
- Introduce the parasitoid into the field every 2 weeks.
- 20 cards per acre

3. Bio control of aphids

APHID KILLER CARDS

- Parasitoid – *Aphidius ervi*
- Lays eggs in aphids and produces mummy galls.
- Mummy galls with the parasitoid are pasted on cards.
- 20 cards per acre every 2 weeks.

4. Bio control of diamond-back moth

DBM Destructor

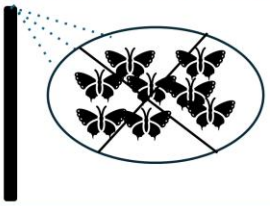
- Parasitoid- *Cotesia plutellae*
- Lays eggs on the DBM larvae.
- Pupal stages are pasted on sticky cards.
- 20 cards per acre every 2 weeks.

3.6 Biological control of pests and diseases

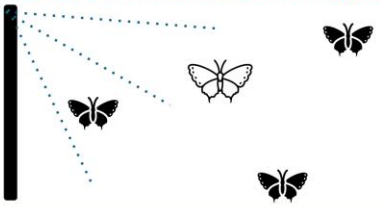
Use of pheromones

- Suitable for controlling specific pests in a large field

Mass-trapping



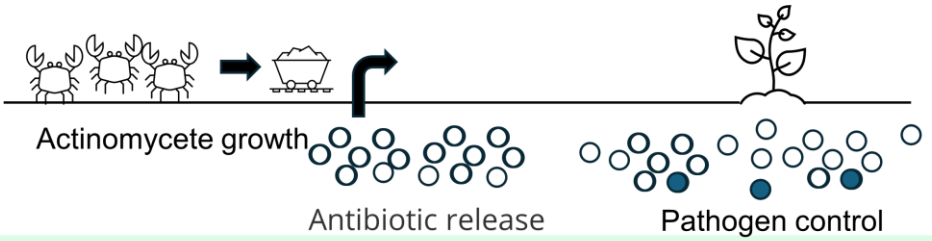
Communication disruption





Use of Micro-organisms

- Increase useful actinomycetes and suppress pathogenic bacteria with antibiotics



- As it has yet to gain widespread adoption at the practical level, verification of its effectiveness requires.
- Future development is encouraged.

Use of pheromones

The smell of a female is chemically synthesized by utilizing the attraction of males to females and is called a synthetic sex pheromone agent.

This pest control method reduces the mating rate and subsequently decreases the number of larvae in the next generation by disrupting the mechanism that enables males and females of the same species to locate each other using sex pheromones.

Mass-trapping method:

- A method in which large numbers of adult males are lured and captured.

Communication disruption method:

- A method in which a certain space is filled with sex pheromones so that the females cannot tell where they are.

Advantages:

- This pest control method is friendly to both crops and the environment.
- Effective against resistant and difficult-to-control pests.

Disadvantages:

- Different pests have different sex pheromones.
- Even if it is used in a small field, adult female insects that have mated outside the area of use may fly in and lay eggs, and it is effective when used in large numbers over an area of 1,000 m^2 or more.

Use of Micro-organisms

In soil, many pathogens invade vegetable roots and cause their death. However, some of these pathogens can be suppressed by increasing the population of beneficial microorganisms.

Example:

- When powdered chitin, such as crab shells, is mixed into the soil, microorganisms like actinomycetes that thrive on chitin multiply and produce antibiotics that inhibit the growth of Fusarium fungi.
- It should be noted that not all Fusarium species can be controlled using this method.

Points to Note:

- Although numerous studies have been conducted on utilizing microorganisms for disease control, significant practical results are rare.
- Additionally, some products may claim exaggerated effectiveness, so careful evaluation is essential.

3.7 Cultural control of pests and diseases

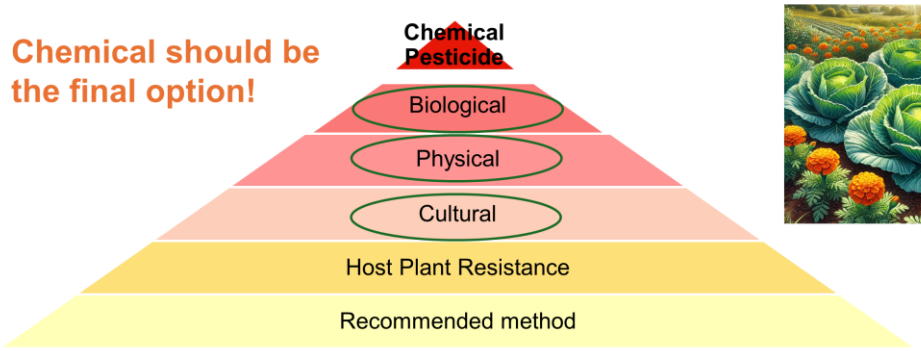
Synergistic effects of growing crops together

Mixed planting of companion plants

Cases in Japan

Crops	Target pest / disease	Companion plants
Cucurbitaceae, etc.	Soil diseases cause repeated cultivation damage	Green onion, Garlic chive, etc.
Various vegetables	Aphid-borne virus	Wheat, Corn, etc.
Various vegetables	Root knot nematode	Sunn hemp
Various vegetables	Root lesion nematode	Marigold (French species)

Chemical should be the final option!





Resistant Varieties, Grafting and Water Management

Use of resistant varieties

Crops	Target pest / disease	Varieties
Beans	Bean Rust (Moderately resistant)	Gannoruwa BIL, Keppetipola Nil
Tomato	Bacterial wilt	Lanka Cherry, Bathiya
Brinjal	Bacterial wilt	Anjalee, Padagoda (MR)

Use of grafting

Crops	Target pest / disease	Rootstock
Water melon	Fusarium Wilt	Pumpking

Water management

Climate type	Target pest / disease	Countermeasure
Rainy area	Viral diseases (Soil / water born)	Deep bed, high ridge
Rainy area	Fungi	Rain shelter tunnel
Arid area	White fly, mite, thrips vector virus	Drip irrigation
Arid area	White fly, mite, thrips vector virus	Silver mulching

Cultural control is a method of pest management that involves selecting appropriate cultivation practices, crop varieties or field environmental conditions to create unfavorable conditions for pest outbreaks, thereby suppressing their occurrence and reducing damage.

Mixed planting of companion plants

By understanding and utilizing the characteristics of vegetables, it is possible to reduce damage from diseases and pests.

Reduction of soil pathogens

- Vegetables in the Allium family, such as chives, green onions, onions and leeks, have the ability to reduce soil-borne pathogens through antibiotics produced by microorganisms that symbiotically live on their roots.
- Growing Allium vegetables alongside Solanaceous crops like tomatoes and eggplants. Cucurbitaceous crops like cucumbers and watermelons, or Apiaceous crops like carrots can help reduce the impact of soil-borne pathogens.
- Allium vegetables are not compatible with Brassicaceous crops like cabbage, Chinese cabbage, and radishes, or Asteraceous crops like lettuce. Planting them together can have negative effects, such as poor cabbage head formation. Mixed planting with Leguminous crops is also not recommended.

Control of nematode

- Marigold roots produce substances that can kill nematodes.
- It is beneficial to cultivate marigolds alongside solanaceous vegetables such as tomatoes and potatoes, brassicaceous vegetables like cabbage or legumes.

Use of resistant varieties

The degree of resistance to pests and diseases varies among different varieties of the same crop. Since the early 20th century, efforts have been made to select and breed resistant varieties.

✓ CR：Clubroot resistance
✓ YR：Yellows resistance

Use of grafting

- In fruit trees and vegetables, grafting seedlings to increase disease resistance has become an established method.
- Fusarium wilt in cucurbits such as watermelons and other cucurbitaceous crops cannot be fully controlled with pesticides but can be effectively managed by grafting pumpkins as rootstocks.
- Take care to ensure compatibility between the rootstock and the scion when grafting.

Water management

- In regions with heavy rainfall, improving water drainage through deep beds and high ridges is effective.
- In wet areas, installing rain shelter tunnels can help reduce whiteflies, mites, thrips-transmitted viruses and fungal diseases.
- In dry areas, irrigation combined with natural enemies and silver mulch can maintain soil moisture and help reduce outbreaks of whiteflies, mites and thrips.
- Typically, during the rainy season populations of sucking pests decrease, while caterpillar-like pests tend to increase.

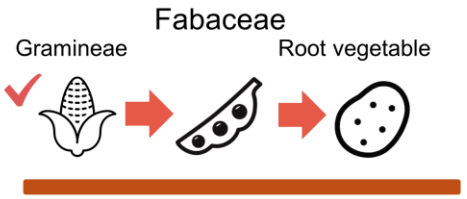
3.7 Cultural control of pests and diseases

Crop rotation to prevent injury by continuous cropping

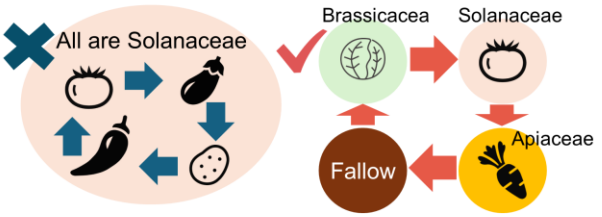
Adverse effects caused by continuous cropping

- ✓ Growing the same crop repeatedly allows pests and pathogens that target it to proliferate.
- ✓ The continuous absorption of the same nutrients creates an imbalance in soil nutrition.
- ✓ Toxic substances secreted from the roots of crops accumulate, affecting the growth of the crops themselves.

Recommended crop rotation



Focus on the "family" of crops



The required break between growing same crop	Major vegetables
Less crop injury from continuous cropping	Carrots, corn, garlic, onions, pumpkin
1 year	Cabbage, green onion, spinach, cucumber
2～3 years	Potato, green bean, lettuce, Chinese cabbage, celery
4～5 years	Chili peppers, green pepper, melon
6～7 years	Field peas, watermelons, eggplants, tomatoes

Field sanitation

Use fully mature compost



Residue is removed and bury or burn



Keep farming tools clean!



See Guidance and Videos for details of field sanitation

Adverse effects caused by continuous cropping

Growing the same vegetables or those from the same family repeatedly in the same farmland leads to continuous cropping damage caused by:

- Proliferation of pests and pathogens
- Imbalance in soil nutrients
- Accumulation of toxic substances

Crop rotation to prevent continuous cropping damage

To prevent damage caused by continuous cropping, it is necessary to practice crop rotation by growing a variety of crops in sequence.

- When planning crop rotation, it is essential to consider plant families.
- Avoid growing vegetables from the same family consecutively, such as planting eggplants (Solanaceae) after tomatoes (Solanaceae).
- Rotating with vegetables from different families, such as cabbage (Brassicaceae), tomatoes (Solanaceae), and carrots (Apiaceae) is preferable.

Recommended crop sequence: grains, legumes, root crops

- Grains (such as corn, leave a large amount of fibrous organic matter in the field, enhancing soil fertility.
- Legumes fix atmospheric nitrogen into the soil, increasing nitrogen levels in the field.
- Root crops extend their roots deep into the soil, acting as natural tillers and improving the soil's physical properties.

The required break between growing same crop

Some vegetables are more prone to continuous cropping issues, while others are less affected.

- Carrots, corn, onions, and pumpkins are less susceptible to continuous cropping problems.
- Peas, watermelons, eggplants, and tomatoes are highly prone to such issues. It is recommended to plant different crops for 6 to 7 years after cultivating these vegetables.

Field sanitation

- Only fully decomposed organic matter or compost should be used, as immature organic matter may attract pests like flies, encouraging them to lay eggs.
- Pathogens can persist in the soil through debris such as stems, leaves, and roots of diseased vegetables. Therefore, after cultivation, residues should be removed and either buried at least 1 meter deep in the soil or incinerated.
- After harvesting, vegetables should be promptly disposed of to eliminate potential breeding grounds for pests.
- Regular cleaning of fields and farming equipment is also crucial for effective pest control. In orchards, the prompt removal of fallen fruits helps prevent pest infestations.

3.8 Chemical control of pests and diseases

Use of pesticides

Insecticide
for Controlling Pests

- Early-stage control is fundamental
- Partial spraying of pests

Fungicide
for Controlling Pathogen

- Preventive spraying is fundamental
- Full field spraying

Insecticides	Fungicides
Used to prevent or control	Primarily used to prevent disease
Application to targeted areas	Uniform application to cover the entire field
Application in the morning or evening, when insects are active	Application before high humidity / rain occurs
Relatively more harmful	Relatively less harmful to other beneficial organisms
It has properties such as destroying and repelling through various methods	

DoA recommended pesticide manuals

Pesticide Recommendations

Information on pesticides recommended by the DOA is provided for the following crops

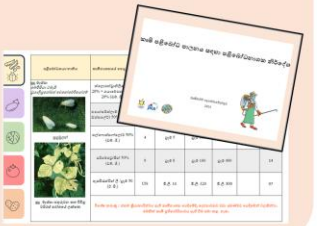
- Food Crops: Rice, Coarse grains, Vegetables and Root and Tuber.
- Other Field Crops: Condiments, Grain legumes and Oilseed crops.
- Fruit Crops: Apple, Pear, Avocado, Banana, Citrus, etc.
- Plantation Crops: Tea, Sugarcane, Rubber and Coconut.
- Export Agricultural Crops: Cashew, Cinnamon, Black pepper, etc.
- Floricultural Crops: Anthurium, Orchids, Rose, etc.



Pesticide Recommendations for Agricultural Pest Control

The manual edited by the SAFE project based on "Pesticide Recommendations".

- Sinhala and Tamil versions have been created.
- Includes photos of pests and symptoms.
- Covers fewer crops than those listed in "Pesticide Recommendations".



Insecticides

- Used to prevent or react. May vary depending on the different stages of pest infestation.
- Insecticides include contact agents, which require direct contact with pests to be effective, and ingestion agents, which are absorbed into the pest's body when they consume leaves or plants treated with the chemical.
- Application to the target areas of the insect is more effective. E.g. underside of leaves, stem, soil
- Droplet size may vary. E.g. contact acting types are fine, and systemic types are quite large - to prevent wind drift
- Time the spraying of pesticides especially for young larvae that have just hatched from eggs.
- Unlike fungicides, applying insecticides across the entire field can reduce the population of natural enemies. Therefore, focus application on areas where damage is observed.
- If pests are present throughout the field, apply the insecticide across the entire field as needed.
- Spray both sides of leaves because pests are often found on the underside. If the pesticides have translaminar action, there is no need to spray both sides.

Fungicides

- Primarily used to prevent disease. Fungal spores work best before they develop.
- Since growth stages spread by different methods and grow in the place of deposition, uniform application to cover the entire field is more effective
- Prevention is particularly important. It is essential to ensure thorough application across the entire field.
- Fungicides are used for prevention or treatment of diseases. Some enhance crop resistance.
- Spraying as fine droplets. Spreading throughout the plant and absorbing well.
- Apply before high humidity/rainfall, allowing time for drying or absorption on the plant
- To avoid the pesticide being washed away by rain before it adheres to the leaves, apply it one day before the rain, or at least four hours prior to rainfall.
- Once the sprayed agent dries, there is no need to spray again even if it rains a little later.

Pesticide Recommendations

The manual created by the Department of Agriculture (DOA) that lists recommended pesticides for each crop. The manual introduces pesticides corresponding to the crops shown in the diagram on the left.

Main contents of the manual
- Name of the pest
- Common name of the active ingredient in the pesticide
- Concentration (strength) and the formulation type
- Mode of Action (MOA)
- Amount of pesticide per commonly used agricultural sprayer (16L)
- Spray volume
- Application interval and Pre-Harvest Interval (PHI) days

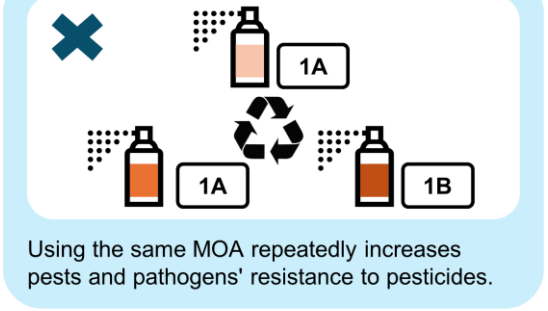
Pesticide Recommendations for Agricultural Pest Control

The manual edited by the SAFE project based on the Pesticide Recommendations manual.

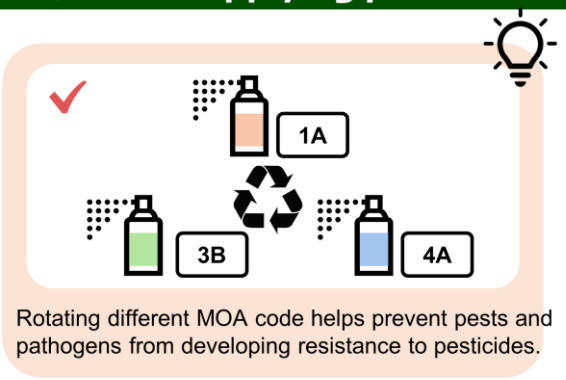
Modifications include:
- In Sinhala and Tamil languages
- Addition of pest and disease photos
- Layout changes

3.9 DoA recommended pesticides application

Check the MODE OF ACTION (MOA) before applying pesticides



Using the same MOA repeatedly increases pests and pathogens' resistance to pesticides.

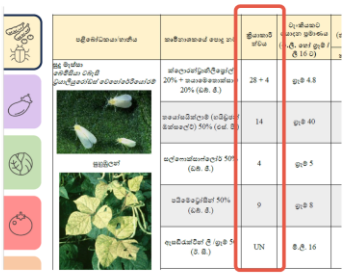


Rotating different MOA code helps prevent pests and pathogens from developing resistance to pesticides.

MOA

Classifications of how pesticides act on pests, pathogens, and weeds to exert their effects.

- For example, in the case of insecticides, there are groups such as nerve inhibition, growth inhibition, and energy metabolism disruption.
- Repeated use of pesticides with the same MOA increases the risk of pests, pathogens, and weeds developing resistance.



Check the MOA listed in the manual.

Selection of the nozzle type

Attribute	Fungicides	Pesticides	Weedicides
How to apply	Uniformly spread adhesion throughout the plant	Contact – systematic is suitable for flying insects and insects in soil	Systematic and Not being blown by the wind, leaning towards the ground
Droplets size	fine - medium droplets sized (100-250 µm)	Fine-medium sized droplets (100-300 µm)	Large sized droplets (250-500 µm)
How to cover	Plant covering throughout the field	Spread throughout target areas. Penetration through foliage and roots	Covered evenly throughout the weeds. Not spread by wind
Spread by Wind	There is a possibility	Varies based on contact and systematic	Avoid spraying non-target crops.
Pressure Requirements	High (40-100 PSI)	Medium (30-80 PSI)	Low (15-40 PSI)

MOA (Mode of Action)

MOA refers to the concept of how pesticides act on their target pests, pathogens, or weeds to exert their effects.

For example, insecticides mainly act on nerve, muscle, and respiratory functions, and within each category, there are multiple MOAs, such as Acetylcholinesterase (AChE) inhibitors and Sodium channel modulators and so on.

When pesticides with the same MOA are repeatedly used, pests, pathogens, and weeds are more likely to develop resistance, making the pesticide less effective. Therefore, it is crucial to use pesticides with different MOAs.

RAC Code

The RAC (Resistance Action Committee) code categorizes and assigns codes to different pesticide modes of action.

- Insecticides: IRAC Code (Insecticide Resistance Action Committee)
- Fungicides: FRAC Code (Fungicide Resistance Action Committee)
- Herbicides: HRAC Code (Herbicide Resistance Action Committee)

Understanding each pesticide MOA can be challenging, but by referring to the RAC code, it becomes easier to select pesticides with different MOAs.

These codes are classified based on the MOA and represented by a combination of numbers and letters.

For example, if a pesticide has an RAC code of 1A, it is recommended not to use another pesticide with the 1A or 1B code consecutively. Instead, choosing a pesticide with a different number in its RAC code helps prevent pests from developing resistance and maintains the effectiveness of pesticides.

Selection of nozzle type

- It is important to select a suitable nozzle for each pesticide type (fungicide, insecticide, herbicide) when expecting efficient control of the targeted pest.
- The above characteristics are expected from using a suitable nozzle .

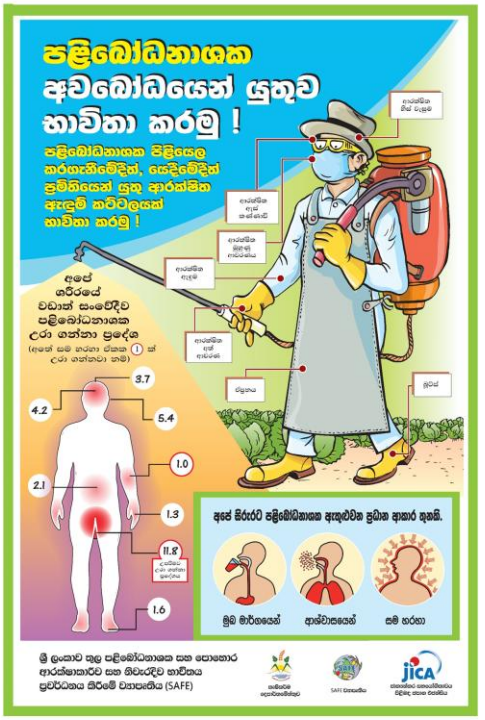
Common directions for applying pesticides

- Spray with the nozzle facing upwards, directing the spray from below to ensure the pesticide coats the undersides of the leaves well.
- Apply generously until the liquid drips from the leaves, then allow it to dry thoroughly.
- It is unnecessary to continue spraying until the pests die and fall off. Agricultural pesticides are low in toxicity and concentration, so their effects are not immediate.
- Pesticides should be applied during the cooler morning hours. High daytime temperatures can cause the pesticide's moisture to evaporate quickly, increasing its concentration and potentially harming the crops.

3.9 DoA recommended pesticides application

Precautions for pesticide application





Is the cause a pest / disease or a physical disorder?

Attention !!

- ✔ Confirm whether the cause is a pest or a disease?
- ✔ Pay attention to the possibility of physical disorder.

Tomato, bacterial wilt



http://www.spchcmc.vn/EN/Plant-doctor-Detail/Bacterial-Wilt-Disease-On-Tomato-5-8418.html

Tomato, excessive N



https://note.com/mirai_scien/n/n4c8fa57c64bf

Some disease symptoms are quite similar to that of physical disorder.

Tomato, leaf mold



https://www.earth.jp/earthgarden/zukan/byouki/hakabi.html

Tomato, Mg deficiency



https://note.com/mirai_scien/n/nb7dc3ee0edcc

In case of physical disorder, you must reconsider the **fertilizer management**.

Precautions when using pesticides

- Prevent from wrong use of pesticide.
- It is important to wear appropriate clothing (PPE: Personal Protective Equipment) when applying pesticides
- Follow the prescribed instructions when applying pesticides.
- Store pesticides properly.

Pests and diseases are not the only cause of plant's malfunction

- For example, the symptom caused by bacterial wilt of Tomato and excessive Nitrogen application are quite similar as you can observe by photos.
- For example, the symptom caused by leaf mold and Mg deficiency of tomato are similar as you can observe by photos.
- It is important to observe without ruling out the possibility of physical disorder.
- If physical disorder is the cause, fertilizer management will need to be reviewed.
- This will then avoid unnecessary application of pesticides.

Exercise



- What other things need to be taken care of for pest control, other than focusing on pest populations?
- What should be taken care of when spraying fungicides and insecticides, respectively?
- I have been consulted by a farmer who says he/she has been spraying with pesticides however increase pest damage. How do you identify the cause and what advice do you give?

Memo :

CHAPTER 4

Production Management by Good Agriculture Practice (GAP)

4.1. Basic of GAP
4.2. Safe crop production
4.3. Agro-Eco System Analysis (AESA)
4.4. Importance of record keeping
4.5. Safe application and storing of pesticides and fertilizers
4.6. Appropriate farm management

4.1 Basic of GAP

GAP implementation contributes to Safe and Appropriate Use of Pesticides and Fertilizer

GAP stands for "Good Agricultural Practices"

GAP is smart and safe ways of growing food that helps to protect the environment, make sure the food is safe to eat, and take care of the people who work on the farm



(DOA)

SL-GAP

- SL-GAP for exporting as well as local consumption
- Those who try to begin GAP are called as GAP beginners

(DOA)

No. of GAP certified farmers is limited

Total SL-GAP certifications in Sri Lanka		
	(Fruits & vegetables)	(Rice)
During 2016-2024	3283	1434

SL-GAP certification during 2024 within project districts		
	(Fruits & vegetables)	(Rice)
Anuradhapura	45	57
Badulla	30	56
Matale	4	0
Puttalam	20	20
Nuwara Eliya	5	0

Focus Point

Reasons why GAP has not become widespread

- Low demand from market
- No proper selling price
- No specific market etc.

GAP

- GAP (Good Agricultural Practices) is a set of principles designed to ensure safe and healthy agricultural production.
- FAO defines GAP as "A collection of principles to apply for on-farm production and post-production processes, resulting in safe and healthy food and non-food agricultural products, while taking into account economic, social and environmental sustainability"
- In short, GAP is "smart and safe ways of growing food that help protect the environment, make sure the food is safe to eat, and take care of the people who work on the farm".

SL-GAP

- SL-GAP is being introduced on a crop basis for fruits and vegetables by the Department of Agriculture.
- Most of the farmers who want to export their products are interested in obtaining SL-GAP certification because it aligns with the majority of requirements set by ASIAN and Global GAP standards.
- SL-GAP product is consumed by not only consumers overseas, but also by local consumer.
- The supermarkets; Keels Super and Cargills sell SL-GAP product, and they are also conducting promotions among their suppliers to get SL-GAP certification, which also leads to popularize SL-GAP.
- It is difficult for some farmers to obtain SL-GAP because there are 106 control points to be followed properly in check-list of SL-GAP.
- The SAFE project call those farmers who do not follow all control point "GAP beginners" and extension service should support them to obtain SL-GAP.

Despite significant efforts by the Department of Agriculture (DOA) to promote GAP, the number of GAP-certified farmers remains very limited.

Current situation

- GAP certified farmers account for nearly 0.1% in the total farmers at each target district of SAFE project.
- Regarding total of 5 districts, it is just 0.001%.

Possible reasons for limited adoption

- Low market and consumer demand for GAP-certified products.
- Lack of appropriate selling prices to incentivize farmers.
- Absence of a specific market dedicated to GAP-certified products.

4.1 Basic of GAP

Prior Stages of GAP

GAP to "Implement"

Focuses on how GAP principles are applied on the ground to improve agricultural practices without necessarily aiming for certification.



GAP to "Obtain"

Focuses on the processes and documentation required to achieve GAP certification from GAP certification body.

Farmers need to prepare and maintain records, undergo audits, and meet specific requirements for certification.



SL-GAP is overlapped with safe use of pesticides and fertilizer

SL-GAP

1.Land use history & land management
2.Seeds and other inputs
3.Soil management
4.Soil fertility management
5.Water management
6.Disease and pest management
7.Post harvest technology
8.Record keeping
9.Workers' health & welfare
10.Pesticide residue analysis
11.Waste management
12.Environmental consideration
13.Complains & reporting
14.Internal audit

SAFE Project Activities

1. Development of nutrient management package (including protected agriculture)
2. Development of fertilizer recommendation based on leaf N status, for N management

1. Upgrading of Pesticides Recommendation manual
2. Development of user-friendly cards for identification
3. Testing of color sticky traps as a scouting / monitoring method
4. Improvement of field hygiene
5. Alternative pest management method (Yellow lighting bulb)

1. Record-keeping format improvement

GAP “certification” is not always a necessity in terms of promotion of safe and appropriate use of pesticide and fertilizer. This is because there are two prior stages of GAP, “GAP to implement” and “GAP to obtain”.

GAP to Implement

This stage focuses on implementing GAP principles in the field to achieve better farm management.

- The purpose is to implement GAP at field and certification does not matter.
- Farmers can refer to GAP documents and implement the principles as much as possible in their agricultural practices.

GAP to Obtain

This stage emphasizes obtaining GAP certification through an authorized GAP certification body.

- After implanting GAP, farmers submit an official application form to GAP certification body.
- If the farm audit is approved, GAP certificate featuring GAP logo and QR code is issued.

In both stages, farmers have to comply with good agricultural practices including safe and appropriate use of pesticides and fertilizer.

The interaction between SL-GAP and the SAFE project

The core elements of SL-GAP strongly overlap with the principles of the safe and appropriate use of pesticides and fertilizer.

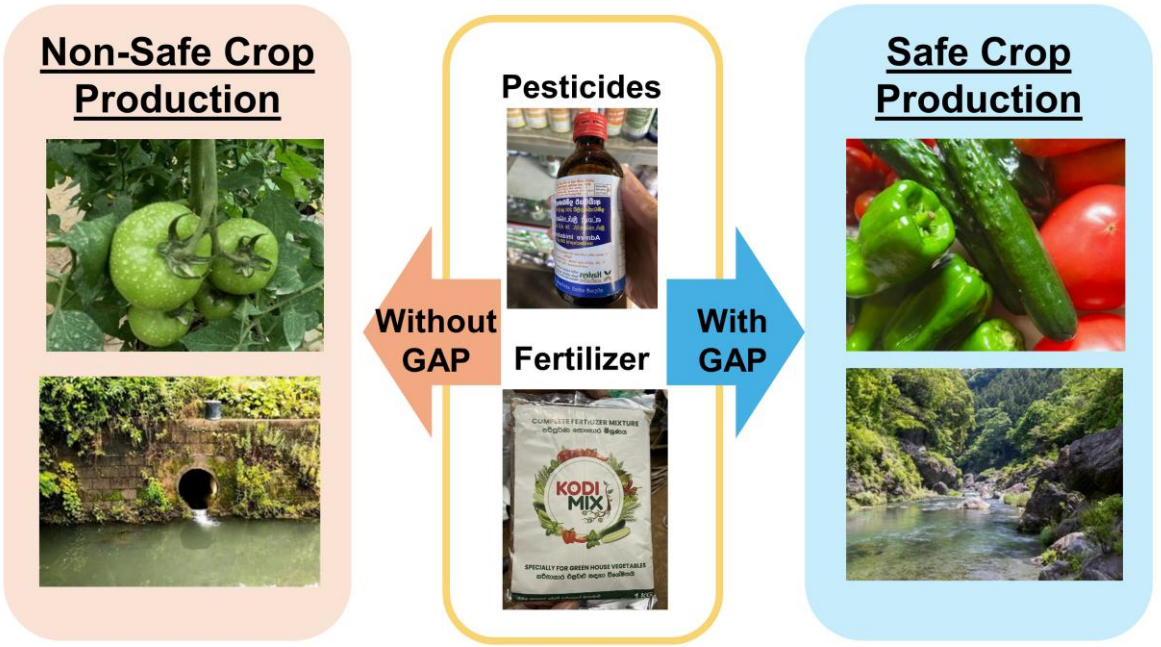
There are 14 core elements in SL-GAP and some of them are directly related to pesticide and fertilizer such as:

- 3. soil management
- 4. soil fertility management
- 6. disease and pest management
- 8. crop record keeping

Therefore, GAP and safe use of pesticides and fertilizer are mutually related each other.

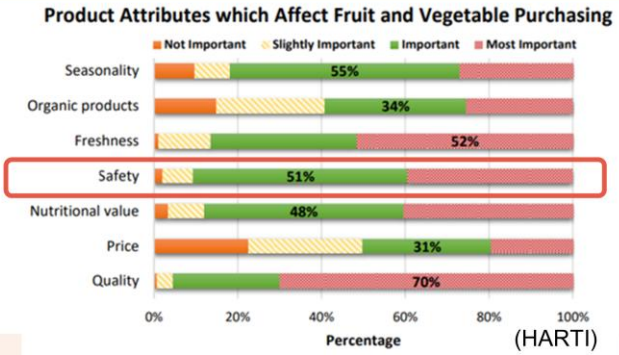
4.2 Safe crop production

Safe and appropriate use of pesticides and fertilizer through GAP can achieve "Safe Crop Production"



Consumers prioritize "Safety" when purchasing fruit and vegetable

- No.1 is "Quality"
- No.2 is "**Safety**" (nearly 90%)
- No.3 is "Nutritional Value"
- No.7 is "Price"



Major retail stores selling GAP certified products

- "Good Harvest" for Cargills
- "Fresh because of You" for Keels
- "Agri fresh" for DoA outlets

Safe crop production can increase farmer's motivation

- High demand of "Safety" among consumers
- Buyers also prioritize "Safety"
- Increase of selling amount and price
- Resulting in increasing farmer's motivation



Crops produced with GAP and those produced without GAP show completely different results in terms of safety.

Use of pesticides in situations where GAP is not followed

- Overuse of pesticides, causing pesticide residues on crops.
- These residues can result in health problems for humans.

Use of pesticides in situations where GAP is followed

- No overuse of pesticides.
- Ensures safe crop production by effectively controlling pests and diseases while increasing profits

Use of fertilizer in situations where GAP is not followed

- Causes water pollution by leaking nitric acid into natural water sources.
- Water pollution can lead to health issues, such as Chronic Kidney Disease (CKD).

Use of fertilizer in situations where GAP is followed

- Prevents water pollution.
- Safe crops, produced through the proper use of fertilizers, boost yield and increase profits.

According to the HARTI report in 2021, 90% of consumers prioritizes “Safety” when purchasing fruit and vegetable.

The top factors influencing consumer choices are:

No.1 - “Quality”

No.2 - “Safety”

No.3 - “Nutritional value” *Price is ranked 7th (lowest among the factors)

This shows that consumers are highly concerned safe crop production.

GAP-certified products in major retail stores

- Cargills sells SL-GAP certified products under its original brand “Good Harvest” with farmer information accessible via QR codes, ensuring traceability.
- Keells ran the “Fresh Because of You” campaign in October 2019, holding 50 GAP training programs for 1,600 farmers in collaboration with the Department of Agriculture (DOA).

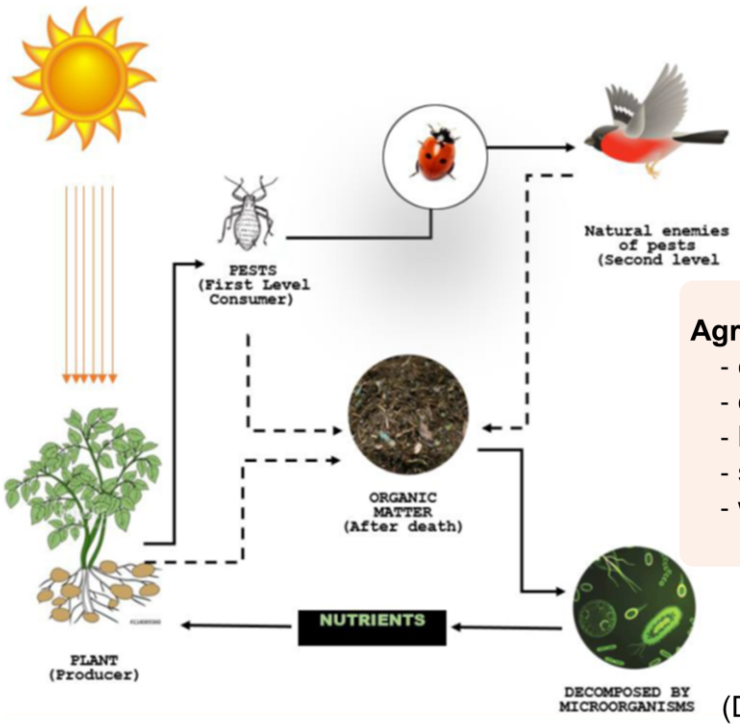
As consumer’s concern on safe crop production is increased, buyer’s concern is also increased.

Safe crop production and farmer motivation

- The growing consumer demand for safe crops has prompted buyers to prioritize safe crop production.
- As a result, farmers benefit from increased sales volumes and higher selling prices.
- Such change of market makes farmers motivated to practice safe crop production.

4.3 Agro-Eco System Analysis (AESA)

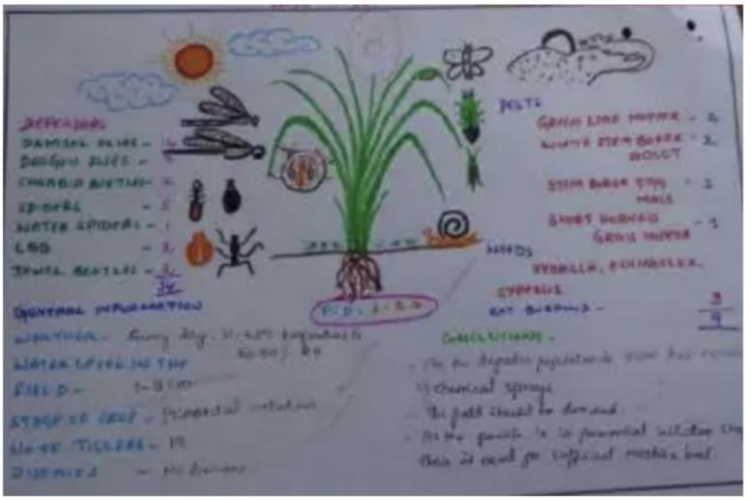
Agro Eco System



Agro Eco System Components:
- crop age, variety, leaf color
- diseases and weeds
- beneficial and harmful insects
- soil depth and texture
- weather condition etc.

(DOA)

Decision-making tool for farm management



(Thai training)

- Applying less pesticide if high number of beneficial insects are observed
- Applying N fertilizer if crop is at early growth stage to expand leaf

An Agro-Eco System (AES) is a human managed ecosystem designed to produce foods.

Key components of an Agro-Eco System include:

Biotic factors

- Crop age, variety and leaf color
- Diseases and weeds
- Beneficial and harmful insects

Abiotic factors

- Soil depth and texture
- Weather conditions

Agro-Eco System Analysis (AESA) is a tool to analyze the dynamic interactions between crops and the surrounding environment.

AESA serves as a decision-making tool for farm/ crops management:

Examples of decision-making

- If farmers observe not only harmful insects, but also high number of beneficial insects as well, they can apply less pesticide to keep the beneficial insects.
- If farmers observe that crop is still at early growth stage to expand leaf, they can apply N fertilizer to promote the leaf expansion. If farmers apply P or K fertilizer at this stage, it may not be effective because they are effective at later fruiting growth stage.

Benefit of AESA

- AESA promotes the safe and appropriate use of pesticides and fertilizers.
- It helps farmers improve their skills and knowledge, ensuring sustainable and efficient farm management.

4.3 Agro-Eco System Analysis (AESA)

Methodology of AESA

STEP 1

Explanation by Facilitator (AI) to Farmers

- Objectives and benefits of AESA
- Guidance on how to observe field



STEP 2

Field Practice by Farmers

- Observe field by farmers
- Note down any findings



STEP 3

Knowledge Sharing among Farmers

- Share findings among farmers
- Summarize information



STEP 4

Group Discussion among Farmers

- Analyze Agro Eco System
- Draw a picture on poster paper



STEP 5

Decision Making based on Agro Eco System

- Consider the best practice to make
- Conduct AESA periodically



AESA consists of five steps:

STEP 1: Explanation by Facilitator (AI) to Farmers

- Facilitator, basically it could be AI, explains the objectives and the benefits of AESA to farmers with special focus on the basic concept of Agro-Eco System in farmer's field so that farmers can understand the necessity of observing the Agro-Eco System.
- AI also gives adequate guidance on how to observe field.

STEP 2: Field Practice by Farmers

Farmers perform field observations and record findings, including:

Condition of the crops with growth stages (nursery stage, vegetative stage, flowering stage, harvesting stage etc.)

- Pest incidence (presence of insects, population, insect damage and severity on plants etc. and natural enemy populations)
- Disease incidence (diseased plant parts, severity of the disease etc.)
- Weather conditions - Soil and water conditions (wet or dry)
- Conditions at the edge of the field
- Conditions in neighboring plots (if available)

STEP 3: Knowledge Sharing among Farmers

- After fieldwork, farmers return to meeting place and share their findings with the group.
- As they share the findings, the facilitator (AI) can summarize the information into same category such as crop growth, pest, disease, etc.

STEP 4: Group Discussion among Farmers

- Farmers discuss shared findings, facilitated by the AI or facilitator.
- A collective analysis of the Agro-Eco System is conducted.
- Farmers create a visual representation (e.g. a poster) of the system's current state.

STEP 5: Decision-Making Based on Agro-Eco System

Based on the picture, farmers can consider the best practice with consideration of Agro-Eco System.

By conducting AESA periodically, farmers can manage their farm well, such as avoiding overuse of pesticide, applying fertilizer properly, and reducing unnecessary expenditure.

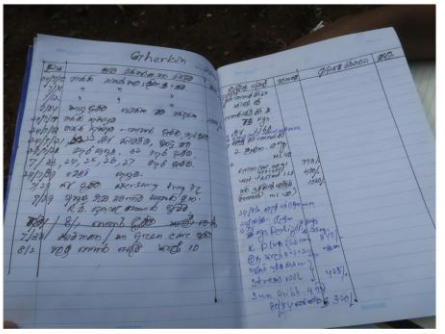
By conducting AESA periodically, sustainable farm management can be achieved by promoting the safe use of pesticides and fertilizers.

4.4 Importance of record keeping

Record keeping and the safe use of pesticides and fertilizer

Why is record keeping important?

- Better farm management
- Food safety and traceability
- Requirement for GAP certification



What is to be recorded?

- Who, what, when, where, and how applied pesticide and fertilizer
- Income and expenditure
- Other general information (ex. variety, planting date, farm work etc.)



What is advantage?

- Reducing the amount of pesticide and fertilizer to be applied
- Decision making based on profitability
- To be selected from market and consumer

Importance of record keeping format based on farmer's needs

"I have never done record keeping before and no idea on how to do"	"I have done Record keeping before, but not utilize it for farming"	"I want to apply GAP certification and plan to export in the future"
Farmer's need on simple and easy format	Farmer's need on useful and helpful format for decision making	Farmer's need on format for GAP certification
Record keeping format with minimum information and easy to use at first glance	Record keeping format with information that is lacking to make better decision by farmer	Record keeping format in SL GAP prepared by DOA for official certification

Why is record keeping important?

Record keeping is crucial for efficient farm management, food safety and GAP certification. Key benefits include:

- **Farm management:** Record keeping helps farmers track and understand farm activities better and provides valuable information on which methods work best.
- **Food safety:** Records of cultivation in record keeping can contribute to traceability, which enhances food safety. Since this is a growing concern on safety agricultural product from market and consumers in Sri Lanka, keeping farm records in good order will reveal the full history of product.
- **GAP certification:** Record keeping is requirement for GAP certification.

Items to be recorded

Farmers are recommended to make a record following points:

- Who, what, when, where, and how applied pesticide and fertilizer: This ensures the safe and appropriate use of pesticides and fertilizers.
- Income and expenditure: Farmers can check these records to improve their profitability.

Other general information, such as crop variety, planting date, farm work details is also helpful for effective farm management.

Advantages of record keeping

- Properly recording pesticide and fertilizer usage helps farmers apply them more efficiently in the future, reducing the overall amount needed.
- Accurate income and expenditure records help farmers identify profitability bottlenecks and make decisions to improve profitability.
- Proper general record-keeping increases the likelihood of agricultural products being favored by markets and consumers, further motivating farmers to continue record keeping.

Different record keeping formats for different farmers' needs

Farmer A (blue) has never done record keeping before and has no idea how to start.

→ A simple and easy-to-use format is most suitable.

To help this farmer to begin, a record keeping format with minimal information and an intuitive design can be used as the first step toward effective record-keeping.

Farmer B (green) has done record keeping before but has not utilized it effectively for farming.

→ A more useful and insightful format is ideal.

A record keeping format that includes missing information necessary for better decision-making can be introduced. This will allow the farmer to use the records effectively and potentially achieve higher profitability.

Farmer C (red) wants to apply for GAP certification and plans to export products in the future.

→ A format meeting GAP certification requirements is essential.

The record keeping format provided by SL GAP and prepared by the DOA for official certification purposes can be used to meet this farmer's needs.

4.5 Safe application and storing of pesticides and fertilizer

Safe application of pesticides and fertilizer



Safe storing of pesticides and fertilizer

Pesticides



Key points of proper pesticide storage:

- Inside barn with proper label in dry place
- Not on ground and not with harvest
- With good ventilation
- In safe for strong poisonous pesticide
- With alarming statements or visuals
- Powders to be stored above liquid
- "First-in and First-out"

Fertilizer



Key points of proper fertilizer storage:

- Inside barn with proper label in dry place
- Not on ground and not with harvest
- With prevention from sun light
- Keeping away from fire
- Covering with sheet especially for organic fertilizer

Farmers should always use PPE when applying pesticides and fertilizers to avoid health risks.

Example of missing PPE:

- No eye wear, nose guard, and face mask.
- No thick long-sleeved vest and no long thick pants.
- No hand gloves.
- No long boots.

Without such PPEs, risks of human health problems are increased when farmer apply pesticide and fertilizer. Sensitizing farmers on proper PPE usage is essential.

Common principles of storing pesticide and fertilizer

Storage Location:

- Inside barn with proper label in dry place to protect pesticides and ensure organization.
- Avoid storing on the ground or near harvested products to prevent contamination and damage.

Specific to Pesticides:

- Good Ventilation: Prevent inhalation of evaporated pesticides.
- Secure Storage for Toxic Pesticides: Avoid theft or misuse.
- Warning Labels: Clearly indicate danger.
- Powders Above Liquids: Prevent cross-contamination if leaks occur.
- "First-in, First-out" Rule: Use older stock before newer stock.

Specific to Fertilizers:

- Protection from Sunlight: Prevent bag damage.
- Keep Away from Fire: Avoid explosions, especially with nitrogen-based fertilizers that contains gunpowder ingredient.
- Covering with sheet especially for organic fertilizer: to prevent leaking from organic fertilizer into environment by raining etc.

4.6 Appropriate farm management

"Farm management" contains many core elements



(FAO)

Based on the context of safe and appropriate use of pesticide and fertilizer…

"Field sanitation" is important





"Field sanitation" is fundamental and easy technology



Pruning

- Infected leaves and fruits
- Old leaves
- Unnecessary branches
- With sanitated scissors



Weeding

- Periodical weeding
- Elimination of habitats for pests and disease



Disposal

- Disposing at one place
- Proper treatment (ex. Burning, burying etc.)



Bagging

- Especially for fruit production
- Maintain safe and high quality

"Farm management" involves several core elements.

According to FAO, "Farm management" is defined as the science and art of optimizing the use of resources in the farm component of farm-households and of achieving the optimal functioning of these systems in relation to household-specific objectives.

In the context of food safety, safe and appropriate use of pesticides and fertilizers is essential for which field sanitation plays an especially important role.

Field Sanitation

Field sanitation is fundamental and easy technology.

The principle is "Doing what to do properly at proper time"

Pruning

Pruning is not only aimed at increasing yield by directing nutrients toward the harvest but also at maintaining proper aeration by regulating crop growth.
The pruning methods are as follows:

- Removing infected leaves and fruits
- Removing old leaves whose color is changed as yellow.
- Removing unnecessary branches, which improves aeration.

All pruning should be done using sanitized scissors to prevent the spread of disease from one plant to another.

Weeding

Weeding is fundamental farm work.

If periodical weeding is conducted properly, it eliminates habitats for pests and diseases, which prevents transmission of them from weed to crop.

Disposal

During pruning or weeding, collected crop residues and weeds should be disposed at one place with proper management like burning or burying.

Bagging

Bagging is a useful technique for fruit production.

- Keeps fruits clean and of high quality.
- Helps farmers estimate harvest timing by noting information on the bags.

Exercise



- Why record keeping is important to achieve appropriate use of pesticides and fertilizer?
- How is field sanitation able to contribute to minimize pesticide use?
- A farmer asks you what is the benefit of practicing GAP. How do you explain and recommend practicing GAP to farmer?

Memo :

CHAPTER 5

Extension Approach

5.1. How to work with farmers?
5.2. How to use technical materials?
5.3. Points to keep in mind when supporting farmers' activities
5.4. How to plan the trainings for farmers?
5.5. How to conduct monitoring and evaluation?

5.1 How to work with farmers?

3 Key Tips to Tackle Farmers' Challenges

1. Listen carefully to the farmer's explanation



- ✔ What the actual problem is?
- ✔ Frequency & Timing of problems.
- ✔ What and how farmer have done so far?
- ✔ How was the result of the action.

2. Work together to identify causes of problems and develop countermeasures



- ✔ Search together to identify the problems.
- ✔ Discuss reasonable action for the farmer.

3. Review the results of the countermeasure together with farmers



- ✔ Estimate whether it was right selection or not.
- ✔ Revisit and try again if it fails.
- ✔ Find out the reason why it succeeded.
- ✔ Estimate what could be the action for prevention.

Focus Point

It is important to be patient and try again and again!
Difficult to solve with the first try only.

Characteristics of Extension Methods

Types	Advantages	Disadvantages
Lecture 	✔ Many people can get information at the same time. ✔ Easy to explain complicated information.	✔ It is difficult to learn how to do it in practice. ✔ Easily forgotten.
Workshop 	✔ It helps deeper understanding and to learn how to do it in practice. ✔ Easy to ask questions while doing it.	✔ Take time ✔ A few people may participate in actual discussion without good facilitation.
Practice at Field 	✔ Learn how to do it in practice on the spot. ✔ Easy to ask questions while doing it. ✔ Hard to forget because it was practiced.	✔ Weather dependent. ✔ Difficult to implement in large groups. ✔ It takes time to prepare.
Visiting Instruction 	✔ You can take the time to discuss and ask questions about a variety of issues. ✔ Discussions can be held while looking at the actual crops.	✔ Time consuming as each person is visited individually

To solve issues effectively, listening to farmers is essential. Be mindful of these three important aspects in the process.

1. Listen carefully to the farmer's explanation

- Ask farmers for detailed information about the issues they face and their previous attempts at solving them.
- Check their history of solutions to identify whether the issue lies in the method of implementation or the solution itself in the first.

2. Work together to identify causes of problems and develop countermeasures

After listening to the farmers' circumstances, work together with them to find a solution. In doing so, pay attention to the following points:

- The approach for solving the problem is feasible to farmers. For example, if purchasing items such as pesticides, ensure they are both economically affordable for farmers and readily available in their local area.
- Farmers truly understand and agree with the proposed solutions and their reasoning.

When addressing problems, it is important not to provide one-sided explanations but to collaborate with the farmers to tackle the issues together.

3. Review the results of the countermeasure together with farmers

Rather than simply presenting solutions once, work with farmers to review the outcomes together.

- If the problem is resolved, identify the factors that contributed to success.
- If the issue remains unresolved, analyze the reasons and develop a better solution.

A clear understanding of both success and failure leads to more effective problem-solving in the future.

Patience is also one of the keys, as most problems cannot be solved on the first attempt and require repeated efforts.

When promoting practices to farmers, extension methods such as lectures, workshops, field practice, and visiting instruction are used.

- Each type has its own advantages and disadvantages, so it is important to choose the appropriate method based on the objective.
- For example, one-to-one visiting guidance is considered the most effective method for technology transfer, but it is time-consuming.

Please refer to the slide for a summary of the pros and cons of each method.

5.2 How to use technical materials?

Materials Created by the Project

Diagnosis of pests & diseases and countermeasures

Pesticide Recommendation for Agriculture Pest Control Manual

The manual compiles photos and recommended pesticides for pest and disease management for vegetable crops.



Pictorial Cards with QR Codes

For each crop, the cards include pest and disease details with recommended pesticides, and additional info is available via QR codes.



Guidance for use of Sticky Trap in Brinjal, Cabbage and Tomato

Information on sticky traps for capturing pests in the field is provided.



Information Sheet on Safe Spraying of Pesticides



SHEP Crop Handbooks

Cultivation practices for 17 crops are comprehensively covered in handbooks, including details on pest and disease control.



Materials Created by the Project

Appropriate fertilizer application

Guidance for Area Specific Nutrient Management

The manuals provide appropriate fertilization practices for cabbage in Badulla and Puttalam, capsicum in Puttalam, and tomato in Badulla.

Information Sheet on Area Specific Nutrient Management
(Summarized version)



Booklet on Growing Media & Nutrient Management in Protected Culture

The manual introduces basic knowledge of cultivation media irrigation practices and nutrient management packages for protected cultivation.

Information Sheet on Growing Media & Nutrient Management in Protected Culture
(Summarized version)



SHEP Crop Handbooks

Cultivation practices for 17 crops are comprehensively covered in handbooks, including details on fertilizer use.



The project developed various technology packages. The materials created by the project are as follows:

Relevant to diagnosis of pest and diseases and counter measures

Pesticide Recommendation for Agriculture Pest Control Manual

- Summarizes the pesticides recommended by the DOA for major pests and diseases of vegetable crops and their important characteristics
- Includes photos of crop damage caused, enabling users to identify the pest or disease and to use the appropriate pesticide.

Pictorial Cards with QR Codes

- Features ten major pests and diseases for each of the five crops (beans, brinjal, cabbage, tomato, and potato), along with DOA-recommended management practices.
- Includes multiple photos on damage and causal organism, and detailed descriptions for each.
- Provides QR codes to access additional related information.
- Designed crop-specific and compact in A5 size, making it easy to carry.

Guidance for use of Sticky Trap in Brinjal, Cabbage and Tomato

- Explains the installation method and effectiveness of sticky traps.
- These traps help to identify the type and number of insects in the field, ensuring the appropriate use of pesticides.

SHEP Crop Handbooks

- Comprehensive handbook covering cultivation methods, pesticide use, and fertilizer information.
- Includes information on 17 crops.

Relevant to appropriate fertilizer application

Area Specific Nutrient Management Manuals

- The manuals introduces the appropriate fertilizer application rates for capsicum in Puttalam, cabbage in Puttalam, cabbage in Badulla and tomato in Badulla.
- The comparison of results among the conventional DOA recommended fertilizer application, the improved fertilizer application and farmers' conventional fertilizer application practices are explained.

Protected Agriculture booklet

- The manual introduces basic knowledge of cultivation media and irrigation practices for protected cultivation.
- Fertilizer applications for tomato and capsicum are introduced.

SHEP Crop Handbooks

- Comprehensive handbook covering cultivation methods, pesticide use and fertilizer information.
- Includes information on 17 crops.

5.2 How to use technical materials?

Materials Created by the Project

Field sanitation and IPM (Integrated Pest Management)

Guidance for Field Hygiene in Brinjal

This manual explains the field sanitation practices required to manage the pests and diseases in brinjal fields.

Information Sheet on Field Hygiene in Brinjal (Summarized version)



Guidance for Field Hygiene in Guava

This manual explains the field sanitation practices required to manage the pests and diseases in guava fields.

Information Sheet on Field Hygiene in Guava (Summarized version)



Guidance for Yellow Lighting to Repel Moths

The manual introduces an eco-friendly pest management strategy for brinjal and cabbage fields, focusing on using yellow LED moth repellent bulbs to reduce pesticide reliance and enhance sustainability.



Materials Created by the Project

Sensitization



Posters

The 3 types of posters are created to raise awareness about the appropriate use of fertilizers and pesticides.

Record keeping books

2 formats have been created: a beginner farmer version and an advanced farmer version.



Booklets on pesticides and fertilizer

The 2 booklets have been created: Pesticides and Fertilizer



Videos

The 3 types of video, 1) introduces field sanitation for guava, 2) introduces field sanitation for brinjal, 3) the installation of sticky traps, 4) the setup of yellow bulbs.



3 versions - Tik Tok version, Technical short version and General long version

Relevant to Field sanitation and IPM (Integrated Pest Management)

Guidance for Field Hygiene in Brinjal

- This manual explains the package of field sanitation practices required to manage the pest and disease incidence in Brinjal in order to get high quality maximum marketable yield ensuring safe and appropriate use of pesticides.
- This particular package of field sanitation comprises practices such as selecting an appropriate nursery location, soil sterilization, avoiding flood irrigation, routine removal of infested plant parts and weeds, cleaning or sterilizing tools appropriately, and so on.

Guidance for Field Hygiene in Guava

- This manual explains the package of field sanitation practices required to manage the pest and disease incidence in Guava in order to get high quality maximum marketable yield ensuring safe and appropriate use of pesticides.
- This particular package of field sanitation comprises practices such as selecting an appropriate nursery location, soil sterilization, irrigation, pruning, routine removal of infested plant parts and weeds, cleaning or sterilizing tools appropriately, and so on.

Guidance for Yellow Lighting to Repel Moths

- The manual introduces an eco-friendly pest management practice of using blinking light of special yellow LED moth repellent bulb system to control the pest damages in Cabbage & Brinjal caused by moths; specifically, their caterpillars.
- This non-chemical method controls caterpillar damages such as Diamond Back Moth and leaf-eating caterpillars in cabbage, and Shoot & Pod Borer, the most severe pest in brinjal.

Relevant to Sensitization

Posters

- The posters were designed to raise the public awareness especially to the farmers and the consumers about the appropriate and safe use of pesticides and chemical fertilizers.
- They can be displayed at the public places where the farmers as well as the consumers frequently visit.

Crop Record Books

- The Crop Record Books help farmers plan and make decisions effectively. Two formats target different farmer categories.
  - **The simple format** is for the farmers who are new to record keeping as well as not so motivated of doing or less capable of doing record keeping.
  - **The advance format** is for the farmers either who have been familiarized with record keeping or not been familiarized but having obvious potential of being adopted to advanced record keeping for better planning and decision-making in commercial-scale farming.

Booklets on pesticides and fertilizer

- Two booklets have been created: on Pesticides and on Fertilizer

Videos

- The videos explains various technical aspects useful for ensuring the safe and appropriate use of pesticides and chemical fertilizers.
- These include how to carry out field hygiene practices in Guava and Brinjal farming, setting up moth-repellent LED yellow bulb systems, the installation and use of sticky traps, and so on.

5.2 How to use technical materials?

Effective Use of Materials

Types	Characteristics	How to use
Recommendation Manual	✔ Like a dictionary, checking only the information you want to know.	✔ Explained and distributed during training.
Books/Booklets	✔ Many information is included. ✔ Take time to read through	✔ Explained and distributed during training.
Videos	✔ Easy to understand. ✔ Visual confirmation. ✔ Easy to explain what is moving.	✔ Broadcast to the masses on social networks and Youtube. ✔ broadcast in a training session
Pictorial cards	✔ Easy access to information. ✔ Visual confirmation.	✔ Explain to farmers how to use it at practice in the field.
Posters	✔ Deliver the message you want to convey with impact.	✔ Putting it up in places where many target people come.
Guidance/Information sheets	✔ Provide a clear overview. ✔ Provides an overview in a short time	✔ Distributed to interested parties in training ✔ Place in relevant institutions
Recordkeeping formats	✔ Remember the items to be mentioned ✔ Aligning them in form makes it easier to compare them.	✔ Distributed to farmers in need. ✔ Explained and distributed during training.

To effectively communicate information to farmers, it is important to carefully consider how materials are introduced and used.

Preparation before distribution

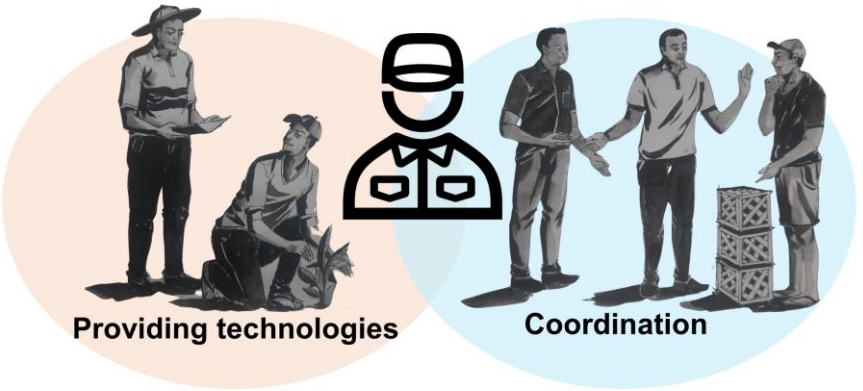
- Check in advance where the information and materials will be obtained, how it will be explained, and how it will be utilized.
- Understand the features of the information and materials thoroughly to ensure accurate communication of their benefits.
- Highlight practical examples, such as record keeping, which is a fundamental action for the appropriate use of pesticides and fertilizers. Even for farmers who find it time-consuming, explain its importance clearly.

Optimize distribution methods

- Materials used to raise awareness, such as posters and booklets, should be posted or placed in areas where many stakeholders gather. For example, agricultural supply shops, community centers and city halls are appropriate.
- The video should be made available to as many people as possible, so that the link can be publicized at stakeholder gatherings or aired on television.

5.3 Points to keep in mind when supporting farmers' activities

Role of Extension Workers



Focus Point

Extension workers are **advisors** and **coordinators**

- ✔ Your role is to coordinate and work together to solve problems until it is achieved.
- ✔ In other words, it is not the end of the job of telling farmer what technology to use to solve the problem.
- ✔ Find appropriate advanced farmer as a leader and communicate well.

Consider why farmer has been practicing like that so far

Analyze Logics There are so many things you can do!

Case Study 1:

Ignorance of wearing PPE

Why not wear PPE?

1. Too hot
2. Expensive
3. No feeling of importance
4. No time

	Countermeasures
1.	✔ Suggest spraying during cooler hours. ✔ Find and introduce cooler types of PPE.
2.	✔ Consider alternatives to standard PPE.
3.	✔ Communicate how pesticides affect the human body. ✔ Providing examples of the impacts happening in Sri Lanka.
4.	✔ Tell them that it is very important and a high priority.

Case Study 2:

Ignorance of Recommendation

Why not follow recommendation?

1. Not available in the market
2. Difficult to manage the amount and timing
3. No feeling of importance

	Countermeasures
1.	✔ Before the training, check if the pesticides on the recommendation are available in nearby shops.
2.	✔ Create materials that make it easy to understand the amount and timing of applying visually.
3.	✔ Explain the benefits of following recommendation. ✔ Explain success stories of farmers who followed recommendation.

What is expected of extension workers has changed as follows.

Past

- Agricultural extension workers were considered “teachers” for farmers, focusing on providing technical knowledge.

Present

- With the increasing availability of information through smartphones, extension workers are now often asked to play the role of "coordinators" who collaborate with farmers to solve problems.
- As cultivation techniques continue to advance, the next major need lies in management skills, such as effective product marketing.
- To achieve profitability in management, efficiency must be prioritized, which naturally requires greater organization.

Despite providing training and advice, farmers do not always easily adopt suggestions. It is important to consider the reasons behind this reluctance.

- Consider carefully the reasons why. Is the suggestion really a realistic option, and what are the reasons for not practicing it?
- Farmers are sometimes hesitant to speak out against an idea and are reluctant to tell us what they really think. Therefore, it is important to first build trust and establish a relationship that makes it easy for them to talk to us.
- Once the logic behind farmers' behavior is understood, corresponding suggestions can be made. And you will realize that there are many countermeasures you can try with farmers

5.4 How to plan the trainings for farmers?

Effective Training Planning for Farmers

1. **Discuss** with farmers what the biggest challenges are and want to learn to solve them.
2. **Coordinate** timing, content and lecturers for training according to farmers' needs

Points	Examples
Why you do	✔ Objective ✔ Farmer needs ✔ Urgency, Feasibility
What to do	✔ Field sanitation ✔ Pest diagnosis ✔ Fertilizer calculation
How to do	✔ Lecture ✔ Workshop ✔ Practice
Where to do	✔ District office ✔ Farmer house ✔ Field
Who to do	✔ Invited Lecturer ✔ SMOs, AI/TA ✔ Advanced Farmer

Identify the challenges

↓

Identify the countermeasures

↓

Plan training for capacity building

Training Plan

Topic:
Date & Time:
Place:
Lecturer:
Participants:
Agenda:
Contents:

Effective Training Aspects

Training Program better include,

Exercise & Practice

- Only lectures are not enough to understand the contents clearly.
- Exercise & practice give chance to make questions.
- It can help you to imagine how you would actually do it.

Exercise in the Lecture Room

- Group work is recommended
- Ask questions that are able to review the lecture
- Create possible challenges that are likely to happen in actual situation.
- Let participants present and have time to exchange ideas.



Practice at the field

- Limit the number of participants to hear and watch well.
- Check the site before you conduct practice.
- Imagine the arrangements and make preparation well.
- Show how to do and let participants try to do.



Understand farmers‘ needs and challenges for planning a training

- First, identify the specific needs and challenges that farmers face in their environment.
- If there are critical issues that farmers may not be aware of, incorporate training activities to raise their awareness.

Plan the training

Clearly define the following aspects.

- Purpose of the training.
- When and where the training will take place.
- Resource persons who will lead the sessions.
- How the training will be implemented.

Utilize available resources

- The Department of Agriculture (DoA) provides a wide range of technical materials.
- The materials created by the project can also be utilized.
- Identify what resources are available and incorporate them into your training plan effectively.

Training is not limited to lectures. Refer to the table on the Characteristics of Extension Methods and determine which type of program is best suited to achieving your objectives.

The training program should consist following aspects

Hands-on Exercise and Practice

- Always create opportunities for participants to engage in hands-on activities, think critically, and present their ideas during the training program.
- For indoor sessions, incorporate exercises, and for outdoor sessions, provide opportunities to practice the skills being taught.

Time Management

- Keep in mind that exercises and presentations may take longer than expected, especially for participants who are unfamiliar with the activities or struggle to summarize their thoughts during presentations.
- Plan your training program with enough time allocated for these exercises and practices.

Group Size

- An ideal group size is 4 to 6 people to ensure everyone can actively participate in the activities and discussions.
- If a group of people are getting together for the first time and seem nervous, play some games to create an atmosphere of openness before starting the exercises.

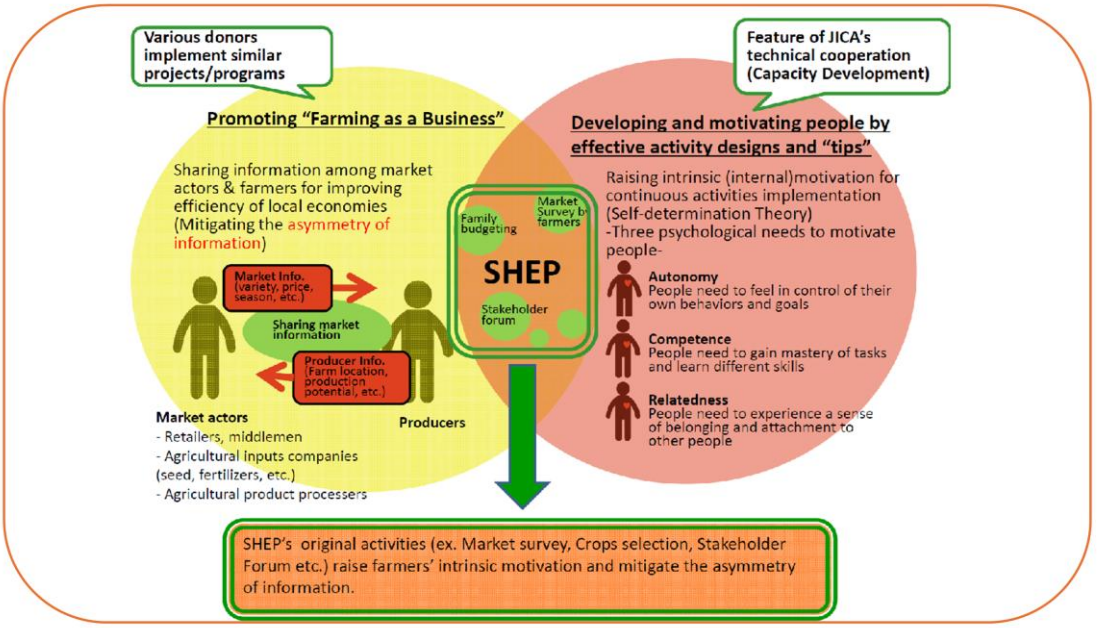
Addressing Communication Barriers

- If it is observed that only elders speak while younger participants remain silent, or men dominate the discussion while women hesitate to contribute, create separate groups such as an elders' team, youth team, men's team, or women's team. This can lead to diverse and interesting presentation results.
- If participants are reserved and hesitant to talk, appoint a moderator or facilitator to guide the discussion and encourage participation.

Smallholder Horticulture Empowerment and Promotion (SHEP) approach in Sri Lanka

Smallholder Horticulture Empowerment and Promotion (SHEP) approach in Sri Lanka

Japan International Cooperation Agency (JICA) supports Department of Agriculture (DoA) in Sri Lanka to implement SHEP approach to address the motivation of farmers as well as ensures their success in farming.



It has developed out of the JICA Technical Cooperation Project which started in Kenya in 2006. An approach which realizes “Market-Oriented Agriculture” and converts farmers mind from “grow and sell ” to “ grow to sell ”

Two key pillars of SHEP approach

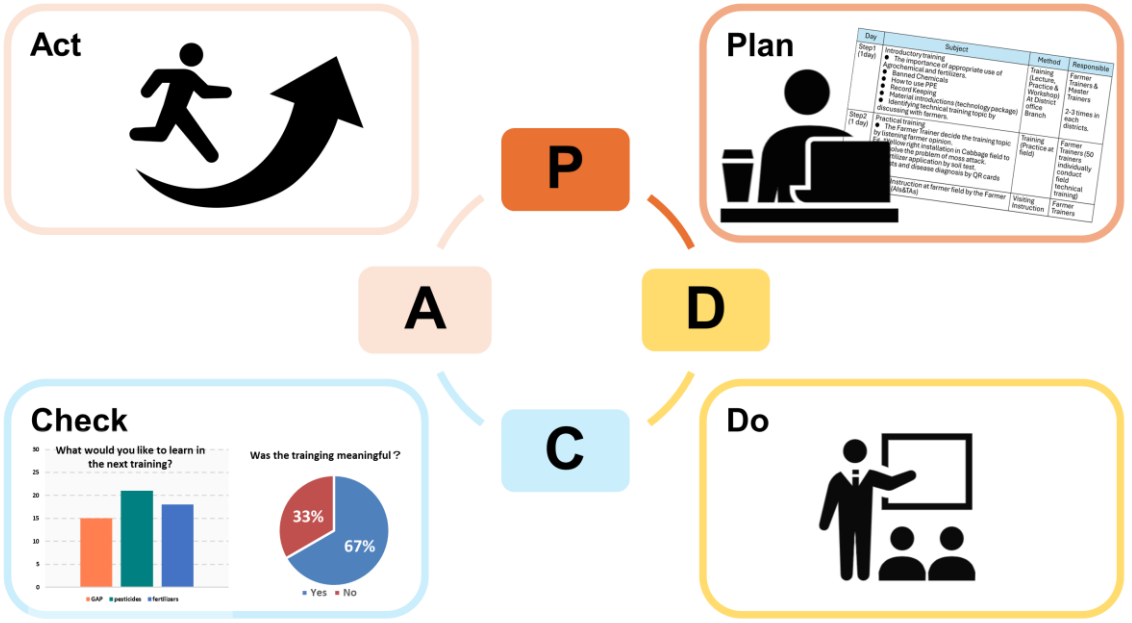
- Promoting farming as a business
- Empowering and motivating

Four steps in SHEP approach

1) Sharing goals with farmers
2) Creating the opportunities for awareness
3) Farmers – led decision – making
4) Providing technical solution

5.5 How to conduct monitoring and evaluation?

Implement the PDCA cycle



Focus Point

No follow-up after training is not enough to achieve objective.

Monitoring and Evaluation

Monitoring

Collects the information regular basis and an interim evaluation for improvement.

Monitoring Sheet

Activities (Trainings)	Objective	Date	Place	Participants	Contents	Feedback from Participants

Before

Monitoring the change

Evaluation

Derive lessons and make improvements

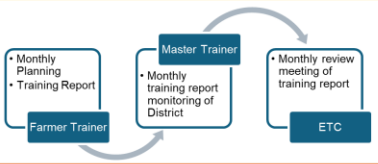
*Important : Evaluation is not a time to criticize and searching for culprits that don't work .

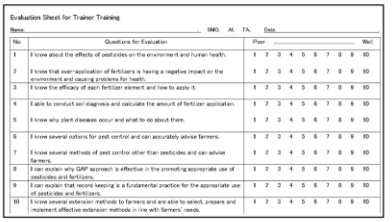
Develop Monitoring & Evaluation procedure before starting activities!

After

Evaluate the difference between before and after

Image





The PDCA cycle, also known as the Plan-Do-Check-Act cycle, is a four-step iterative process used for continuous improvement in various organizational processes.

Plan: Set realistic and achievable targets

- Sometimes people make excessive plans to appeal to everyone, but there is no value in setting unachievable goals.
- Success comes from setting goals that are both challenging and realistic.

Do: Implementation according to the plan

- When implementing the plan, keep records and use them to check.

Check: Evaluate achievement

- Check not only what was done or not done, but also the process and find the causes.
- No follow-up after training is not enough to achieve objective.

Act: From the findings, improvement measures are developed

- Reflect them in the next plan, starting with those with the highest priority.
- Although it may be uncomfortable, reflecting on mistakes is a valuable opportunity to learn and improve future plans and actions.

Monitoring

- Monitoring involves regularly collecting information required for evaluation.
- Conducting interim evaluations can help improve ongoing activities.
- Think of monitoring as a series of smaller evaluations. Go beyond data collection by analyzing and evaluating the findings.
- It also enables necessary adjustments to the plan's direction during implementation.

Evaluation

- Evaluation confirms whether activities have been implemented as planned and if the targets have been met.
- The main goal is to derive lessons learned and make improvements.
- To visualize qualitative data like capacity development, conduct pre- and post-implementation surveys to measure changes.

Exercise



- What is important when interacting with farmers in extension work?
- What is your role as an extension officer?
- Let's plan a Farmer Training

Day	Subject	Method	Responsible
Step1 (1day)	Introductory training ● The importance of appropriate use of Agrochemical and fertilizers ● Banned Chemicals ● How to use PPE ● Record Keeping ● Material introductions (technology package) ● Identifying technical training topic by discussing with farmers	Training (lecture, practice & discussion) at district office branch	Farmer Trainers & Master Trainers 2-3 times in each district
Step2 (1 day)	Practical training ● The Farmer Trainer decides the training topic by listening farmer opinion Eg. * Yellow light installation in Cabbage field to solve the problem of moth attack * Fertilizer application by soil test * Pests and disease diagnosis by pictorial cards	Training (practice at field)	Farmer Trainers (50 individually)
Step3	Instruction at farmer field	Visiting instruction	Farmer Trainers

Memo :


JICA