Democratic Socialist Republic of Sri Lanka

Ministry of Agriculture (MoA)
Agriculture Sector Modernization Project (ASMP)

Assessment of Current Pest Management Strategies Implemented by the MoA & Preparation of a Pest Management Action Plan

Final Report

VOLUME 4

PM Guide for Training & Promotion

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Table of Contents

1. Introduction

A guide to promote PM tools and adoption of PM best practices in small farm crop production systems is developed and recommended to integrate to training and technology transfer interventions as appropriate. This guide identifies different practices/ technologies under each PM tools considering the stage-wise crop growth and production cycle.

Pests are defined as an organism that directly or indirectly interferes with the interest of man. The organism may not be considered as a pest until its activities and life processes cause any harm to human health, convenience, comforts or profits. Accordingly the pest of different types comprise pests affecting food, fiber, shelter; pests of public health; and nuisance pests.

1. Origin & types of Pests

Since the beginning of classical agriculture in 8000 BC, diverse organisms continually compete with humans at both primary and secondary stages of agricultural production. Collectively pests are identified as below;

Insects, mites, arachnids, ticks, other ecto parasites of animals

Nematodes and harmful parasitic worms of plants and animals

Fungi, Bacteria, Viruses, Protozoa

Poisonous plants, Weeds

Birds and mammals

2. Traceability of pest origin

Naturally occurring pests; Evolved naturally in association with man/ animal and plants

Accidental pest; (alien pests) accidentally/ unintentionally introduced outside their native range.

Monoculture ecosystems; Crops grown provide dense aggregation/ availability of abundant food resources encourages proliferation and increases pest population.

Cultural practices; continuous cultivation of land without a resting period or rehabilitation allows for building up of pests.

Inappropriate use of pesticides; Prolonged/ misuse of pesticides eliminate natural enemies and creates pesticides resistance in pest populations.

Storage of crops; Increased food security concerns promotes storage of food. This led to provide more conducive platforms for evolving pests of storage produce.

Insects; Thrives in wide range of environmental conditions in earth's surface, within the soil, in water, every area on earth, than any other group of animal. It was reported that the

world is infested by more than 8000 species of insects. The insects by nature are small in size, high rate of re-productivity, adaptability in every habitat where crop production takes place causing high competition with man for crops grown by damaging them indirectly or directly on yield/quality. Insects cause damage in many ways;

Feed on leaves. Roots/ seed/ nuts, tunnel/ bore in stems/ stalks/ branches, suck sap from leaves/ stems/ roots/ shoots/ flowers/ fruits and carry plant disease organisms.

Thrips; found in flowers, buds, tender leaves-cause misshapen or poorly developed flowers/ buds/ fruits/ leaves.

Aphids/ leaf hoppers/ spittlebug/ scale insects; suck sap from plants, carry plant disease agents, reduce plant vigour/ vitality/ yield.

Moths and butterfly; damage caused during the larvae stage (caterpillar) of the insect damaging leaves, stems, tubers and fruits

Beetles and weevils; adult and larvae stage causes damage to stored food and plants.

Mites- varied behaviour and habitat and found in soil/water and Arial. They feed on plant/plant derivatives/ stored food and grains. In stored food, diverse types of mites are infested and not detected until injury is noticed. Feeding on live plants/ parts cause whitish/reddish or brown foliage/ buds. Also cause scars on fruits, Crop become weak, leaf/ fruit shredding/ forms of blemishes leading to low market attraction.

Snails & slugs - Snails are covered with hard shell and slugs have no shells. They both feed on foliage. These pests feed on lawn, landscape planting and green houses and crops such as Yams, Maize, and vegetables.

Vertebrate pests- mainly mammals and birds. Birds of various species are known to be grain eaters and most destructive are parrots, peacocks, and quail among others. The important type of crops these pests feed on include rice, maize, millet, sesame, long bean, green gram etc.

Among the mammals, rats/ mice feed on rice, ground nuts and yams. Squirrels and rabbits damages the young plants by eating the shoots causing plant death. Larger vertebrates like monkeys and wild boars are capable of reducing the crop yields by eating/ destroying the fruits/ yams/ falling plants/ branches. The elephant damages rice crops, vegetables, melons and maize as often reported by farmers. The severe losses due to mammals are yet to be mitigated and farmers continue to encroach forest lands by clearing and making room for large mammal to enter the cultivated lands where an abundance of food is available. Thus, the conflict continues.

Weeds- is a plant which is out of place. It may be annuals, biennial and perennials. Weeds causes an increase in the cost of production, reduces yield by competing for resources, provide host to insects and its life cycle can be poisonous or contaminate foods.

Common annual Weeds- grasses, sedges and broad-leaf weeds including; *Echinochloa* spp., *Ischaemum rugosum, Leptochloa chinensis, Cyperus difformis, Cyperus iria, Fimbristylis* spp. *Ludwigia* spp.*Eclipta alba, Isachne globosa* in rice fields.

Annual weeds in legume cultivation *Digitaria sanguinalis, Echinochloa* spp.,*Eleusine indica Lolium* spp., *Cleome* spp.,*Portulaca oleracea, Ageratum conizoides,Digitaria* spp

Annual weeds in Onion cultivation- - *Sida acuta, Amaranthus* spp., *Cleome* spp. *Digitaria,*spp.,*Echinochloa* spp. *Setaria,*Spp,*Eleusine indica*

Annual weeds in Maize cultivation- *Sida acuta, Amaranthus* spp. *Cleome* spp. *Digitaria* spp., *Echinochloa* spp. *Setaria* Spp, *Eleusine indica,*

Disease causing pests- These live and feed on plants and are responsible for causing harm to the plants normal growth. Most common causal agents are nematodes, fungi, bacteria and virus.

Nematodes- most of them feed on or inside the roots. Some feed above the ground plant parts (leaves, stems and seed).They may feed at one location or move through roots or other plant parts by puncture plant cells and feed on the cell content. Nematodes do not kill the plants but weaken the plant growth, reducing the vigour and makes it susceptible to other disease agents.

Fungi- are responsible for a majority of plant diseases. The main categories of fungi causing most of the plant diseases are identified as Phycomycetes, Ascomycetes, Basidomycetes and fungi imperfecti.

Bacteria- responsible for soft, mushy, odorous regions on leaves or stem causing rings of different shaped lesions on various parts of plants.

Viruses- cause plant diseases that are carried by insects (vectors aphids/ plant hoppers) and they are recognized by their effects on plants. Also carried easily in plant bulbs, roots, cuttings, suckers and seeds. It is evident it can be transmitted by tools used for pruning/ harvesting, machines land preparation/ inter-cultivating and men by contact with plants etc.

Pest characteristics –feeding and reproduction are major determinants of pest status. Pest status of any organism is a function of the degree of loss it causes to humans in economic terms. It is the rank on the status of a pest relative to economies of control. The major determinants of pest status are characteristics and density.

Indirect damage; Pests feed on non-marketable parts of plants, causing yield loss.

Direct damage; Feeds on marketable parts of plant, causing quality loss.

Vector diseases; Transmit organisms that cause plant disease, causing yield loss and quality loss.

Contamination; Presence of pests, pest excretes, pest parts, reduces the value of product, loss of quality.

Pest density – identifies the abundance of individuals and types of nuisance or injury inflicted. The economic injury level is computed based on the density of pests. It is determined by the lowest population density that cause economic damage. The parameters used include;

The cost of control

The market value of the crop

The yield loss attributable to unit number of insects

The effective control

2. History of PM

History has shown that man at any point of time has never achieved his objective of sustained economic yield to ensure food security for all, despite innovative milestones in agriculture mechanization and technology approaches. It is widely recognized that the crop losses are associated with pests. There is no records available that any crop of economic importance to man had not been attacked by pests. Globally the crop losses due to pests is estimated at 35% of potential yield. Unless vigorous and concerted efforts are made to improve agricultural productivity along with strategies to tackle the pest problem, a catastrophic food shortage may soon be imminent in the world.

It is clear that many factors interact with each other in determining the crop yield. However, it is clear that pest densities cause significant damages to crops. Therefore it is important that pest problems/ organisms be correctly identified and economics of losses or damage be adequately assessed to make appropriate decisions on the measures of control to be applied.

Insecticides usage was first recorded in 2500BC by Sumerians (region of ancient Mesopotamia/ currently –Iraq and Kuwait), where sulphur compounds were used to control insects/ mites. In 1500BC, a description of cultural control by manipulating the planting dates was established. During 1200 BC the botanical insecticides were identified and used for seed treatments and as fungicides. By 950BC the burning method was introduce as a traditional control practice. During 200BC the Romans used oil sprays derived from plant extracts for pest control. Pests such as caterpillars, locusts, and rodents were recorded in the ancient chronicles of Rome, Egypt and Greece. In13BC the first rat proof granary was built by Roman Architect, Marcus Pollio. In 300AD predatory ant (Oecphylla smaragdina) the first biological control was introduced in citrus orchards in China using Bamboo Bridges to connect trees for the ants to move between trees to predate on caterpillars and beetles. In 1000-1300AD a mechanical weed control device; hoe was introduced along with crop rotation and cultivation methods However, the scientific developments of biological understanding of the nature of pests was recorded only after the 15th Century. In 1732 farmers begn to grow crops in rows to facilitate weeding. The Agriculture revolution spurred in EU in 1750 to 1880, with intensive crop protection/international trade and discovery of botanical insecticides Pyrethrum & Derris. Also the biological control of the potato leaf eating caterpillar identified resistant varieties for control of powdery mildew in Grapes, which led to the discovery of the first commercial spraying machine. In 1901 the first successful biological control of Lantana weed in USA made headlines. In 1909, the breeding and development of fusarium wilt resistant varieties for melon, cowpea and cotton was produced. The year 1944 saw the dawn of the first hormone based herbicide 2-4 D. Introduction of the concept of economic threshold, economic injury levels and integrated control was observed in 1959. In 1960 the first insect sex pheromone was isolated, identified and synthesized in the gypsy moth. Environmental Awareness during the 1960s grew multifold – a new awareness of ecology and the environmental impact of pesticide pollution resulted in a public outcry about environmental contamination found in the air and foul water found in rivers and streams. The concept of PM introduced in 1961.

Integrated Pest Management- In 1967 the term IPM was introduced. 1972 saw the release of Bacillus thuringenisis (BT) for control of lepidopterous pests. In 1973-1975 development and release of synthetic pyrethroids insecticides; permethrin and cypermethrin. IPM was adopted as policy by various world governments during the 70's and 80's. In 1985 India and Malaysia declared IPM as official Ministerial Policy. In the 1980s IPM was introduced in Sri Lanka, mainly for rice farming under irrigation settlement schemes. In 1986 Germany make IPM official policy through the Plant Protection Act. Indonesia, Philippines enforce IPM implicitly in presidential decree. In 1987 IPM is implicit in parliamentary decisions in Denmark and Sweden. In 1988 Indonesia recorded major success in implementing IPM for rice cultivation. In the year 1991 the Netherland cabinet decision for multiyear crop protection plan was reported. In 1993 it was reported that 504 insect species are known to be resistant to at least one formulation of insecticides. At least 17 species of insects are resistant to all major class of insecticides. 150 fungi/ other plant pathogens are resistant to nearly all systemic fungicides. Five kinds of rats are known to be resistant to the chemicals used against them and 100 weed bio types and 84 species become resistant to weedicides. In 1997 ETL for IPM published.

Yet the struggle against pests continues due to inadequate attention needed to consider the different methods/ contribution of crop production practices/ technologies, environmental and human safety aspects, before pushing for hazardous chemical methods.

The modern PM involves the use of available practices/technologies to keep pests below economically harmful levels while protecting the environment and humans from hazards. It is not solely the pest control measures that are considered in PM but the Crop tolerance to pest attack is also important. This is greatly influenced by growing conditions. Accordingly the agronomic practices such as land preparation, water availability, soil fertility, nutrients. etc., affect the general health of crops that contribute towards the strength of the crop to withstand the pest attack. However, the challenge lies on the knowledge skills and abilities of farmers and extension services to promote/ adopt appropriate plant health management technologies for control of pests below injury levels and recognize the relevant action to be implemented in order to combat any pest problem.

3. PM approach

This is not altogether a new concept. It was practiced before the advent of modern chemicals. Dates of planting of a crop were carefully studied to ensure that a crop was not being planted when it would encounter severe pest problems, cultural practices such as ploughing after harvest, timely weed control, well timed irrigation and a reduced use of fertilizers all contributed to reduced pest population. Most of these methods were curtailed when modern pesticides become available. It was thought that these chemicals alone could control pests, but now we know that this is not possible, and the single method of approach to pest control is not feasible. Hence, an ecological approach in which utilization of all available techniques of pest control to reduce and maintain the pest population at levels below economic injury level is followed. Pest management is to implemented 24 hours a day, every day of the year.

This is possible and must be integrated into the cultivator's daily thinking and routine of activities. PM technologies/ practices are a way forward in controlling pests by adoption of Plant Health Management (PHM) technologies that will cover all aspects on Crop management (Integrated Crop Management-ICM-) and Soil Health Management (SHM). ICM integrates the practices on IPM, Integrated Water Management (IWM), and Integrated Nutrient Management (INM). Accordingly the PM is a broad concept that incorporates/ considers all aspects of PHM; IPM, IWM, INM, and SHM. Hence the PHM is impacted by several factors; soil health, nutrient management, abiotic stresses, pest populations, ecological balance of pests and beneficiary insects. In order to reduce crop losses due to pests, expertise is required in plant health management (PHM), the science and practice of understanding and overcoming biotic (living things that directly/ indirectly affect the organisms/ environment) and abiotic (sunlight, temperature, rainfall, climate and soil conditions) factors that limit plants from achieving their full genetic potential as crops.

4. Ecological engineering for pest management

Ecological engineering for pest management has recently emerged as a paradigm for considering pest management approaches that rely on the use of cultural techniques to effect habitat manipulation and to enhance biological control. The cultural practices are informed by ecological knowledge rather than on high technology approaches such as synthetic pesticides and genetically engineered crops (Gurr et al. 2004).

Natural enemies may require;

1. Food in the form of pollen and nectar for adult natural enemies.

2. Shelters such as off seasonal sites, moderate microclimate, etc are needed.

3. Natural enemies may also require an alternate host when the primary hosts are not present.

Ecological engineering for pest management – Above ground:

- Raising the flowering plants / compatible cash crops along the field border by arranging shorter plants towards main crop and taller plants towards the border to attract natural enemies as well as to avoid immigrating pest population.
- Growing flowering plants on the internal bunds inside the field.
- Not to uproot weed plants which grow naturally like Tridax procumbent, Ageratum sp. Alternanthera sp., which act as nectar source for natural enemies,
- Not to apply broad spectrum chemical pesticides, when the. P: D (pest; Defender ratio) is favorable. The plant compensation ability should also be considered before applying chemical pesticides.

- Ecological engineering for pest management – Below ground:
  - Crop rotations with leguminous plants which enhance nitrogen content.
  - Keeping soils covered year-round with living vegetation and/or crop residue.
  - Adding organic matter in the form of FYM, Vermicomposting, crop residue which enhance below ground biodiversity.
  - Reducing tillage intensity so that hibernating natural enemies can be saved.
  - Applying balanced dose of nutrients using bio fertilizers.
  - Apply mychorrhiza and Plant Growth Promoting Rhizobacteria
  - Applying Trichoderma as seed and nursery treatment and Pseudomonas fluorescens as seed, nursery treatment and soil application (if commercial products are used, check for label claim).

Due to enhancement of biodiversity by the flowering plants, the number of parasitoids and predatory natural enemies will also increase due to availability of nectar, pollen, fruits,

insects, etc. The major predators are a wide variety of spiders, lady bird beetles, long horned grasshoppers, Chrysoperla, earwigs, etc.

5. Application of PM –PHM

As described above, the PM (PHM) is considered the holistic approach based on various criteria governing the selection and adoption of PM measures/technologies which is necessary to encourage the departure from the use of single control methods in small farm agriculture production. Accordingly, the approaches identified through the PM tools combined with modern crop production technologies are capable of producing desired results. Thus success of the PM program depends on a wide array of operational factors determined by nature pests, farming systems, environment, type of control, logistics, etc.

The following guidelines training/ promotion and adoption of PM tools are established through FPOs in the project provinces. The stage wise adoption of PM technologies to be established accordingly and to be based on the crops selected. A sample of the PM fact sheet is included at the end of the general guidelines on PM technologies**.**

6. General guidelines to training & promotion of PM tools in FPOs in ASMP project provinces.

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
Cultural/ Agronomic practices	Land preparation/ pre planting	Cleaning dead/diseased plants/ plant parts/roots	Destroys stages of pest life cycle (egg/ Caterpillar/pupa)	Training/ demonstration
		Deep ploughing –using a disc at least once a year	Reducing the pest population by destroying eggs/ caterpillars/ Nematodes Hibernating pupa/ cysts exposed to sunlight, predatory birds and destroyed.	Training/educating farmers.
			Improves the soil aeration/ drainage/root zone depth. Vigorous/healthy plant growth	Field demonstration
	Soil management	Soil testing-fertility Microorganisms/composition/moisture holding capacity	Decide on best recommended nutrient/organic matter for select plants. Vigorous/healthy plant growth	Guide farmers for soil testing /INM practices
		Stale seed bed –prepare the seed bed irrigate and allow for 7-10 days to emerge the weeds. Followed by shallow (3-4cm) tillage using a rake. Deep tillage will bring in the weed seeds from deep soil.	Reduce the weeds. Vigorous/healthy plant growth	Demonstrate and train farmers in techniques to remove weeds under stale seed beds.
	Soil treatments	Managing the soil acidity level, fumigation/sterilization, rehabilitation Solarization; cover planting beds with 45gauge(0.45mm) polythene for 10-15 days before planting	Reducing incidence of soil borne diseases/pests. Creating ideal environment for Vigorous/ healthy plant growth.	Increase skills of FPOs
	Raising	Introduce nursery on soil- less culture.	Transplanting Stress/shock/ damages	Increase farmer awareness and

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
	planting materials	Planting trays with compact pellets for all vegetables. Use sterilized planting media for raising fruit plants.	due to pulling seedlings avoided. Plant withstands/ increases tolerance to diseases pests.	demonstrate the potentials with exposure visits.
		Lengthen the nursery period during climate change conditions.	Delay transplanting and manage nursery plants to withstand the climate change and save seedlings from pest attacks.	Train farmers to observe and identify climate change status as a group activity. PMC to be involved.
	Seed selection	Select seeds which are resistant/tolerant to pests and diseases in the farming area. Care should be paid in selecting new varieties which are not specifically tested for the selected location or the area.	Reduce pest attacks in vegetative growth	Training and advice PMC to be involved
		Use healthy/high viability/ certified seeds free from weed/other type seed.	Maintains optimum growth of plant strengthening tolerant level with evenly grown plants within the FPO.	Training & advice PMC to be involved
	Crop rotation	Rotational planting of different crop families/ varieties and mix cropping/intercropping of selected varieties of different families. Increase the productivity of each land unit.	Destroys pest life cycle, population build up is limited, due to changing host plants.	Enhance FPO knowledge and skills with scientific inputs/advice.
	Crop/Farm waste disposal	Maintain good hygiene and environment cleanliness. Remove all weeds around the cultivation.	good sanitation of crop and surroundings help in reducing pest/disease attack	Improve FPO attitudes on field /crop hygiene
	Time of planting	Planting schedule determined by observing climate and pest life cycle	Uniform planting by FPOs helps to minimize crop damages due to pest and	Organize pre seasonal cultivation meetings-PMC to be involved

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
		depending on the crop Avoid planting in wet weather	diseases.	
	Plant spacing	Use recommended plant spacing and densities.	Increased plant health and tolerance to pest & disease	Training for FPOs to identify the different crop spacing and effects on yield/pest & diseases
		Dense planting requires special care and attention.	manipulate the plant structure to allow healthy plant growth	
	Training/ pruning	Based on type of crop use recommended type of trellises, support structures, for climbing plants	Establish plant structure that allows more light penetration, maintain crop sanitation, easy observations for pest/ diseases and increase productivity	Training, demonstration and field exposure visits for FPOs PMC to be involved
		overlapping/overcrowding branches pruned Pruning/training the plant to develop a strong plant frame		
		Cleaning the trees after harvesting, remove diseased/ malformed/dried/dead parts, and cobwebs, collect all fallen plant parts/fruits /stems	Sanitized crop environment will reduce the incidence of pest & diseases.	
	Nutrients management	Identifying available soil nutrients and agro ecological regions.	Determine appropriate nutrients with required rates/intervals to achieve vigorous plant growth.	Enhance knowledge and skills by participatory training/experiments/demonstration PMC to be involved
		Use recommended rates of different nutrients and enable intervals for application.	Strengthen the tissues and protect from pest attack.	
		Foliar nutrient supply Hormone used for fruit setting/control of	Increase crop resistance for pest & disease	

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
		malformation. Be alert about the farmers' non recommended practices and help them to correct those if not effective	improve the yield/quality, minimize the flower drop	
		Organic manure – Poultry litter/cattle dung/FYM/ Vermicomposting.	Improve the soil health and plant health. Increase crop ability to withstand pest attacks. Green Manure crops sunhemp, Green Gram and cowpea raised and incorporated	
	Water management	Identify crop water requirement. Maintain optimum soil moisture. Use modern irrigation systems Avoid flood irrigation	Stress free plant growth. Mitigates the climate change challenges. Reduces the cost of labour. Avoid issues on labour health. No water logging. Low infestation of pest & disease.	Training /demonstration on designing/installation and maintenance for micro irrigation systems.
	Border crops/trap crops	Create live plant fences/grow guard crops around the main crop	Tall crops in border crop like sorghum, maize, agate(sesbania grandiflora) restrict the white fly/Aphids population inside the crop area	Participatory Training
		Intercropping with native /introduced pest repellant plant. Chrysanthemum Spp., sesbania Spp., Crotelaria Spp.,	Marigold (100plants/ac-1row/18rows of chili), citronella, Sun hemp, Basil, Intercrop-Red Onion, cowpea, coriander, Cycus (Madu), Derris (Kalawel), Neem, Eupholsia (Daluk) native repellant plants "Mee" a native plant attracts birds.	

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
			Pomegranate is a preferred host for the guava butterfly.	
		Pheromones 4-5traps /acre Trap/monitor adult moths	Attracts insects and traps. This has to be repeated every 2-3 weeks with fresh Pheromone traps.	
		Wind breaks	Reduces chances of bruising/ wounding and infections.	
	Weed management	Control weeds to avoid competing with crop plants –Keep crop field weed free for 3-4weeks from planting	Stale bed/row reduces weed growth Row planting facilitates mechanical weeding/ inter-cultivating	
		Identify and destroy weeds that harbour pests & diseases life cycle	Weeding at vegetative stage will reduce pest population. Enhance healthy plant growth	
		Prevent spread of weed seeds	Keep boundary bunds free of weeds. Remove left over weeds after harvesting.	
		Use of mulch –straw, polythene, covering the beds	Mulching with Low Density Polyethylene (LDPE) 30 micron thickness by burying both the ends into the soil to a depth of 10 cm. will avoid weed growth.	
		Intercropping in perennial crops to suppress weed growth by legume crop/Earthening up after irrigation or rain to avoid water logging/destroy weed/weed seeds	Provide manure to soil, avoid pest build up and allow plant to grow vigorously.	

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
Mechanical Practices	Hand/Machine/tool destruction	Manual pulling. Slashers, Hand weeders, hoe, intercultivators- practices used for weeding.	suppress weed growth, control pest attacks by removing host plants	Participatory training/exposure visits
	Barriers	The stale bed practice	reduces the weed infestation	Participatory training to improve the skills/for use of appropriate technologies. PMC to involve
		Removal of infected plants/parts	Egg clusters/pupae/larvae destroyed-reduced pest population	
		Sprinkler/jet irrigation	Water sprinkled on the canopy washes away Aphids/ thrips/ other insects.	
		Hand picking and removing	Reduce pest infestation	
		Water ghost, wind ghost,	Sound keeps away the pests	
		Sweep nets, Winnowing,	insects/pest caught to net or trapped in sticky winnower	
	Traps	Bait/ food traps	Especially for rats	
		Light traps/ sticky traps/ spore traps/ pheromone traps	pests/insects	
Physical practices	Trenches/furrows	"V" shape 25cm deep/45^0 angled trenches with polythene lining	Limits movements of caterpillars	Awareness and technical training required.
	Fencing	Insect proof nets 1-3meter high	Limits pest infestation	
		Fabrics/polythene 1-2meter high		

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
	Mulching	Polymulch- white/grey shiny top and black bottom- UV treated aluminized materials could be used for several seasons	Allow the plants to grow vigorously in weed free soil bed. Indirectly increase the tolerance level to pests	
		Waxed paper/ plastic cups/ cans placed around the stem of seedling	Deter feeding of pest on stems (caterpillar)	
	Inert dust	Lime, salt, sand, wood ash, paddy husk, silica aerogels, Gypsum	Suppress pest infestation especially in storage	
	Pneumatic	Blowing air around cultivation	Effective way to dislodge pests from plants	
	Bagging	Waxed paper bags, Polybags of different colours(banana)	Protect fruit from sucking pest damages. Increase appearance	
	Heat	Slow burning of moist beds, especially nursery.	Destroy pests (cysts, pupae, caterpillars nematodes, fungi)	Training and demonstration for appropriate technology adoption
		Sun drying/machine drying	Expose and destroy pests in grains	
		Manipulate and reduce moisture	Prevents attack on stored grains	

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
Biological practices	Natural enemies	Predators, insectivorous species Parasitoids, organisms live in host Pathogens, Bacteria, fungi, virus Predators; Lady bird beetle, Hover fly, Green lace wing, spider, Red mite,	Predators consume large number of pests directly or lay eggs on host/larvae to feed on. .Pathogens cause infection in host & kills. Number of species of	Increase awareness and train to identify / propagate/ preserve/use natural enemies

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
		Parasitoids; Trichogamma spp.	natural enemies in Rice pests – 36, Tea pests – 34, Coconut pests – 18 , Grain legume pests – 56. Chilli pests – 24, Cabbage pests – 16, Cucumber pests – 11	
	Genetical options	Sterile Insect Technique (irradiation technology)	controls fruit flies, screw worm, diamond black moth	Enhance farmer knowledge/skills by training/demonstrations and participatory activities
		Naturally occurring and genetically altered bio-insecticides, which include arthropod natural enemies, entomopathogens (bacteria, nematode, virus, and fungus), plant-derived insecticides and insect hormones.	products registered include bacteria (104 products, mostly are B. thuringiensis), nematodes (44 products),fungi (12 products), viruses (8 products), protozoa (6 products) and arthropod natural enemies (107 products)	
Chemical practices	Pesticides	Insect repellants/ attractants /inhibitors	Keep insects out of crop area, trap insects, and break the life cycle by destroying one or more stages (egg/ pupae / larvae).	Train FPOs to build their capacities and confidence in crop production practices and its contribution for the pest and disease control and use chemical only when need arises as determined.

PM tool	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
		Toxic chemicals	Last option- If necessary use “soft” insecticides; Soap sprays (5 tablespoons of soap in 4 litres water). Vegetable oil (1 cup cooking oil; 2 cups water; 1 teaspoon dishwashing liquid. Dilute the mixture at 3teaspoons per half litre of water and spray on the infested leaves). Commercial products with petroleum oil: Plant-derived products, such as Neem, derris (Kalawel), pyrethrum and chilli (with the addition of soap). Note, varieties of Derris exist in Sri Lanka that contain 2-3% rotenone, and are effective insecticides. Check if Derris is available locally in your province.	Improve technical knowledge on bio pesticides and plant based extracts/ materials for effective control of pests/ diseases.

PM monitoring tools	Activity	Technology/Practice/methods	Relevance to suppress pest incidence	Promotional strategy
Identification	identify pests/ beneficial insects	Determine the families/ species/life cycles/ symptoms of damages	Differentiate pests and beneficial insects.	Participatory training – increase skills and knowledge Improve the skills/ knowledge to pest forecasting, maintain records. Train farmer to maintain records and determine the ETL for decision making on pest control measures.
Surveillance /Forecasting	Analyse the pest dynamics in a particular crop area	Observations made through collected pest/ beneficial insects regular basis	forecast the level of infestation	
Diagnosis	Proper identification of symptoms/signs of infestations	Determine/detect pest characteristics and disease symptoms connecting the climate change factors	Detect early symptoms of pests & disease	
Scouting	Regular assessment of pest & disease infestation	Type of pests/diseases at different crop stages, beneficial insects	Identify the pests and beneficial insects balance to determine the level of infestation	
ETL	Population density and its effect on economic yield	Published ETLs used as base to justify the need for applying a control measure	Economic importance of pest dynamic identified	

7. Stage- wise crop fact sheets for promotion/ adoption of PM tools in FPOs under ATDP provinces

Fact sheet 01

Chilli – Capsicum annum

Provinces cultivated- North Central, Northern and Eastern.

Ecological regions -

Province	Ecological regions	Chili verities cultivated
North Central	DL-1	MICH-2,MI-2,KA-2,Galkiriyagam selection
Northern	DL-1,DL-1d,DL-3,DL-4	Super (874) indium, MI 2, Jaffna selection (similar to PC1)
Eastern	DL-1,DL-2,DL-2a	PC-1

Chilli can be raised from sea level up to 2000 meters. Optimum temperature for yield of fruit is 24^0 C. When the nocturnal temperature is below 10 ^{0} C fruit set is restricted. Fruit weight, length, girth and pericarp thickness is high at 25^0 C by day and 18^0 C by night.

Pests & diseases of provincial interest-

Description	Identified organisms
Pests	Thrips, White fly, Mites, Aphids, Pod borer, Nematodes
Diseases	Damping off, Leaf curl complex, Virus, collar rot, Leaf spot, Anthracnose, Coaniphora blight, Powdery mildew.
Weeds	Cyperus rotundus, Amaranthus Virids, Digitaria spp., Desmodium blue (Wal ratakaju), Wal kottamalli, Protulaca oleracia, Eleusine indica, Seteria Spp.

Stage-wise crop PM by maintaining PH (PHM)

Stage	Management	Activity *(Cultural (Cu)/ Mechanical /Physical (MP) /Biological (Bi) /Chemical (Ch.)*)
Land prepn.	Soil health - Soil borne fungus, nematodes, and resting stages of insects	Deep ploughing/ harrowing/ levelling. Expose soil borne pests/ nematodes. (Cu) Neem cake 100kg/ac when transplanting (Bi)
	Minimize weeds,	Stale bed technique limit the weed growth. (Cu) Poly mulch (0.45 mm thickness) over soil bed for 3wks(MP)
	Improve soil nutrients	FYM 25t/Ac add during land preparation (2-3wks BTP) (Bi). Soil testing –identify nutrient status to determine recommended NPK and micro nutrients(Ch)

Nursery	Damping off – /nursery beds and seedlings Pre –emergence and post emergence	Facilitate drainage, use raised beds height above 15cm.(Cu) spread by Oospores/sclerotia in soils carried through irrigation water
	Field-ready and better rooted seedling. Healthy/Vigorous plants	Raising seedlings in planting trays of individual cells Sterilized planting media (compressed pellets of coir dust). (Cu). Avoid using soil beds/use planting trays. Resist pest & disease attack, avoid damping off and free from weed(Cu)
Transplanting	Nutrients based on soil testing Increase phosphorous absorption. Planting. Micro irrigation system	Basal application of NPK and micro nutrients. (Ch.) Root dip treatment phosphorous solubilizing bacteria (Bi). Recommended spacing 60x45cm two plants/hill. Sprinkler Irrigation 5-10 day's intervals. (Avoid flood irign.). May need daily irrigation in 1st week after transplanting
Vegetative	Plant nutrients	45 DAP after 20Kg N +10Kg K, 60 DAP and 75 DAF similar quantity. NAA 2-3 at 15 day intervals reduce flower drop. Foliar spray of micronutrients if any deficiency symptoms.(Ch)
	Reduce weed growth	Polymulch 30 micron cover planting beds. Pulling/burying between rows and tightly sticking to bed surface is essential (Cu).
	Thrips	Barrier crop –sesbania grandiflora, conserve predators –Hover flies, mired bug, Neem cake (Bi). (or Ch if required)
	Aphids	Conserve parasitoids - Aphidius colemani, Aphelinus spp. Conserve predators Syrphid/ hover flies, green lacewings (Mallada basalis, lady beetles, spiders, wasps.
	Mites	Border crop with two rows of Maize at every 0.5ac (Cu), Conserve predators- predatory mite (Amblyseius ovalis), predatory bug (Orius spp.), spiders. If the incidence of mites is low, spray neem seed powder extract 4% at 10 days interval.
	White fly	Sticky traps-pale yellow –Monitor/suppress (Cu), micro irrigation-sprinkler at 0600 hrs and 0200 hrs. Using bug blaster attachment(MP), Predators-Lady bird, lacewigs, bio oils,(Bi)
	Pod borer	Field sanitation/ rouging/ Nylon netting/ fabric cover/ intercrop (cowpea, onion, coriander, black gram. Border crop –Maize 4rows around the field. Repellent plant- Basil, pheromone

	 trap crops- Marigold	traps 4-5/acre and replace every 2-3 wks. Ovipositional trap crops –marigold-100plants/acr in ratio of 1MG row for every 18 rows of chili (Cu). Parasitoids -Tetrastichus spp. (egg), Telenomus spp. (egg), Campoletis chlorideae (larval). Conserve predators - King crow, common mynah, wasp, dragonfly, spider, fire ants, , earwigs, ground beetles.(Bi)
	Choeanephora blight	Adopt recommended spacing to maintain adequate air circulation/ grow resistant varieties.
Reproductive	Nutrients	Micronutrient deficiency should be corrected by foliar spray of particular micronutrient.
	Weeds	Left over weeds should be removed from the field to avoid further spread of weed seeds.
	Fruit rot/die back	Transplant pathogen free plant is key, use quality assured treated seed, good field hygiene, weed free fields, good drainage.
	Bacterial blight	
	Anthracnose	Alternate host-tomato, root crops, mango, Papaya. Avoid overhead irrigation as water splash spreads these fungi, Control weeds and volunteer capsicum and chilli plants. Crop rotation, ploughing in deep and remove infected crop residues.
	Thrips, Aphids, White fly, pod borer	measure same as vegetative stage

Fact sheet 02

Passion fruit – Passiflora Spp. (P.edulis edulis/P.edulis flavicarpa)

Varieties; Horana Gold/Yellow/Purple

Provinces cultivated- North Central, Northern and Uva

Ecological regions

Province	Ecological regions	Passion fruit varieties cultivated
North Central	DL-1	Yellow
Northern	DL-1,DL-1d,	Yellow
Uva	IL-1C,IL-2,DL-1	Horana Gold & Yellow

PF can be raised from sea level up to 3000 meters. Optimum temperature for fruit set is 22 - 32^0 C. Night temperature below 10 ^{0} C fruit set is restricted. Well distributed Rainfall of 1000-1500mm/year required for healthy growth and better yield performance. Cultivated in sandy loam/ latertic/ clay loamy soils with a pH of 6.0-6.5.

Pest & diseases of provincial interest-

Description	Identified organisms
Pests	Waxy scale insect (Gascardia brevicauda, Ceroplastes destructer),Beetle-Vine girdler-Thrips, White fly, Mites, Aphids, Nematodes
Diseases	Mosaic virus, anthracnose, mildew Damping off, collar rot, Leaf spot, Anthracnose, Coaniphora blight, Powdery mildew.
Weeds	Cyperus rotundus, Amaranthus Virids, Digitaria spp., Desmodium blue (Wal ratakaju), Wal kottamalli, Protulaca oleracia, Eleusine indica, Seteria Spp.

Stage	Management	Activity *(Cultural (Cu)/ Mechanical /Physical (MP) /Biological (Bi) / Chemical (Ch.)*).
Land prepn.	Soil health - Soil borne fungus, nematodes, and resting stages of insects,	Deep ploughing/ harrowing/ levelling. Expose soil inhabited pests/ nematodes/pathogens. Trimming all bunds/destroy any existing rodent burrows, (Cu). Uproot/collect all infested/dried plant parts and destruction to avoid spread of pest/diseases, (MP).
	The soils should be well-drained	Plants will not withstand waterlogging or flooding.
	Minimize weeds,	Remove all weed roots/parts before preparing planting holes, (Cu). Stale bed technique to reduce weed growth at planting time.
	Improve soil nutrients –facilitate healthy plant growth and resistance for pest & diseases	Each Planting holes-*PH*- (60x60x60 cm) filled with 10kg compost, add Mychorrhiza 5-10gm and FYM 10kg *(poultry manure 5kg* per *PH* at least 2-3 weeks before planting. (Bi). Soil testing –identify nutrient status, and determine recommended NPK and micro nutrients (Ch). If

Stage	Management	Activity *(Cultural (Cu)/ Mechanical /Physical (MP) /Biological (Bi) / Chemical (Ch.)*).
		soil pH is below 5.5 add dolomite, 0.5kg/*PH* annually. 2-3 days before planting add RP 80gm,MOP 40gm, Urea 45gm & kieserite-Mg & S- (soluble form Epsom salt)55gm per *PH*
	Root rot/crown rot (Fusarium wilt) affect the plants in nursery and field	Keep soil pH Acidic at 6-6.5. Apply manure and lime in the holes/surroundings to reduce the soil acidity effects. (Cu). Avoid planting in previously diseased fields. Always use healthy/quality assured seedling, avoid injury to plants during weeding, and Keep the field andits periphery weed free. Sterilize the planting media for nursery.
Nursery	Plant Nursery and seedlings	Raised seedlings in separate pots (6" h x 4" d) through cuttings or seeds. Cutting provides uniform fruit characteristic. Cutting to be obtained from disease free mother plants. Use sterilized potting media (compressed pellets of coir dust). (Cu).
	Field-ready and better rooted vigorous seedling.	Individual pot/cells resist pest & disease spreading/attack. Healthy/Vigorous plants free from weed(Cu)
Transplanting	Planting/Spacing	Recommended spacing 3-4x 3-4m row-to- rao 2m between rows and 4.5m in the row (plant to plant is the recommendation and plant to plant. Sprinkler Irrigation 5-10 day intervals. (Avoid flood irign.). Daily irrigation in the first week after planting would be better.
	Support structure/training vines	Iron/ concrete / bamboo/ wooden posts of 2.5m ht. Trellis run across north –South direction East – Westor across the slopes to facilitate maximum exposure to sunlight (help reducing soil borne disease). Prune laterals before touching the ground (diseased parts should be pruned with separate knife to avoid spread of diseases.
Vegetative	Plant nutrients	2,6 & 10 MAP RP 80gm, MOP 40gm, Urea 45gm *PH* & kieserite-Mg & S- (soluble form Epsom

Stage	Management	Activity *(Cultural (Cu)/ Mechanical /Physical (MP) /Biological (Bi) / Chemical (Ch.)*).
		salt) 55gm per *PH* at 10th month.(Ch).
	Weed	Mulch around root zone, remove all weeds around the plants manually (Cu). Keep the field weed free to reduce host plants for pests. Intercrop with Turmeric, Ginger, Chili, Mustard, Coriander, Green leafy Vegetables
	Thrips	Destroy crop debris. Enhance parasitic activity by avoiding chemical spray, when 1-2 larval parasitoids are observed. Use blue sticky trap for thrips @ 4-5 trap/acre. Avoid intercropping with legumes.(Bi).
	Aphids	Avoid using high dose of Nitrogen, Yellow sticky traps 4-5 trap/acre (Cu). 1st instar larvae of green lacewing 4,000 Nos/acre. Spraying with tobacco decoction (1 kg tobacco boiled in 10 lit of water for 30 minutes and making up to 30 lit + 100 g soap). Collect insects using wet cloth pieces/ gunnies/ clay tiles placed on field to trap the insects, Trap insects using baits. Conserve parasitoids - Aphidius colemani, Aphelinus spp. Conserve predators Syrphid/ hover flies, green lacewings, lady beetles, spiders, wasps.
	Scale insects	Destroy infected plants/ parts, Hand scrape remove insects from young vines, field observation. Conserve *Aphytis spp.* Sugary excretes of scales attract black fungus infestation.
	Mites	Periodic inspections of the orchard and other adjacent hosts, including weeds, are essential to verify the occurrence and first symptoms of mite attacks (Cu). Neem seed powder extract 4% at 10 days interval. Border crop with two rows of Maize at every 0.5ac (Cu), Conserve predators- predatory mite (Amblyseius ovalis), predatory bug (Orius spp.), and spiders.
	Mealy bugs	Prune affected shoots during winter Maha Season?, Destroy ant colonies, Intercrop coriander to attract wasps (Cu), Use sticky barrier 0.5cm length on trunk (MP),

Stage	Management	Activity *(Cultural (Cu)/ Mechanical /Physical (MP) /Biological (Bi) / Chemical (Ch.)*).
		Use lady bird beetle 10 per plant (Bi)
	White fly	yellow sticky traps for whitefly, @ 4-5 trap/acre –Monitor/suppress(Cu), micro irrigation-sprinkler/using bug blaster attachment (MP), Predators-Lady bird, lacewigs , bio oils,(Bi)
Reproductive	Nutrients	14th, 18th, & 22nd MAP recommended to apply Urea 90gm, TSP 90gm and MOP 70gm per plant. Therafter, at every 4 month intervals apply Urea 135 gm, TSP 130gm and MOP 105gm. Zinc and Boron are most used micronutrients – any deficiency symptoms should be corrected by foliar spray. Tally with the soil testing reports and nutrient availability in the soil to make any adjustments.
	Weeds	Apply mulch around the plant root zone Left over weeds should be removed from the field/surrounding to avoid further spread of weed seeds.
	Fruit Fly	Elimination of over-ripe fruits in which the flies breed and on which the adults feed. Removal of wild host plants. Installation of 05 traps/ac., Hanging of bottle traps containing 100 ml of water emulsion of methyl eugenol (0.1%) during fruiting season.
	Anthracnose	Use recommonded spacing, install wind barriers, trimming vines, and reduce the density of pathogens. Maintain crop/ field sanitation. Avoid overhead irrigation as water splash spreads these fungi, Control weeds and volunteer capsicum and chilli plants. Crop rotation, Ploughing in deep and remove infected crop residues.
	Thrips, Aphids, White fly, pod borer	measure same as vegetative stage

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