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TRAINING MANUAL
INTEGRATED PEST MANAGEMENT
FOR POTATO FARMERS



The Agribusiness Project – Agribusiness Support Fund

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Integrated Pest Management Training Manual for Potato Farmers – The Agribusiness Project

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This manual is a live document which can be changed as the project progresses. Any suggestions for further improvement are most welcome. Project staff is particularly encouraged to identify areas for further improvement.

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BACKGROUND/INTRODUCTION

Integrated Pest Management (IPM) grew from a history of damage to agricultural environments resulting from inappropriate cultivation practices. The green revolution, which aimed at increasing agricultural productivity to meet the growing need for food, in fact gave rise to new problems. The green revolution only stressed higher productivity, while ignoring the capacity of the environment to support continued use and paying no attention to increasing farmers' incomes.

Pesticides and chemical fertilizers did initially result in substantially larger harvests, but were utilized unwisely without any clear understanding of exactly how to use them. Ultimately, farmers became dependent, unable to farm their fields without using chemical fertilizers and pesticides.

The program had negative effects and led to fresh problems such as new pests, problems controlling pests and diseases, environmental pollution, and farmers' dependence on products from outside. Farming sustainability became threatened, as it was no longer profitable. These problems lead to the realization that the farming system had to change. The central problems were those relating to pests, therefore, pest management had to become an important focus of attention.

Initially, the basic concept of IPM was a pest management approach stressing balanced agro-ecosystems and making the best possible use of nature. The hope was this concept could change farmers' minds away from "pest eradication" and towards "pest management". The "management" approach emphasizes a balance between pests and natural enemies in a managed environment able to support that balance. You do not eradicate pests, but manage them in such a way that their numbers do not damage crops. When you eradicate pests, you also exterminate their natural enemies, as pests and natural enemies are mutually interactive.

PRINCIPLES OF IPM

The basic principles of IPM are:

- Grow a healthy crop.
- Conduct routine field observations to look at development of pests, diseases, weeds, plants, natural enemies, and the surrounding environment.
- Preserve natural enemies.
- Farmers as IPM experts in their own fields.

The original concept has now changed. IPM no longer focuses on pests alone, but has expanded to encompass the whole cultivation system. IPM combines various approaches and technologies in an effort towards sustainable and healthy farming. IPM will be more effective when implemented across whole farming blocks with groups of farmers than in individual fields as to ensure a stable ecological balance at the ecosystem level. IPM has to be the concern of farmer groups, traders, consumers, government agencies, non-governmental organizations, and farming businessmen.

OBJECTIVES OF IPM

- Strengthening and Building the capacity of Farmers and crop growers and field staff of Department of Agriculture and other stakeholders in effective management of fruit and vegetable crops
- Application of effective crop management tools and approaches
- Promote best pest management practices
- Improve crop yield by implementing different components of IPM
- Foster linkages between farmers and other stakeholders for joint ventures in better managing the crop diseases and pests
- Enhance the understanding of farmers and stakeholders in the areas of pest management and safe use of pesticides on their farms

POTATO AN OVERVIEW

The potato (*Solanum tuberosum*) originates from South America, most likely from the central Andes in Peru. The potato was domesticated and has been grown by indigenous farming communities for over 4,000 years. Introduced into Europe in the sixteenth century, the crop subsequently was distributed throughout the world, including Asia (Smith, 1995).

The potato is a major staple fulfilling human nutritional requirements. Worldwide, the potato comes forth in terms of production after wheat, maize, and rice. In many countries potato serves as their staple food because of its excellent nutritional content.

- Its potential for high productivity.
- Its potential for being extremely profitable and easily marketed.
- Its price is relatively stable.

Its production challenges include:

- It is vulnerable to pests and diseases hence implying a high risk of failure.
- Growing potatoes requires substantial capital.
- It needs intensive care and attention.

The main constraints to potato farming in Indonesia are farmers' lack of healthy seed, and attack by late blight, bacterial wilt, viruses, and leafminer fly. Other important constraints for farmers include potato tuber moth, weeds, unfavorable weather, low soil fertility, inadequate post harvest management, and marketing.

POTATO GROWTH AND DEVELOPMENT

The potato plant

The potato plant consists of the following parts: leaves, stems, roots and tubers. Some potato varieties planted in particular environments can produce flowers and berries. The function of each of these plant parts are as follows:

- Leaves are the part of the plant used for supplying nutrients.
- Stems are for supporting plants, and have vessels and growth cells inside.
- Roots absorb nutrients from within the soil.
- Tubers are receptacles for storing nutrients.

Potato plant growth

There are no *fixed* development stages in potatoes as these are influenced by varieties, shoot size, soil fertility, weather etc. Unlike rice, potato development stages overlap with each other making it difficult to distinguish between stages. For example, sometimes during the early growth stage, developing tubers have already begun to grow from the roots. Nevertheless, a division of potato growth stages can provide a picture of crop's critical development periods. This knowledge is extremely important for developing management strategies.

Potatoes planted from seed have the following growth stages:

Sprout development stage

This stage begins with several eyes sprouting when the tuber is in storage, continues through planting and up until shoots emerge from the surface of the soil. The time involved for the shoots to emerge from the ground varies greatly depending on the length of the shoot, moisture in the soil and other environmental conditions. With a sprout at the ideal length of 1-2 cm, shoots should begin emerging from the ground at around 21-30 days after planting (DAP). During this stage the plant still uses nutrient reserves stored in the tuber.

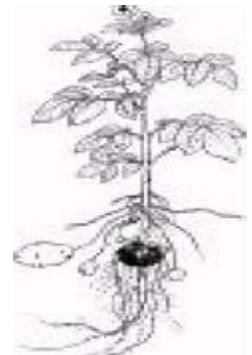
Vegetative growth stage

This stage shows rapid growth of leaves, stems, new shoots and roots. The plant still relies on food reserves stored in the seed tuber, but has already begun to take small quantities of nutrients from the soil. With the Granola variety this stage generally occurs between 30-50 DAP.

Tuber initiation stage

In the Granola variety, although tuber-forming roots begin to form during the vegetative stage, formation of actual tubers only occurs at 40-55 DAP. This stage takes place over a relatively short period of about 10-15 days. Tubers formed after 65 DAP will not reach optimum size when harvested. Plants require nutrients in large quantities during this stage.

form during the

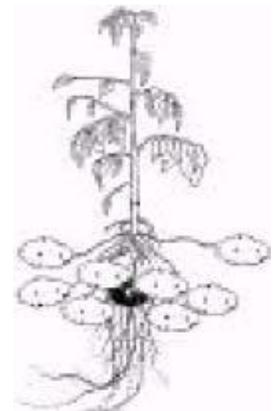


Tuber bulking stage

At this stage, the plant itself has already stopped growing, and only the tubers become any larger. In the Granola variety, this stage occurs at 50-80 DAP.

Tuber maturation stage

Yellowing leaves and drooping stems characterize this stage. Tuber skins gradually harden and do not pare away easily. Tubers harden due to their increased starch content. In Granola variety this stage occurs at 80-95 DAP. The best time to harvest a plant is at over 100 days old, because tubers will have reached maximum maturity signified by their hardness and sturdy skins.



Potato growth stages and vulnerability to pests and disease

At each growth stage plants are vulnerable to certain pests and diseases. The critical time for a potato plant is during the vegetative growth and tuber formation stages. Severe pest and disease infestations during these stages can reduce yield and can even cause crops to fail. Experience from highland areas in Indonesia shows leaf wilt infection at 30-45 DAP, along with high levels of rainfall and humidity, causes plants to die before forming tubers. Appropriate plant management and pest and disease control during the critical growth stages will support successful potato cultivation.

APPLICATION OF FERTILIZERS/MANURE

Manure can be applied before or after it is decomposed. Direct application of non-decomposed manure is not recommended for the following reasons:

- It may contain pests and diseases that can negatively affect plant health.

- It is difficult to apply because it smells bad and is too wet.
- Applying fresh manure at planting time can actually temporarily reduce quantities of available nutrients in the soil, because of decomposers using nutrients for decomposition processes.
- Fresh manure needs the oxygen in the soil in order to decompose, so direct application can starve plants of oxygen.
- It contains toxic gases that can kill plants. It also reduces soil pH.

Chemical fertilizers

Chemical fertilizers are fertilizers that contain one or a few nutrients and are mined or produced in factories. The most common nutrients contained in chemical fertilizers are nitrogen (N), phosphorus (P) and potassium (K). Chemical fertilizers are generally applied directly to the soil. They contain nutrients in a form that plants can readily absorb, so they must be applied when plants require them.

Chemical fertilizers are categorized according to their composition into single nutrient and compound fertilizers. Single nutrient fertilizers are chemical fertilizers that contain one type of nutrient. For example, KCl contains potassium, Urea contains nitrogen and SP- 36 contains phosphorus. The benefits of using single nutrient fertilizers are their cheaper prices and they can be applied to suit plants' requirements for a certain nutrient at any given crop growth stage. For example if a plant only needs N then you only need to apply urea. In certain conditions, single nutrient fertilizers can be mixed to replace compound fertilizers. To mix them properly, you need to know the nutrient content of each single nutrient fertilizer.

How to apply fertilizer

Successful fertilizer use is determined by application strategy covering fertilizer types, dosages, times and methods. Application strategy is based on a crop's nutrient requirements during different stages of its growth. In IPM there are no fixed recommended doses for fertilizers since the required dose depends on the specific conditions in a specific field. Table 5 below provides some guidelines that, however, should be tested and adapted in each specific field. General principles for the application of the various commonly used fertilizers are given in the paragraphs below.

A. Organic fertilizer

Apply at planting time by mixing it straight into the soil or by placing it to the left and right of the seeds. Organic fertilizer requirements for potato crops are minimally 20 ton/ha. Using more than this will further improve soil structure and fertility.

B. Nitrogen

Is particularly needed during the vegetative growth and tuber initiation stages. Nitrogen is very soluble and volatile, so is best applied in split application. Avoid applying it when fields are flooded or there is water flowing on the surface of the soil. Nitrogen evaporates easily so should be covered over by soil immediately after application. It is best to do two (or three) applications, applying 25% at planting (0 DAP) and 75% at 30-35 DAP, by putting it 10-20 cm deep into the soil.

To save energy and expense, you can apply nitrogen fertilizer at the same time as weeding and hilling up.

C. Phosphorus

Required during the vegetative growth and tuber bulking stages. P fertilizer takes time to release its P content into a form readily available for plants to absorb. It bonds easily to minerals in the soil. It is best to apply it at planting time as basal application. Soils in mountainous areas generally contain natural P, so they need little P content fertilizer.

D. Potassium

Is essential during the tuber bulking stage. K fertilizer releases its K content in a form available for plants. K fertilizer is applied once at 30-35 DAP. K easily dissolves in water and should therefore be covered by soil after application.

Potato plant fertilizer requirements

Balanced fertilizer use will produce healthy plants that can resist pests and diseases and compensate for any damage done. For example: adequate levels of potassium helps hardening the cell walls, making them less penetrable to fungal growth. Healthy potato plants can produce additional cells around a leafminer fly egg and hence push it out of the leaf tissue, after which the egg drops to the ground and dies. Important things to know when applying fertilizer are:

- Plants' nutrient requirements in relation to estimated yield.
- Quantities of nutrients in the field available for plants.

It is difficult to recommend a fertilizer use balance for potato crops as requirements vary greatly for different times, seasons, plant types, growth stages and environmental and market conditions. Fertilizer balance should be based on experimentation in each location. Farmers' experiences are the basis for experimenting with quantities of fertilizers used.

Pest management

Biological control

Biological control will develop better if supported with another strategy, i.e. using natural pesticides, which originate from plants and are less likely to disturb or kill natural enemies. Plant materials that can be used as insecticides are the following:

Neem:

Neem (*Azadirachta indica*) is a tree that is toxic and repellent to numerous pests, particularly insect larvae, aphids and thrips. All parts of this plant are toxic, but toxicity is highest in the seeds. Pulverize plant parts until they are soft, and dilute them with clean water. Spray the mixture onto plants. To help it stick to the leaves you can add detergent. Because the toxicity does not last long in direct sunlight, it is best to spray in the late afternoon. If the mixture is too concentrated, it will poison plants leaving them looking as if they have been burnt.

Tuba:

The tuba plant (*Derris elliptica*) is commonly found in tropical forests. All parts of the plant are toxic, but the roots have the highest toxicity. This plant can be used to control leaf-eating insects such as caterpillars, grasshoppers, aphids, thrips, etc. Squeeze plant roots in clean water and leave them to soak overnight. The water can then be sprayed directly onto the plants. As with neem, you should spray in the late afternoon, and make sure the mixture is not too concentrated.

MAJOR POTATO PESTS AND THEIR MANAGEMENT

Leafminer fly

The potato leafminer fly (*Lyriomyza huidobrensis*) originates from North America, and was accidentally introduced into Southeast Asia in the 1990s on ornamental plants. This pest affects numerous crops and weeds, and has more than 40 species of host plants, including potatoes, kidney beans, green beans, okra, Indian mustard, and several weeds. Farmers control this pest mainly with insecticides, but this has been ineffective and has actually increased their numbers. Leafminer flies that are accidentally introduced are generally already resistant to insecticides.

Life cycle

The leafminer fly reproduces by laying eggs. Its life cycle is divided into egg, larval, pupal and adult fly development stages: • *Eggs* - Laid inside leaves, they are very small and clear in color. Larvae hatch after about two or three days.

- *Larvae* – These remain inside leaves. They are very small and have no legs so cannot move from one leaf to another. The larval stage lasts around 6-12 days.
- *Pupae* – These are formed in the ground or inside leaves. On potato plants, pupae usually fall to the ground. The pupal stage lasts around 14-16 days.
- *Adult flies* – These are extremely small at 2-4 mm in length, black in color with two yellow spots on their backs. They are most active in the morning from 7:00 to 9:00 and in the afternoon from 16:00 to 18:00. Adult flies produce an average of 166 eggs per female. They are attracted to the color yellow.

Damage symptoms

The leafminer fly damages plants during its larval and adult stages mainly on the lower third of plants. Larvae begin eating the insides of leaves immediately after hatching, and bore mines inside them. In instances of severe infestation, all that is left of leaves is their upper and lower skins. Affected leaves become dry and drop off the plant. Adult flies puncture holes in leaves in order to lay eggs and feed on plant juices. If this pest infests a crop during the early plant growth stage, potato yield can be reduced by up to 70%.

Management

Methods for managing this pest are: • Clearing and destroying non-crop host plants and residues. • Planting trap crops such as green beans and pulses at the right time and in the correct quantities. • Hilling up at the appropriate time (four to six weeks after planting). This is to bury and kill the pupae that have fallen to the ground

1. Aphid Myzus persicae

Aphids are always found on potato crops, from when shoots emerge up until the end of the vegetative growth stage. They are small, soft and green-yellow in color. Some of the adults have wings and some have not. These pests always group together, especially on those parts of plants shaded from direct sunlight.

Life cycle

Aphids reproduce in two ways: by laying eggs and having live young. Which birth process is used depends on environmental conditions and the availability of food. When food is plentiful, aphids give birth to live young. Populations develop

quickly as this pest has many young, a short lifespan and pre-adult insects can also give birth. Eggs hatch after three or four days. Young aphids, called nymphs, need five to eight days to become adults.

Damage symptoms

Direct damage: Aphids damage plants by puncturing them and sucking their juices. They damage the young and soft parts of plants, such as new leaves and shoots. Signs of damage are leaves not opening properly and being smaller in size. Severe infestation can cause shoots to wilt and dry out.

Indirect damage: Aphids have wings and can move from plant to plant spreading viral diseases, picked up from infected plants.

Aphids secrete a sugary liquid that stimulates black sooty mold growth. It can cover the surface of leaves which affects the way they absorb sunlight.

Management

Aphids have many natural enemies: parasitoids, predators and pathogens. Potential predators include ladybird beetles, both adult and grub and, syrphid larvae all of which are commonly found in potato fields not sprayed with insecticides. A common parasitoid is *Dieretella* spp, easily recognized by the presence of mummified aphids in the colony. Aphids can also be killed by fungal infections and dead aphids blanketed in a white powder (the spores of the fungus that has killed them) are often found in fields that are not sprayed with insecticides.

Observation methodology

It is best to observe aphids in the morning by opening new leaf shoots or observing the undersides of young leaves. Another way to detect their presence is by looking for ants on the potato plants as they feed on the sugars secreted by aphids.

2. Cutworm *Agrotis ipsilon*

Cutworms (*Agrotis* spp.) can be found in potato fields from when they are tilled up until crops are ready for harvesting. Cutworms not only damage potato plants, but also affect almost all types of plants including weeds.

Life cycle

Cutworms reproduce by laying eggs. Their life cycle includes eggs, larvae, pupae and moths. It takes up to 36 days for them to develop from eggs to adult insects. The various stages display the following characteristics:

- *Eggs* are laid on the surface of the soil, but are very difficult to see. On average, each female adult insect produces about 970 eggs, with a maximum of 2,370.
- *Larvae* live in the soil and are either yellow or blackish- green in color. They have striped markings running down the sides of their bodies. It is during this stage of their life cycle that cutworms affect potato plants.
- *Pupae* are brown, about 1.5 to 2.0 cm in length and are usually found in or on piles of leaf mould.
- *Adult insects* are black and white colored moths. They are not pests, as they feed on nectar.

Damage symptoms

These pests damage plants and tubers, especially after dark. They attack young plants by severing their stems, pulling all parts of the plant into the ground and devouring them. Plants with severed stems have difficulty growing again. This pest can cause serious damage; particularly when crops are at 25 – 35 DAP. Signs of damage on tubers are boreholes larger than those made by potato tuber moths.

Management: Management practices for this pest include:

- Collecting larvae when tilling soil, planting, weeding and hilling up. Any larvae collected should be destroyed by burning or fed to chickens. You can collect larvae by dismantling the soil around affected plants.
- *Attracting cutworm larvae using rice bran* – Heaps of rice bran should be placed in several places in the late afternoon. Cutworm larvae are attracted to rice bran (and vegetable residues, such as chopped cabbage leaves) and will usually come to eat them. They can be removed from the rice bran the following day and destroyed.
- *Bio-fumigation*- The use of bio-fumigation derived from brassica residues could be considered on soils heavily infested with cutworms.
- *Flooding field prior to planting*- Where/whenever possible farmers can consider temporarily flooding fields, particularly on severely infested fields.

Observation methodology

You can make observations in the morning, by looking for signs of cutworm damage and dismantling soil around affected plants. However, it is sometimes difficult to find the remains of affected plants as they are pulled into the ground. It is relatively easy to identify the larvae of the cutworm; when picked up, the caterpillar will curve itself in a characteristic C-shape.

3. Whitefly *Bemisia tabaci*

Whiteflies not only affect potato plants but also other vegetable and grain crops. This pest has never caused a potato crop to fail.

Life cycle

Their life cycle is divided into egg, pre-adult and adult stages. Generally, it is easy to find adult whiteflies in potato fields. They are small in size (1-2 mm long), have wide wings, are white in color and are usually found on the underside of leaves.

Damage symptoms

Whiteflies damage plants by sucking their juices. Affected leaves become weak and eventually dry out. Whiteflies secrete sugars that stimulate growth of black mold, which affects the way leaves absorb sunlight.

Management

Conserve natural enemies and avoid the use of insecticides. Insecticide use actually triggers the resurgence of this pest.

Observation methodology

You can observe white flies by looking at the undersides of leaves.

4. CATERPILLAR WORM *Sodoptera spp*

Adults are white moths ranging in size from 4 to 6 cm. Females lay eggs in groups on the leaves and pseudo-stem. Larvae are reddish brown and eventually migrate to fruit bunches, where they feed and then move to the soil to form the chrysalis.

Smaller larvae affect the fruit most eating outer part of the skin and leaving streamer-shaped scars. Generally the damage is not of economic importance.

Management recommendations:

Since larvae prefer eating suckers and sprouts, they should be managed appropriately to prevent pest population increases.

FRUIT FLY *Bactocera Spp*

Cultural Control and Sanitary Methods

One of the most effective control techniques against fruit flies in general is to wrap fruit, either in newspaper, a paper bag, or in the case of long/thin fruits, a polythene sleeve. This is a simple physical barrier to oviposition but it has to be applied well before the fruit is attacked. Little information is available on the attack time for most fruits but few *Bactrocera* spp. attack prior to ripening.



Chemical Control

Although cover sprays of entire crops are sometimes used, the use of bait sprays is both more economical and more environmentally acceptable. A bait spray consists of a suitable insecticide (e.g. malathion) mixed with a protein bait. Both males and females of fruit flies are attracted to protein sources emanating ammonia, and so insecticides can be applied to just a few spots in an orchard and the flies will be attracted to these spots. The protein most widely used is hydrolysed protein, but some supplies of this are acid hydrolysed and so highly phytotoxic. Smith and Nannan (1988) have developed a system using autolysed protein. In Malaysia this has been developed into a very effective commercial product derived from brewery waste.



SCALE INSECT:

Parlatoria sp

DAMAGE: Scale insects obtain food by sucking vital fluids from the host plant, causing yellowing and possibly stunted growth of the affected leaves or needles. A heavily infested plant will have extensive leaf yellowing, premature leaf drop, and possibly branch dieback. A plant weakened by a scale population is often more susceptible to damage by a secondary pest that may ultimately kill the plant. Although sooty mold growth does not damage the plant, it looks unsightly and in large amounts can interfere with photosynthesis, slowing plant growth.



with photosynthesis, slowing plant growth.

Management/Control

The best defense against severe scale infestations is to monitor landscape plants weekly throughout the year, paying close attention to the undersides of leaves and stems for scale, and avoid over-fertilization. Insects often lay more eggs and survive better on plants that are lush from heavy doses of nitrogen.

CHEMICAL CONTROL

Smothering scale insects by applications of horticultural oil is the easiest and often the most effective means of control. There are numerous types of oils, each with different temperature capabilities. There are some ultra light oils that can be used during the growing season, but it is critical to read the label carefully for guidelines on plant sensitivity and temperature restrictions. Most contact insecticides cannot penetrate the protective covering of the immobile scale nymphs and adults. Only the crawler stage is susceptible to contact insecticides. Systemic insecticides may provide control of soft scales, but is generally not effective for armored scales.

PEST MONITORING & SCOUTING

Following steps are involved for effective and comprehensive monitoring and scouting of Pests:

- **Scouting procedure**
 - The document title
 - Date and Name Field
 - A Map Key
 - More Fields
 - The document title
 - Date and Name Field
 - A Map Key
 - More Fields

- **Monitoring**
 - ✓ Monitoring Traps for banana aphids by using Yellow and Blue Sticky Traps.
 - ✓ Magnifiers & Scopes
 - ✓ Magnifying Glasses/Loupes
 - ✓ Stereoscopes
 - ✓ Weekly scouting and disease records
 - ✓ Scouting and record keeping

METHODS/TOOLS OF IPM (BIOLOGICAL, CULTURAL, CHEMICAL MECHANICAL CONTROL)

There is a wide variety of techniques that can be applied under IPM approaches. Applicability of individual techniques depends on various factors, including the crop, the cropping system, the pest problems, the climate, the agro-ecological conditions, etc. Generally, IPM involves a combination of techniques. Some examples of such techniques:

Cultural practices that can help prevent build up of pests

- Crop rotation
- Inter-cropping,
- Field sanitation and seed bed sanitation,
- Use of pest-resistant crop varieties,
- Managing sowing, planting or harvesting dates
- Water/irrigation management,
- Soil and nutrient management (including mulching, zero/low tillage, fertilizer management)
- Practices to enhance the buildup of naturally existing predator populations
- Hand-picking of pests or hand-weeding
- Use of traps or trap crops
- Post harvest loss prevention

Biological inputs

- Biological control through release of predators, parasites or pathogens
- Biological control through fish, ducks, geese, goats, etc.
- Release of sterile male insects
- Bio-pesticides
- Biological preparations (e.g. neem extract)

Chemical inputs

- Chemicals that disrupt insect behavior (e.g.: pheromones)
- Growth-regulators
- Conventional pesticides

S # METHODS-IPM**PRACTICES**

1	MECHANICAL	Trapping and collecting; mowing, chopping, crushing, and grinding plant residues, pests, and other forms; hand pulling and picking
2	CULTURAL	Use resistant varieties; rotate crops; chop stalks and dispose of refuse after harvest; tillage approaches; times for planting and harvesting; pruning and thinning with some crops; fertilizing based on crop needs; sanitation; water and runoff control; using trap crops
3	BIOLOGICAL	Using natural predators, such as beneficial insects; using parasites, such as bacteria; using genetically engineered crops; releasing sterile or incompatible pests
4	PHYSICAL	Using high and low temperatures; irradiation, particularly with seed and food grains; light traps
5	CHEMICAL	Poisons; growth regulators; attractants and repellants; sterilants
6	REGULATION	Quarantines; government-sponsored eradication and suppression programs

PROPOSED PEST SPECIFIC PESTICIDES FOR INTEGRATED PEST MANAGEMENT (IPM)

Pesticides can be classified or grouped in many different ways. Following are the key pesticides used for IPM.

S #	PESTICIDES	PEST CONTROLLED
1	Insecticide	INSECTS
2	Miticide	MITES
3	Acaricide	TICKS and SPIDERS
4	Molluscicides	SNAILS and SLUGS
5	Fungicide	FUNGI
6	Avicide	BIRDS
7	RODENTICIDE	Rodents
8	Nematicide	Nematodes
9	Bactericide	Bacteria
10	Herbicide	Weeds
11	Piscicide	Fishes
12	Predicide	Predatory Animals

USE OF BIOPESTICIDES

ORGANIC PESTICIDES-PLANTS PARTS

Bio-pesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals.

For example, canola oil and baking soda have pesticidal applications and are considered biopesticides.

At the end of 2001, there were approximately 195 registered bio-pesticide active ingredients and 780 products. Biopesticides fall into three major classes

- ✓ Microbial pesticides
- ✓ Plant-incorporated-protectants (PIPS)
- ✓ Biochemical pesticides

There are two level's of benefit for pesticide use

- Primary
- Secondary

➤ **Controlling pests and plant disease vectors**

- Improved crop/livestock yields
- Improved crop/livestock quality
- Invasive species controlled

➤ **Controlling human/livestock disease vectors and nuisance organisms**

- Human lives saved and suffering reduced
- Animal lives saved and suffering reduced
- Diseases contained geographically

CHEMICAL CONTROL

Smothering scale insects by applications of horticultural oil is the easiest and often the most effective means of control. There are numerous types of oils, each with different temperature capabilities. There are some ultra light oils that can be used during the growing season, but it is critical to read the label carefully for guidelines on plant sensitivity and temperature restrictions. Most contact insecticides cannot penetrate the protective covering of the immobile scale nymphs and adults. Only the crawler stage is susceptible to contact insecticides. Systemic insecticides may provide control of soft scales, but is generally not effective for armored scales.

ROLE OF BIOLOGICAL CONTROL OF INSECT PEST, IMPORTANT BENEFICIAL INSECTS (PARASITOIDS AND PREDATORS) AUGMENTATION AND CONSERVATION IN THE FIELD.

AUGMENTATION

In order to promote biological control practices it is imperative to enhance and augment the desired population of beneficial insects (Predator and Parasitoides) through the purchase and release of commercially available beneficial species. However, there has been relatively little research on releasing natural enemies in gardens and landscapes. Releases are unlikely to provide satisfactory pest control in most situations. Some marketed natural enemies are not effective. Praying mantids, often sold as egg cases, make fascinating pets. But mantids are cannibalistic and feed indiscriminately on pest and beneficial species. Releasing mantids does not control pests.

Only a few natural enemies can be effectively augmented in gardens and landscapes. These include entomophagous nematodes, predatory mites, and perhaps a few other species. For example, convergent lady beetles (*Hippodamia convergens*) purchased in bulk through mail order and released in very large numbers at intervals can temporarily control aphids; however, lady beetles purchased through retail outlets are unlikely to be sufficient in numbers and quality to provide control. Successful augmentation generally requires advanced planning, biological expertise, careful monitoring, optimal release timing, patience, and situations where certain levels of pests and damage can be tolerated. Desperate problems where pests or damage are already abundant are not good opportunities for augmentation.

CONSERVATION

Conservation of beneficial predators and parasitoids is key toll to promote biologically control practices. Most pests are attacked by several different types and species of natural enemies, and their conservation is the primary way to successfully use biological control. Ant control, habitat manipulation, and selective pesticide use are key conservation strategies.

PESTICIDES MANAGEMENT

Broad-spectrum pesticides often kill a higher proportion of predators and parasites than of the pest species they are applied to control. In addition to immediately killing natural enemies that are present (contact toxicity), many pesticides are persistent materials that leave residues that kill natural enemies that migrate in after spraying (residual toxicity). Residues often are toxic to natural enemies long after pests are no longer affected. Even if beneficial survive an application, low levels of pesticide residues can interfere with natural enemies' reproduction and their ability to locate and kill pests.

Biological control's importance often becomes apparent when broad-spectrum, persistent pesticides cause secondary pest outbreaks or pest resurgence. A [secondary outbreak](#) of a different species occurs when pesticides applied against a target pest kill natural enemies of other species, causing the formerly innocuous species to become pests. An example is the dramatic increase in spider mite populations that sometimes results after applying a carbamate (e.g., carbaryl or Sevin) or organophosphate (malathion) to control caterpillars or other pests.

Eliminate or reduce the use of broad-spectrum, persistent pesticides whenever possible. Carbamates, organophosphates, and pyrethroids are especially toxic to natural enemies. When pesticides are used, apply them in a selective manner. Treat only heavily infested spots instead of entire plants. Choose insecticides that are more specific in the types of invertebrates they kill, such as *Bacillus thuringiensis* (Bt) that kills only caterpillars that eat treated foliage. Rely on insecticides with little or no persistence, including insecticidal soap, horticultural or narrow-range oil, and pyrethrins.

A less-persistent pesticide can result in longer control of the pest in situations where biological control is important because the softer pesticide will not keep killing natural enemies. One soft pesticide spray plus natural enemies can be effective for longer than the application of one hard spray.

EXAMPLES OF BENEFICIAL INSECTS

S #	COMMON NAME	BENEFITS
1	Bees	Bees play key role in pollination of different plants
2	Butterflies	Butterflies are significant agent of pollination
3	Moths	These insects are highly beneficial in pollination
4	Flies	Flies are important agents of pollination and also play key role in the eco-system
5	Honey bees	Honey bees highly beneficial and produces honey and beeswax
6	Ants	Ants aerates soil
7	Lady bug beetles	It is important predator and prey on harmful insects
8	Mantids	It is important predator and prey on harmful insects
9	lacewings	It is important predator and prey on harmful insects
10	Silkworm moth	These insects cocoons provide silk fiber
11	Honey ants	human food
12	Flying ants	human food
13	Grasshopper	human food
14	Scarab beetles	These beetles are highly helpful in decomposing carrion (dead flesh), dung, and vegetation

COMMON NATURAL ENEMIES OF POTATO PESTS

Predators

1. **Ladybug**
2. **Ground and rove beetles**
3. **Hoverfly or Syrphids**
4. **Spider**
5. **Praying mantis**
6. **Earwig**
7. **Predatory fly**
8. **Other predators**

Other predators found in potato fields are dragonflies, crickets and red ants. These insects are highly abundant on potato crops that have not been sprayed with insecticides, and are suitably effective at controlling insect pest numbers. Predatory ability depends on the species and development stage of the predator and its prey.

Parasitoids

Parasitoids of leafminer fly

A. Hemiptarsenus varicornis

B. Opius sp.

C. Gronotoma sp.

Adult insects have black bodies and jointed antennae that look like beads. This insect solely parasitizes leafminer fly larvae. Parasitoid larvae live inside the bodies of leafminer fly larvae. Parasitized leafminer larvae can pupate, but will not develop into adult flies.

Parasitoids of other potato pests

Other parasitoids are found not only on leafminer flies, but also on other insect pests, such as aphids, cluster caterpillars, potato tuber moth larvae or cabbage looper larvae. The appearance of mummified aphids is a clear indication of the presence of the common parasitoid, *Dieretella* spp. Another way to determine whether parasitoids are present is to remove insect pest larvae from the field and keep them in an enclosure for several days. Observe what insects emerge, the insect pest or a parasitic wasp or fly.

Pathogens

Granulosis Virus (GV)

Bacillus thuringiensis (Bt)

Nematodes

Nematodes (tiny worms) can be a component in biological control as they can attack and kill pests. One insect susceptible to nematodes is the leafminer fly in its pre-adult and adult forms. Various species of nematodes, both those in the ground and on plants, can infect leafminer flies. They infect them by entering their bodies, growing inside them and eating their bodies from the inside. Affected flies will eventually die.

Fungal pathogens

There are many types of fungal pathogens that can infect insects. Some examples are *Beauveria bassiana* and *Metarhizium anisopliae*. Collecting diseased insects and observing their symptoms will provide a lot of information about these pathogens that can be developed as agents of control. Some commercial formulations are currently available on the market.

HAZARDS, SAFE AND EFFECTIVE USE OF PESTICIDES

1. {PESTICIDE – An Economic Poison} Any substance used for controlling, preventing, destroying, repelling or mitigating any pest. They include fungicides, herbicides, insecticides, nematocides, rodenticides, desiccants, defoliant or plant growth regulators.
2. Poison: A chemical substance which exerts an injurious effect in many cases in which it comes in contact with living organisms during normal use. Fatality from pesticides poisoning results only from accidents, ignorance, suicide or homicide.
3. FORMS: Emulsifiable Concentrates, Wettable Powders, Oil Solutions, Fogging Concentrates, Dusts, Aerosols, Granular, Fumigants, Impregnated materials, Baits.
4. Identify Pest Problem and justify need for Pesticide. Decide on what Pesticide is necessary, type, where available, dose, dilution, timing, frequency, method of application, precautionary measures, cost, confirm it is not in a banned list.
5. PURCHASE: Ensure correct product based on recommendation is purchased. Buy from reputable source, avoid fake products. Buy pack commensurate with usage rate. Watch out for expiry date. Avoid damaged, leaking packs or those without original labels or tampered seals. Keep pesticides away from passengers, livestock or foodstuff during transportation
6. STORAGE: Check label for recommended optimum storage conditions. Avoid overstocking, keep stock for just a season. Secure store to avoid unauthorized access and theft. Store pesticides according to different classes. Inspect store regularly to identify and remove damaged or expired products. Never store pesticides in living quarters or offices. Always keep pesticides in original containers.
7. CLASSIFICATION OF PESTICIDES: Products are classified according to their hazard levels. Toxicity values provide a guide to product toxic effect expressed as LD50, expressed as milligram (mg) of toxicants per kilogram body weight, the dose which kills 50% of the test animals to which it is administered under experimental conditions.
8. POISON ROUTES: Pesticides in both wet and dry state can enter our body via the skin, the respiratory organ and the mouth.

9. Entry via the Skin: 90% of cases worldwide. Concentrate penetrates skin more rapidly than water mixtures. Hands, arms and feet – the most likely contact zones. Wettable powders, granules or dusts less readily absorbed but sweat enhances skin penetration. Handling, decanting, mixing concentrates exposes operators to higher risk than actual application. Degree of hazard depends on dermal toxicity, extent of exposure, amount of body surface exposed, and part of the body exposed (eye versus palm), time lag between exposure and decontamination
10. Exposure through Inhalation: Through spray droplets or dust. Can cause damage to nose, throat and lung tissues. Vapours and aerosols with droplet sizes below 10 microns would reach lungs, 50-100 microns impact on the nasal lining. Higher risk when working in enclosed spaces, aerosol sprays in green houses, living and bed rooms, or when transferring volatile compound from one container to another. Product with fumigant action
11. Exposure through the Mouth: Less common in practice but serious consequences. Smoking, eating or drinking when mixing pesticides. Attempt to wipe off sweat from face with contaminated hand. Clearing spray nozzle by blowing them. Accidental touching the skin around the mouth when removing respirator or nose mask. Accidental contamination of foodstuff during transportation.
12. Measuring & Mixing: From label, select dose & rate & mixing instruction appropriate for area to be treated and application equipment to be used. Always adhere to recommended dose rates and dilutions. Higher doses would not produce better effects. Lower doses would be less effective. Concentrates which mix easily with water can be measured out and poured directly into sprayer tanks partly filled with water. Wettable powders are best pre-mixed (creamed) with a little water before pouring with spraying tank. Do not fill sprayer to the brim - may leak during use. Prepare only what would be used same day
13. Avoid skin contamination when mixing. Wear protective clothing as recommended. If contamination of skin occurs, wash off immediately using plenty of water. Splashes in the eye must be washed out with plenty of water for about 10 minutes. Do not measure out or mix pesticides in or near houses or where livestock are kept. Take care not to contaminate water supplies or puddles from which animals may drink. Use suitable equipment. Never scoop or stir pesticide with bare hands.
14. Use cleanest available water, filter out debris. Pour liquids carefully to avoid spillage and splashes – use a funnel if necessary. Never suck up any liquid

pesticide with a tube. Handle dust and wettable powders carefully to avoid fluffing up. Stand up-wind so that dust or splashes blow away. Wash all equipments after use. Throw washing water into a hole in the ground away from dwellings, wells, waterways and crops. Mixing vessels and measures for pesticides must never be used for any other purpose. Always keep pesticide in their original containers. Do not transfer into drink bottles or food container. Leftovers and unwanted concentrates should be tipped into a hole in the ground away from dwellings, wells, waterways & crops.

15. Disposal of Containers: All empty containers must be safely dealt with. Metal cans & drums – wash out, puncture & bury (Note: do not puncture aerosol cans). Plastic – Wash out, puncture, burn or bury. Cardboard packaging – burn. Burning must take place away from dwelling & crops. Do not stand in the smoke of such fires. Pesticide containers must not be reused or washed in streams, rivers or ponds. Do not use pesticide containers for food or drinking water for humans or animals because adequate cleansing is very difficult to achieve.
16. Pesticide use in the Field: Do not apply herbicide without adequate training. Never allow children to apply or be exposed to pesticides. Read and follow label instructions strictly. Do not allow workers into the field during application. Take heed of weather conditions particularly wind, avoid drift. Drift can render application ineffective as product is blown into non target area when it could also cause damage. Some products are easily washed by rain avoid application when rain is threatening.
17. Protective Clothing: A secondary line of defense, protective clothing as good as the way it is used – When an how to wear. The material it is made of the quality of maintenance it gets.
18. Types: The most essential items of protective clothing are : Boots – unlined made of rubber. Gloves, unlined made of nitrile or neoprene. Head cover, wide brimmed hat. When using UL formulations or when mixing. Respirator with filters – filters must be exchanged after about 8 hours of wear during operation (check with manufacturer’s recommendation). Overall: when wearing overall, the trouser legs should be put over the rubber boots to avoid drainage of pesticide into the boots.
19. Other protective clothing: Apron, PVC-Coated, nitrile or neoprene material Optimum Protection requirement for protective clothing
20. Symptoms of Pesticide Poisoning: Weakness and fatigue, Headache, Excessive sweat, Blurred vision, Vomiting, Muscle twitching, Dizziness, confusion, Extreme salivation, Difficulty with breathing, Itching and burning of the eyes,

Skin irritation, Narrow pin point pupils, Abdominal pain, diarrhea, Unconsciousness.

21. First Aid Management at Scene of Incident: Speed is essential do not wait for external help. Calmly and methodically avoid self contamination during treatment. According to the priorities of the patient: the highest priority is adequate breathing it must be maintained continuously, decontamination, terminate the exposure, remove person from scene avoid further skin contact and or inhalation, remove contaminated clothing quickly and completely.
22. Remove pesticide from skin, hair or eyes, wash with copious quantity of water for at least 10 to 15 minutes, do not look for special washing solution if no water is available dab or gently wipe skin with cloth or paper avoid harsh rubbing or scrubbing, keep patient calm and strictly at rest, place patient on his side with his head lower than the rest of the body and turn to one side, if patient is unconscious keep the chin pulled forward and the head back to ensure breathing take place, if patient is extremely hot and sweating excessively cool by using cold water sponging. If he feels cold cover with a blanket to maintain normal temperature
23. Induce vomiting ONLY if chemical swallow is highly toxic, likely to prove fatal and medical assistance not readily available. Induction of vomiting can only be carried out on conscious patient if considered necessary. Never give anything by mouth to an unconscious patient. If breathing stops (patients face or tongue may turn blue) pull chin forward to avoid tongue dropping into back of throat. If fits occur place padded material between teeth and avoid patient injuring himself. Do not forcibly restrain. Do not give milk.

HAZARDS, SAFE AND EFFECTIVE USE OF PESTICIDES

PLANT QUARANTINE

The Pakistan Plant Quarantine Act 1976 and Rules 1967 are enforced through which the country is protected from the entry and spread of exotic insect pests and disease and trade of plants and plant products is facilitated.

PESTICIDE REGISTRATION

Pesticides are regulated through the Agricultural Pesticides Ordinance 1971. The responsibility of registration / permission for import and quality control is executed through the Department of Plant Protection. Due to the efforts of the Department, the prices are not only contained but declined by 30-40% despite devaluation of Pak Rupee.

PERSONAL SAFETY MEASURES FOR HANDLING AND APPLICATION OF PESTICIDES

Personal protection equipment such as respirators, chemical resistant (CR) gloves, CR footwear, coveralls with long sleeves, protective eyewear, CR headgear, CR aprons and a first-aid kit should be available immediately outside the storage area. The first-aid kit should include the following items: adhesive strips, tape, eye pads, gauze bandages and tweezers. The phone number 800-222-1222 for the Poison Control Center should be posted in a prominent location.

It is essential that protective eyewear be worn during mixing/loading. The protective eyewear should consist of safety glasses that provide front, brow and temple protection, goggles or a face shield. Workers should be instructed in the correct procedure for the removal of contaminated clothing. Eye wash stations or portable eye wash bottles should be easily accessed by each person engaged in the operation and should be capable of flushing eyes for a minimum of fifteen minutes. At a minimum, a hose and nozzle should be on hand. Routine wash up facilities, equipped with soap, hand cleanser and single use paper towels should be available near the storage area.

PESTICIDES SPILLS AND OTHER ACCIDENTS

An absorbent material such as re-usable gelling agents, vermiculite, clay, pet litter or activated charcoal should be on hand along with a garbage can and shovel to quickly contain and clean up any spills. All discharges to the environment or spills should be recorded. The records should include the date and time of the incident and the cleanup. The Massachusetts Department of Agricultural Resources must be notified within 48 hours if a pesticide spill leads to pollution.

SITE SECURITY

The storage cabinets should be kept locked and the door to the storage area should contain a weather proof sign warning of the existence and danger of pesticides inside. The door should be kept locked. The sign should be visible at a distance of twenty five feet and can contain a notice such as:

DANGER PESTICIDE STORAGE AREA, ALL UNAUTHORIZED PERSONS KEEP OUT, KEEP DOORS LOCKED WHEN NOT IN USE

The sign should be posted in both English and the language or languages understood by workers if this is not English.

PESTICIDES DISPOSAL

Proper disposal of pesticides and their containers is an important phase of pesticide management. An improperly disposed product can be hazardous to people and the environment. Rinse liquid pesticide containers three times when emptied: fill the containers about one-third full and swish it around. Allow the containers to drain well between each rinse (30 or more seconds). The rinse material should be poured into a spray tank and applied to a registered site. Triple-rinsed containers are considered non-hazardous and should be disposed of according to state recommendations. Never reuse an empty pesticide container. If an empty triple-rinsed container cannot be disposed of immediately, store it in a safe, locked area. Before throwing out powders or granular pesticide containers, be sure to remove all contents from the containers.

PESTICIDES TRANSPORTATION

Depending on the hazard and the quantities of pesticides and hazardous materials (fertilizers, fuel, etc.) at a minimum the following checklist can be helpful for transporting pesticides:

- Driver is a licensed or certified pesticide applicator
- Inspect vehicle for leaks or other problems
- Pesticide containers secured in place
- Pesticide containers stored in a dry and lockable portion of the vehicle but not in the same compartment of driver
- Binder of pesticide labels and MSDS
- Emergency phone numbers
- First aid kit
- Fire Extinguishers
- Cleaning up supplies for spills (kitty litter, shovel, plastic bags, etc)
- PPE (gloves, goggles, coveralls, etc)
- At least 5 gallons of potable water for emergency eye or skin decontamination
- Obey all traffic laws and use signals