PAN Germany
Pestizid Aktions-Netzwerk e.V.

How to Grow Crops without Endosulfan

Field Guide

to Non-chemical Pest Management in

banana, cabbage and other crucifers , cassava, citrus, coffee, corn, cotton and other fiber crops, cowpea, eggplant, forage crops, forest trees, garlic, lettuce, mango, mungbean, onion, ornamentals, peanut, pepper, pigeon pea, oil crops, ornamentals, potato, rice, sesame, sorghum, soybean, squash and other cucurbits, string bean, sweet potato, tea, tomato, and wheat production

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Pesticide Action Network (PAN) Germany
Hamburg, 2008

Pesticide Action Network (PAN)

Founded in 1982, the Pesticide Action Network is an international coalition of over 600 citizens groups in more than 60 countries, working to oppose the misuse of pesticides and to promote sustainable agriculture and ecologically sound pest management.

PAN Germany was established in 1984 as part of this global network and has continually been involved in initiatives to reduce the use of hazardous pesticides and to promote sustainable pest management systems on national, European and global levels.

Acknowledgements

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We also wish to thank all the individuals, groups and organizations that have prepared the bases of the most control measures presented in this field guide, may it have been by preserving traditional experience, on field trials, on field research or in the lab.

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Table of contents

Prologue

Pesticides worth more than 30 billion US dollar are intentionally released into the global environment every year. Many of these are highly toxic and have immediate adverse effects on human health, wildlife, local food sources such as cattle or fish, beneficial insects and biodiversity. Several of them have chronic effects including cancers, reproductive problems, birth defects, hormonal disruption and damage to the immune system. Impacts come from direct exposure in use, spray drift, washing work clothes used while spraying, home pesticide storage, pesticide dumps, and persistence in the environment. One of these highly problematic pesticides is Endosulfan.

Endosulfan is an organochlorine insecticide. It is widely considered to be a persistent organic pollutant (POP). It is volatile and has the potential for long-range atmospheric transport. It therefore contaminates environments far from where it is used. And it is bioaccumulative. Residues of Endosulfan have been found in indoor air, rain, lakes, rivers, stream sediments, groundwater, well water, spring water, municipal water supplies, marine water and sediment, prawn ponds, lagoons, estuarine and river sediment, soil, tree bark, aquatic plants, fish, crocodile eggs, and other biota. They have been found in many countries. Residues have also been found in food around the world. They were found in dairy foods, meat, chicken, vegetable oil, peanuts, seeds, fruit, honey, rice, and many different vegetables. In Europe Endosulfan has been among those pesticides with the highest frequency of exceeding the maximum residue level allowed by the European Commission. Endosulfan is a leading cause of poisonings from pesticides. It has poisoned numerous people, livestock and wildlife. As an endocrine disruptor Endosulfan is threatening the reproductive capacity of living beings and it is increasing the risk of breast cancer. In some communities it has left a legacy of deformity and malfunction. Many cases of poisoning, including fatalities, have been reported - in Benin, Colombia, Costa Rica, Cuba, Guatemala, India, Indonesia, Malaysia, Philippines, South Africa, Sri Lanka, Sudan, Turkey, and USA. It is one of the main causative agents of acute poisoning in Central America, in southern India and other areas.

Pesticide Action Network (PAN) is working towards reducing the overall use and risks of pesticides as well as the dependence on pesticides and to increase support for community-based control over a sustainably produced food supply. PAN is committed, in its projects, strategies and campaigns to place pesticide concerns in the broad political and economic context in ways that will advance the fight against rural poverty and enhance pro-poor development and ethical trade. PAN aims to help local communities use the initiatives to benefit their day-to-day lives. One of the various activities of PAN to detox plant protection and pest management is to call for the global elimination of the use of Endosulfan and to provide information on alternatives to the use of this toxic pesticide.

PAN Germany is part of the international Pesticide Action Network. Being part of this alliance PAN Germany is working on the national, European and international level and is among others supporting non-chemical pest management on tropical crops that are commonly grown by small landholder farmers through the project Online Information Service for Non-chemical Pest Management in the Tropics (OISAT).

www.oisat.org is part of a web-based system to distribute information on non-chemical pest management in the tropics and sub-tropics that is scientifically based and at the same time easy to read. Information provided via www.oisat.org is relevant to small-scale farmers who intend to produce crops using safer and more affordable non-chemical pest management practices. It provides varied information on how to lower the costs of production based on recommended insect/mites pests, disease, and weeds control methods.

The content of this publication is based on the information provided at www.oisat.org. It enables to provide farmers with practical guides to avoid the use of Endosulfan. The recommended practices are scientifically based. Most of the farm practices described in this publication, the farmers can do by themselves. The materials needed can be found in the backyards of farmers or in their kitchens or can be purchased in the local agricultural suppliers.

By this publication we want to contribute to efforts to avoid harm to men and environment caused by the use of Endosulfan.

Carina Weber
(PAN Germany Program Director)

I. Introduction

For centuries, subsistence farmers have grown traditional crops for their food and income. They have used various methods to grow crops and to control the pests the natural way. However, with the pressing demands for higher yields and income to support their increasing family sizes and needs, farmers must look for options. Thus, the shift from the traditional farming system to the use of commercial synthetic pesticide takes place with the following reasons:

1. Farmers can not increase their cropping areas;
2. Potential food is lost because of the attack of insects and mites, diseases, nematodes, and rodents;
3. Synthetic pesticide is one of the most commonly accepted methods in pests' control because of the misconception that it is a medicine that cures and kills pests the fastest way;
4. Most of the governments' agricultural programs for increased production support the use of high yielding varieties and agrochemicals, like fertilizers and pesticides; and
5. There is a difficulty for extension services, GOs/NGOs, and farmers to get a comprehensive overview on alternative control/management methods, especially in a form, which can be integrated easily into extension training materials and applied by farmers.

Every year, an estimated of one to five million cases of pesticide poisonings occur that resulted in several thousand fatalities among agricultural workers. Most of these poisonings happen in the developing countries where safe health standards are inadequate or not implemented. Even though these countries use only approximately 25% of the global pesticide production, they account for a staggering 99% of the related deaths.

The vast majority of these poisoning cases involve farmers and farm workers who have the direct contact with these chemicals. Either farmers are directly applying pesticides on crops or working in fields where pesticides are used. They may be lacking of the appropriate clothing's to prevent the intake of pesticides and they may not be practicing the necessary precautionary measures while handling and preparing these solutions. In some instances, they may be wearing contaminated clothing throughout the day and may be eating and drinking contaminated food and water with their contaminated hands. Other family members, particularly children and infants, are also extremely susceptible to pesticide residues when the mothers bring their infants while doing weeding or harvesting and let the children help out with other farm activities where pesticides are used.

Endolsulfan is one of these synthetic chemicals. Endolsulfan was first introduced in the 1950s, commercially sold in several trade names but Thiodan is popularly used. It is a chlorinated hydrocarbon insecticide of the cyclodiene subgroup which acts as a contact poison in a wide variety if insects and mites (EXTOXNET, 1992). It is used to control aphids, thrips, beetles, foliar feeding larvae, borers, cutworms, bollworms, bugs, whiteflies, leaf-hoppers, termites, tsetse fly and non-insect pests like mites and slugs that are attacking on citrus and other fruit trees, vegetables, forage crops, oil crops, fiber crops, grains, cotton, tobacco, coffee, tea, forest trees, and ornamentals (Cornell University, 2004).

Endolsufan is a highly toxic substance (EXTOXNET, 1992) but is widely and indiscriminately used by subsistence farmers. There are strong evidences regarding its detrimental effects on

their health and the environment. It is an important cause of human, animal, and aquatic resources poisoning in many poor countries.

In 1991, several countries started issuing regulatory status of Endolsufan use. It is banned in Singapore, Cambodia, Belize, and is highly restricted in Southeast Asia, Korea, Russia, Canada, Denmark, Finland, Great Britain, Kuwait, and Netherlands (Macfarlane, 1999). Nevertheless, despite of all the restrictions, reports showed that Endosulfan is still widely used in the countries with the regulatory status (Weber, 1996).

With the increasing detrimental effects of synthetic chemical pesticides and the wide gap of the needed information at the field levels on the alternatives measures, there is a need for a mechanism that information on pest management practices will be in-placed and operational.

In January 2003, PAN Germany launched a project, 'Online Information Service for Non-chemical Pest Management in the Tropics', OISAT, with the aim of limiting the use of and dependence by the poor farmers on the hazardous pesticides, as well as the risk that may be incurred; and of providing them with safer alternatives.

OISAT has two components: *OISAT Info* and *OISAT PartnerNetwork*.

OISAT Info is a web-based information tool offering trainers, extension workers, and farmers a quick access to up-to-date information for their work and for organizing agricultural learning processes in order to minimize pest damage in a safer, more effective, and ecologically sound way. Its structure is based on the cropping season of the major crops, indicating key pests for each growth stage and plant part. Furthermore, detailed information is presented on preventive and curative pest management practices with the aim of providing basic and practical information for a holistic approach in pest management, which is both flexible and situation-specific. The descriptions contain illustrations, photographs, and clear advices, together with a glossary of technical terms.

The existence of OISAT *Info* on the internet is not effective enough to reach the farmers significantly. Therefore, PAN Germany is continuously seeking a partnership with carefully identified training and extension providers to whom *OISAT Info* is a potentially appropriate information tool. The resulting OISAT *PartnerNetwork* is a platform for information dissemination, information validation, exchange and feedback to the OISAT database. Through the integration of the online information into training and extension services, an effective and efficient information flow "From Web to Field to Web", will be ensured. The final aim is to make OISAT accessible to smallholder farmers and to offer them reliable solutions for their pest problems, which can be adopted by them. The feedback from the field will be stimulated through the OISAT *PartnerNetwork* to further expand and adapt the content and service of OISAT Info to the needs of its users in the field, leading to a significant adoption of the information provided.

OISAT was launched online 1st of July 2004 with the web address: www.oisat.org and with the E-mail address: oisat@pan-germany.org

The information of this handbook, "Pest Management Practices as Alternatives to Endosulfan and other Synthetic Pesticides", is mostly taken from OISAT *Info*.

II. General Pest Management Practices

Pest management is preventing, suppressing, or eradicating unwanted organisms such as insect pests, mites, snails and slugs, rodents, diseases, weeds, vertebrates, etc., that are causing problems to agricultural crops. The general pest management practices are classified according to the approaches or the methods used to deal a pest problem. The approaches used can either be prevention, suppression, or eradication of the problem pests. The methods can be chemical; cultural and physical; biological; and legal.

Since PAN Germany does not support the usage of synthetic chemical pesticides in pest management practices, it promotes the integration of approaches and methods that takes into consideration the environmental ecology and health and economic gains of the farmers.

The pest management methods - cultural and physical and biological (use of beneficial insects and plant extracts and other homemade solutions) - that are promoted by PAN Germany are well elaborated in each respective method.

III. Pest Management Methods

1. Cultural and physical methods

Cultural methods that aid in the prevention, suppression, or eradication of pests include; field sanitation; proper seed and variety selection; proper seedbed preparation; planting date; row spacing; seeding rate; fertilization; water management; crop rotation; planting of trap crops and hedge rows; companion planting; and intercropping, among others.

Physical or mechanical control includes proper land preparation; hoeing; weeding, bagging of fruits; baits and traps; row covers; mulching; handpicking; and pruning, among others.

Generally cultural practices contribute to the "belowground biodiversity" with the help of healthy and biologically actives soils. They contribute to "aboveground biodiversity" by providing a habitat for diverse natural enemies. Furthermore, cultural practices contribute to prevent, suppress, or eradicate pest build-up by disrupting the normal relationship between the pest and the host plant and thus make the pest less likely to survive, grow, or reproduce.

2. Biological control methods

2.1. Beneficial insects

The major categories of natural enemies are predators, parasitoids, pathogens and some vertebrates such as birds, snakes, etc. This publication focuses on the beneficial insects as part of the natural enemies in biological control.

Beneficial **insects** are divided into two groups - **predators** and **parasites**, like other natural enemies. A predator is an organism that during its development consumes several preys. A parasite is an organism that lives in or on the body of its **host** without killing the host but usually weakening the host to some extent. A parasitoid (also a parasite) is an organism that during its development lives inside or on the body of another host organism – and eventually killing its host.

The presence of beneficial insects is stimulated by various intercropping schemes, the integration of insectary plants, etc. By creating farming systems which are high in biodiversity, the self-regulatory mechanisms are increased and the system tends to be more "dynamically stable". This means that the variety of organisms provide more checks and balances on each other, which helps prevent one species (i.e., pest species) from building up a population level that causes economic damage.

To conserve the beneficial insect population is to plant crops that are producing nectars either as main crop, companion crops, intercrops, multiple crops, and along the hedges or along the farm peripheries. Modify the cropping practices by practicing crop rotation. Practice

mulching and other form of ground covers in some sections of your field to provide a habitat for the ground beetles and spiders. Provide permanent beds and perennial plantings to protect beneficials' population.

It is important to be able to identify the beneficials to those that are not. Weekly field monitoring or a visual inspection of plants is important to notice the presence of pests and beneficial insects in order to consider when to make pest management decisions.

2.2. Plants used in pest control and other homemade solutions

Curative pest management practices should be used in an integrated manner and consider potential side effects on human health, the environment, the sustainability of the agricultural system and the economy. A number of natural products can be used in curative pest management. Some general traits of plants used in pest control and other natural products include the following:

a) Fast breakdown. Plant extracts used for pest control degrade rapidly in sunlight, air, and moisture, and by detoxification enzymes. Rapid breakdown means less persistence and reduced risks to non-target organisms. However, precise timing and/or more frequent applications may be necessary.

b) Toxicity. Some plants in pest control are also used as medicinal plants, others may have low to moderate mammalian toxicity, and some are highly toxic (e.g., nicotine). They can express acute toxicity or cause chronic to sub-chronic effects on human health. Therefore, information on side effects and toxicity are important. During processing and application they should be handled with the same caution as synthetic pesticides. Plants in pest control are most effective when used in an integrated pest management (IPM) program, which includes sanitation, cultural practices, mechanical controls, use of resistant plant varieties, and biological control among others.

c) Selectivity. The rapid break down and fast action make botanicals more selective to certain plant-feeding pests and less harmful to beneficial insects.

d) Phytotoxicity. Most plants used in pest control are non-phytotoxic. However, insecticidal soaps, sulfur, and nicotine sulfate may be toxic to some vegetables or ornamentals.

e) Cost and Availability. Plants used in pest control tend to be more expensive than synthetics, and some are not produced in a great supply or are no longer commercially available (e.g., nicotine). The potency of some botanicals may vary from one source or batch to the next.

Plants used in pest control should ideally possess the following characteristics:

- Be effective at a rate of max. 3-5% plant material based on dry weight
- Be easy to grow and require little space and time for cultivation or procurement
- Recover quickly after the material is harvested
- Be perennial
- Not become a weed or a host to plant pathogens or insect pests
- Possess complementary economic uses
- Pose no hazard to non-target organisms, wildlife, humans or the environment
- Be easy to harvest; preparation should be simple, not too time-consuming or require too high a technical input
- Applications should not be phytotoxic or decrease the quality of a crop, e.g. taste or texture

When preparing the plant extract formulations and other homemade solutions, the following procedures MUST be observed:

- Select plants and/or plant parts that are pests-free.
- When storing the plants/plant parts for future usage, make sure that they are properly dried and are stored in an airy container (never use plastic container), away from direct sunlight and moisture. Make sure that they are free from molds before using them.
- Do not use cooking and drinking utensils for the extract preparation. Clean properly all the utensils every time after using them.
- Do not have a direct contact with the crude extract while in the process of the preparation and during the application.
- Make sure that you place the plant extract out of reach of children and house pets while leaving it overnight.
- Always test the plant extract formulation on a few infested plants first before going into large scale spraying.
- Wear protective clothing while applying the extract.
- Wash your hands after handling the plant extract.

III. 1. Cultural and physical control methods

Bagging of fruits

Bagging prevents insect pests, especially **fruit flies**, from finding and damaging the fruits. The bag provides physical protection from mechanical injuries (scars and scratches) and prevents female flies' laying activities, **latex** burns, and fungal spots on the fruits. Although laborious, it is cheaper, safer, easier to do, and gives you a more reliable estimate of your projected harvest.

How to make a bag?

1. Cut old newspapers measuring 15 x 22 cm or 12.5 x 27.5 cm for mango and for fruits of similar size.
2. Double the layers, as single layer breaks apart easily.
3. Fold and sew or staple the sides and bottom of the sheets to make a rectangular bag.

How to bag a fruit?

1. Blow in the bag to inflate it.
2. Remove some of the fruits, leaving 1 on each cluster.
3. Insert one fruit per bag then close the bag using coconut midrib or firmly tie top end of bag with string or wire.
4. Push the bottom of the bag upwards to prevent fruit from touching the bag.
5. Use a ladder to reach as much fruits as possible. Secure the ladder firmly on the ground and for bigger and higher fruits trees, secure or tie the ladder firmly on big branches.

Reminders

- Bagging works well with melon, bitter gourd, mango, guava, star fruit, and banana.
- Start bagging the mango fruit 55-60 days from flower bloom or when the fruits are about the size of a chicken egg.
- When using plastic bags, open the bottom or cut a few small holes to allow moisture to dry up. Moisture trapped in the plastic bags damage and/or promotes fungal and bacterial growth that caused diseased-fruits. Plastic also overheats the fruit.
- Bags made of dried plant leaves are good alternatives to plastic.

Remove the bags during harvest and disposed them properly.

Companion planting

Companion planting is the growing of diverse groups of crops.

Advantages

1. Giving off scent or chemicals that repels insects
2. attracting beneficial insects that are predators to harmful insects
3. Attracting insects that are pollinators for other plants
4. Attracting harmful insects and therefore distracting them from the main prize crop
5. Absorbing minerals from the soil so they can be ploughed back into the soil as fertiliser, for example, green manures
6. Fixing nitrogen in the soil to reduce the need for nitrogen fertiliser
7. Creating shade for lower-growing plants that do not thrive in full sun
8. Acting as a windbreak for more tender plants
9. Providing natural support for climbing plants
10. Acting as ground cover to prevent weeds

Table 1: An example list of companion crops	
Vegetable (main crop)	***Companion crops***
Cabbage	Aromatic herbs, Celery, Onion
Cassava	Cowpea, Canavalia, Crotalaria, Peanut,
Carrot	Lettuce, Rosemary, Onion, Garlic, Sage, Tomato, Medic
Corn	Irish Potato, Beans, English Pea, Pumpkin, Cucumber, Squash, Canavalia, Desmodium, Milinis grass
Eggplant	Beans, Marigold
Garlic	Basil, Beets, Cabbage, Carrots, Lettuce, Marigold
Pepper	Beans, Carrot, Marigold, Marjoram, Onion, Tansy
Onion	Basil, Beets, Cabbage, Carrots, Lettuce, Marigold
Potato	Corn, Barley, Buckwheat, Lupine, Peas, Radish, Sunflower, Tansy
Squash	Beans Corn
Tomato	Onion, Nasturtium, Marigold, Asparagus, Carrot, Parsley, Cucumber

Composting

Composting is the biological decomposition (rotting and decaying) of plant residues, farm animal manures, and kitchen scraps under controlled conditions. Once these materials are completely decayed, the end product is called compost. Compost is a decayed organic matter that is earthy, dark, and crumbly.

Pile or Heap Composting

What to prepare

1. A semi-shaded 3 ft x 3 ft area (90 cm x 90 cm)
2. Composting materials
   a) Green materials that are rich in nitrogen (freshly cut grasses, twigs, branches and barks that are cut into small pieces, kitchen scraps, farm animal manures)
   b) Brown materials that are rich in carbon (dried leaves, straws, cornstalks and other dried plant residues, and cut old newspapers
   c) Garden soil
   d) Water
3. Garden fork or shovel

Step by step procedure

1. Spread a layer of several inches thick (about 6 inches; 15 cm) of the brown materials on the surface soil. This is the first layer.
2. Add for the next layer, the green materials, about 6 inches thick (15 cm).
3. Top this with a thin layer of garden soil.
4. Sprinkle enough water to make the layers moist but not wet or soggy.
5. Repeat the steps 1 - 4, until your pile reaches the height of 3 feet (90 cm).
6. Turn the pile after 2 weeks to heat it up. Use a garden fork or shovel to turn the pile. To mix, move the decomposing materials at the middle towards the outside and the outside materials towards the center of the pile. Then you can mix it every 5-7 days, thereafter. If your compost has a strong odor, turn it more often as your is pile is tightly packed and is poorly aerated.
7. Ensure that the pile is heating up. When you first turned the pile, you may see steam rising from it. This signals decomposition. You can cover the pile to keep the heat in.
8. Add nothing to the pile once the composting process has begun.
9. The compost is finished when the pile is no longer heating up and the original materials turn earthy and black.

Pit Composting

What to prepare

1. Compost pit that is; 1-1.5 m length x 1-1.5 m width x 1 m deep
2. Composting material

   a) Green materials that are rich in nitrogen (freshly cut grasses, twigs, barks and branches cut into small pieces, kitchen scraps, farm animal manures)

   b) Brown materials that are rich in carbon (dried leaves, straws, cornstalks and other dried plant residues, and cut old newspapers

   c) Garden soil

   d) Wood ash

   e) Water
3. Long, sharp, pointed stick/s
4. Farm implements such as wheelbarrow, watering can, hoe, machete/bolo

Step by step procedure

1. Dig the compost pit in a semi-shaded and non-water logged area.
2. Place dry plant materials as the first layer. This should be about 20-25 cm thick. Sprinkle enough water to make the composting materials moist but not wet.
3. The next layer will be composed of green materials, either fresh or wilted grasses or weeds. Twigs and branches can also be added unless they are chopped into smaller pieces. This layer should also be 20-25 cm thick.
4. Top this with a mixture of animal manure, soil, and ash. This layer should be 10-15 cm thick.
5. Repeat the steps 1-3 until the pile reaches a height of 1 m. You make the pile thicker in the middle (than the sides) to create a dome-shaped pile. This makes turning the pile easier.
6. Place the stick/s vertically into the pile to allow the air to circulate into the various layers.
7. Cover the pit with broad leaves plants like banana leaves, taro leaves, etc.
8. Turn the pile every two weeks. The compost is ready after 3-4 months.

Tips for better composting

1. Keep the pile moist.
2. Keep the pile well-aerated.
3. Maintain a balance of the green and brown materials. Too much of one slows down decomposition. The best ratio is 1 part green to 1 part brown material. Shredding and chopping these materials into smaller pieces will help speed the composting process and increase the pile's surface area.
4. Do not add diseased plants, human wastes, cats and dogs feces as the harmful pathogens found in these waste products may not be killed in the process of decomposition.
5. Do not add matured weeds as their seeds may not be killed in the process of decomposition and may germinate once you use the compost in your field.

Uses of Compost

1. An excellent source of organic matter that has plenty of beneficial organisms.
2. Adds soil nutrients necessary for plant growth.
3. Improves plant growth.
4. Controls plant disease pathogens.
5. Controls soil borne pathogens.
6. Improves the soil condition and texture. It breaks up clay soil, helps sandy soil retains moisture, and relieves compaction.
7. Improves soil drainage.
8. Reduces soil erosion.
9. Helps rehabilitate infertile soils.
10. Makes the soil easy to cultivate.

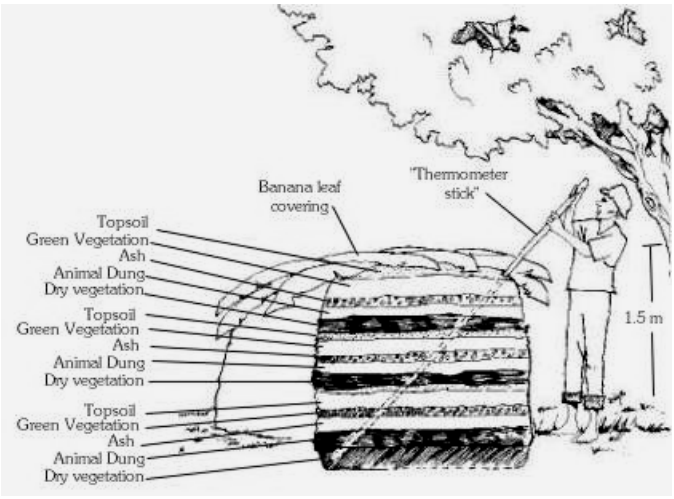


Photo source: Sustainable Agriculture Extension Manual

Crop rotation

Crop rotation is one of the oldest and most effective cultural control strategies. It means the planned order of specific crops planted on the same field. It also means that the succeeding crop belongs to a different family than the previous one. The planned rotation may vary from 2 or 3 year or longer period.

Some insect pests and disease-causing organisms are hosts' specific. For example, rice stem borer feeds mostly on rice. If you don't rotate rice with other crops belonging to a different family, the problem continues as food is always available to the pest. However, if you plant legume as the next crop, then corn, then beans, then bulbs, the insect pest will likely die due to absence of food.

Advantages of crop rotation

1. Prevents soil depletion
2. Maintains soil fertility
3. Reduces soil erosion
4. Controls insect/mite pests.
5. Reduces reliance on synthetic chemicals
6. Reduces the pests' build-up
7. Prevents diseases
8. Helps control weeds

Useful tips in planning crop rotation

1. Know the family where your crops belong to make sure that you plant on the next cropping a crop that belongs to a different family than the previous one.
2. Make a list of the crops you want to grow by also taken into consideration the market's demand of your produce. For example, plant leafy vegetable on the first cropping season, next fruit vegetables, then root crops, then legumes, then small grains
3. Grow legumes before grains or cereals
4. Practice green manuring
5. Always keep farm records

Crop rotation as a means to control to insect pests is most effective when the pests are present before the crop is planted have no wide range of host crops; attack only annual/biennial crops; and do not have the ability to fly from one field to another.

Table 2: An example list of crops that belong to the same family

Family	***Common names***
Allium	Chive, garlic, leek, onion, shallot
Cucurbit	Bitter gourd, bottle gourd, chayote, cucumber, ivy gourd, luffa gourd, melons, pumpkins, snake gourd, squash, wax gourd,
Crucifer	Bok choy (petchay), broccoli, Brussels sprouts, cabbage, Chinese cabbage, cauliflower, collard, kale, kohlrabi, mustard, radish, turnip, watercress
Legume	Common beans, black bean, broad bean (Fava), clover, cowpea, garbanzo, hyacinth bean, kidney bean, Lima bean, lintel, mungbean, peanut, pigeon pea, pinto bean, runner bean, snap pea, snow pea, soybean, string bean, white bean
Aster	Lettuce, artichoke
Solanaceous (Nightshade family)	Potato, tomato, pepper, eggplant
Grains and cereals	Corn, sorghum, rice, wheat, oat, barley, millet
Carrot family	Carrot, celery, dill, parsnip, parsley
Root crops	Cassava, sweet potato, taro, yam, water chestnut
Mallow family	Cotton, okra

Fruit fly traps

Jar trap

1. Make a paper funnel.
2. Place the paper funnel into a jar containing few amounts of fruit bait.
3. Place the jar trap wherever fruit flies are seen.

Fruit fly plastic bottle trap

Materials needed

- 1-liter plastic bottle
- 6 mm iron rod
- String
- Scissors
- Bait

Procedure

1. Heat the iron rod.
2. Make holes on the neck using the heated iron rod.
3. Make a hole on the lid, big enough for the string or wire to pass through.
4. Insert a string or wire at the lid's hole.
5. Place the bait inside the bottle.
6. Hung the trap in a shady part of the tree just above the lower leaves.
7. Replace the bait at least 2 times in a week. Fresh bait is often attractive to the flies.

Fruit fly baits

- Ripe banana peel cut into small pieces and mixed with sugar, flour, and water
- Mixture of 1 tsp vanilla essence, 2 tbsp ammonia, ½ cup sugar, and 2 liters water
- Mixture of 1 cup vinegar, 2 cups water, and 1 tbsp honey
- Mixture of sugar, soya sauce, and ammonia

Handpicking

Handpicking is an excellent method of controlling pests especially when only a few plants are infested. It is the easiest and direct way to kill the visible and slowly moving pests. By handpicking the adults before they have the chance to lay their eggs and by crashing the eggs before they hatch prevent the pests' build-up and the resulting damage.

Methods

1. Use an old soft brush or a used soft cotton cloth wetted with alcohol to remove aphids, scales, and mealybugs.
2. Run the infested plant surfaces in between your fingers to kill aphids.
3. Rub or scrape scales and mealybugs from plants.
4. Use a pointed wooden/bamboo stick to pick caterpillars. You can also use improvised tongs, pinchers, or tweezers.
5. Remove the infested leaves tunneled by leafminers. Early removal of the diseased leaves is also helpful to prevent disease transmission to the rests of the plants.
6. Handpick beetles and caterpillars and drown them in soapy water. Japanese beetles play dead when disturbed. Shake the plant onto an old newspaper for the easy collection. Chicken also feast on them.
7. To collect vine borers, make a lengthwise slit along the vine and get the borers out.
8. Attract rice bugs with baits, like crab or snail meat for easy collection.
9. To get snails and slugs, water the infested area in the late afternoon to let them crawl out in the evening. Use a lamp or flashlight to find them. Handpick and put them in a sealed container to feed on your chicken the following morning or drown them in soapy water. You can also crush them to die in the area where you fine them. For easy collection, place snail and slug baits.
10. Handpick cutworm at night. Use a lamp or flashlight to find them.
11. Handpick, crush, and kill insect pests with your bare hands.

Reminders

- Visit your plants daily or several times in a week to monitor the presence of pests. Careful observation leads to successful handpicking of the pests. Look out for the pests that fly or crawl into your garden and those that come out from the soil.
- Most of the insect pests blend nicely with the leaves. Make a thorough inspection with very observant eyes.
- Look also for the pests' possible hiding places, like under the plant debris and on the soil.
- Always inspect the underside of leaves. Remove the eggs, larvae, pupae, and adults that you come across.
- Know the beneficial insects and be able to identify them so that you will not kill them by mistake.
- You cannot completely get rid of the plant pests but you can reduce their population.

Light trap

Light trap is a device used at night in the field to collect moths and other flying insects such as:

1. Armyworm
2. Bugs
3. Cutworm
4. Flies
5. Gnats
6. Heliotis/Helicoverpa
7. Leafhoppers
8. Planthoppers
9. Stem borers

How to make a light trap?

a) Materials needed

1. Bamboo or wooden poles
2. String or rope
3. Nails
4. Oil/kerosene lamp or electric bulb
5. Shallow basin with water or jute sack

b) Procedure

1. Install the light trap near or within the field where you want to trap the flying insects.
2. Secure the poles firmly on the ground.
3. Mount the lamp or the bulb on the frame, five meters from the ground. When using electric bulb, make sure that the bulb and wiring are not in contact with water to avoid electrocution.
4. Place the shallow basin with soapy water or the jute sack underneath the light.
5. Put the light trap from early evening until early morning.
6. Collect the trapped insects daily and dispose them properly.

Mulching

Mulch is a protective layer of either organic or inorganic material that is spread on the topsoil to

- improve soil condition
- act as barrier against pests
- prevent rainfall and irrigation water from splashing soil borne pathogens onto the plants that cause plant diseases
- prevent weed growth
- provide home for earthworms and natural enemies found in the soil
- retain soil moisture
- reduce soil compaction from the impact of heavy rains
- maintain a more even soil temperature
- prevent soil erosion

Types of mulch

1. Organic mulch

Organic mulch helps improve the soil condition. It provides organic matter which helps keep the soil loose, as it slowly breaks down (decomposes). This improves the root growth, increases the infiltration of water, and also improves the soil water holding capacity. It is also a good source of plant nutrients and provides a better place for earthworms and other natural enemies found in the soil.

Organic mulch includes cut grasses, leaves, straws, hays, bark chips, animal manures, seaweeds, corncobs, pieces of corn stalks, coffee berry pulps, saw dusts, old newspapers

Amount to apply (thickness)

- 2-3 inches for cut grasses
- 2-4 inches for bark mulch and wood chips
- 3-4 inches for compost and mold leaves
- ¼ inch for sheets of old newspapers for the control of weeds and to prevent thrips from reaching the soil to pupate. Cover lightly with other mulch materials to prevent paper from flying.

2. Inorganic mulch

Inorganic mulch is made of colored aluminized plastic and aluminum foil. The reflection from the sun confuses and repels the flying insects from coming onto the plants.

To make you own reflective mulch, place strips of aluminum foil on both sides on the sown seeds or newly transplanted seedlings. Studies showed that red repels root maggots and other flies, orange on potato whiteflies, and blue reflection confuses winged aphids and thrips. Black plastic mulch discourages sawbugs and other crawling pests that cannot withstand the heat and keeps leafminers from emerging and prevents their return to the soil to pupate. However, you must do your own study as the pests from different regions react differently to various colors.

Pest controlled

1. Aphids
2. Colorado potato beetle

3. Leafminer
4. Potato tuber worm
5. Root maggots and other flies
6. Thrips
7. Whiteflies
8. Sawbugs and other crawling insects
9. Soil borne pests that include insects/mites, weeds, and diseases

Reminders

- When mulching trees and other perennials, place mulch 1-2 inches away from the trunks and or main stems.
- Monitor plants regularly to know the presence of slugs, snails, and mice. Mulch attracts these pests.
- When mulching to control weeds, apply mulch immediately after soil cultivation/preparation to prevent sunlight from reaching weed seeds and the migrating seeds to settle in.

Pheromone traps

How to make?

1. Make 10 to 12 holes into an old 1 liter plastic bottle or 3 holes on each side of 1 liter ice cream container, to allow moths to enter.
2. Heat a small piece of metal to make the holes easily.
3. Put a wire from the cover to suspend the bait.
4. Secure the pheromone dispenser align with the entrance holes inside the trap.
5. Make a rectangular opening into the lower part of the container for removing the moths caught.

How to use?

1. Half-fill the trap with soapy water.
2. Put bait in the pheromone dispenser or suspend the pheromone capsule from the lid using string or wire.
3. Close the container.
4. Attach the trap to a bamboo or wooden stake or hang on branch of a tree.
5. Place traps for different pests at least 3 meters apart. If traps are used for monitoring the pests, 2-3 traps are enough for 1 ha field.

Pests controlled

1. Cabbage looper
2. Cotton bollworm
3. Cotton boll weevil
4. Corn earworm
5. Diamondback moth
6. Fruitfly
7. Hornworm
8. Leaffolders

Reminders while using pheromone traps

1. Buy the pheromone that lures the pest you want to control.
2. Always label the trap. The name of the species you are trapping, the date the bait was placed, and the name of the bait if you are using several.
3. Change bait according to manufacturer's recommendation.
4. Dispose properly the bait wrappers. The tiny amount of pheromone left near the traps will compete with your bait.
5. Wash your hands between handling baits. Minute traces of other chemicals can render the baits completely ineffective.
6. Always remove all captured adults during each visit. Discard them away from the field. Put live ones into a bucket with soap solution to drown.

Pruning

Pruning is the selective removal of specific plant parts like shoots and branches but the roots, flower buds, fruits, and seed pods can also be pruned. Pruning done in a regular basis as part of plant care achieves the following:

- makes the plant less dense
- improves the air circulation and sunlight penetration that decrease the incidence of diseases and the conditions that promote fungal growth
- improves the plant's appearance and health
- gets rid of the pests infested parts
- allow the natural enemies to find their preys easily
- controls the size of a plant
- trains the young plants to become what you want them to be
- influences the plant's flowering and fruiting (proper pruning of flower buds encourages early vegetative growth)
- repairs and renews the appearance of old plants
- allows a better access for pest control

Pruning for pest control

1. Prune diseased, damaged, and/or dead plant parts. The prompt removal of these parts prevents the spread of the disease and speeds the formation of plant tissues that seal the wound.
2. Prune leaves with egg masses.
3. Prune insect/mite pests' infested tender shoot tips or any other parts where they are found in great numbers.
4. Prune webbed leaves.
5. Prune mined foliage.
6. Prune the crossing branches and those that are rubbing or interfering with each other.

Reminders

- Pruning is done best during dry weather as it minimizes the spread of the pathogens causing diseases.
- Always use sharp pruning tools to have clean and smooth cuts angled to shed water and absorb sunlight.
- Snap-off suckers with your hand while they are tender for least re-growth.
- Dip your pruning tools into container with 10% bleach solution and wash your hands in between pruning the diseased plants.
- After pruning, disinfect your pruning tools, rinse them with water, and oil all the metal parts to prevent from rusting.
- Ask for assistance from your local agriculturist for the proper pruning techniques on fruit trees.

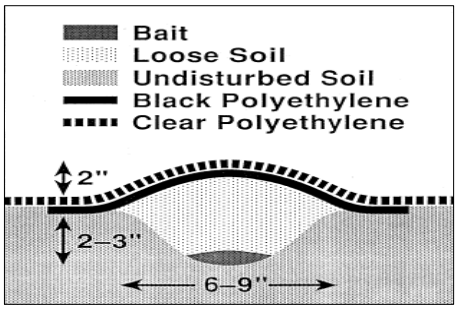
Soil baits

Corn/wheat seed mixture bait

1. Soak mixture in water for 24 hours to facilitate germination.
2. Make a hole of 12 cm wide by 30 cm deep.
3. Place 1/2 cup (of a 1:1 corn/wheat seed mixture) in a hole.
4. Cover with soil.
5. Cover the topsoil with plastic to warm the surface and to speed-up germination.
6. Cover the edges with soil to prevent wind from blowing away the plastic.
7. Remove the plastic, the soil cover, and the bait after one week.
8. Destroy and kill the larvae trapped in the baits. Feed larvae to chicken or put them in a pail of soapy water to drown.

Potatoes/carrots soil bait

1. Cut potatoes or carrots into chunks.



Source: Marlin Rice

2. Remove the potato 'eyes' to prevent from growing.
3. Make the pieces big enough and put in sticks.
4. Bury "staked potatoes/carrots" at a depth of 3-6 cm in the ground. The stick serves as the handle to easily pull the baits out.
5. Bury randomly in the field.
6. Leave baits in the soil for 2-3 days. Wireworm will feed on the baits.
7. Dispose properly the baits and the wireworm.

Pests controlled

1. White grub
2. Wireworm

Soil traps

1. Deep ditch

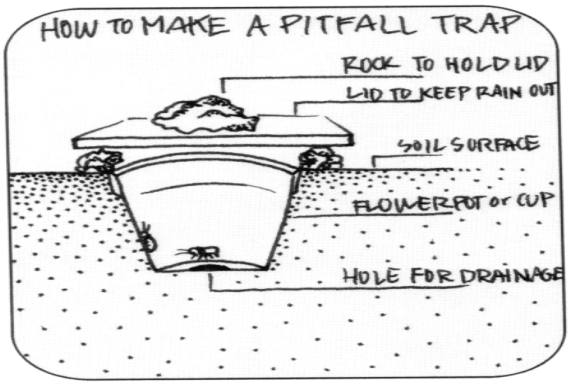
Plow a deep ditch and keep it filled with water, if larvae are found to be moving towards your field crops from adjacent fields. This will prevent larvae from transferring. They will drown if they try. Another method is to dig a deep ditch with vertical sides to trap larvae and prevent them from crawling out. Holes with a diameter of a fence post should be dug every 10 meters apart in the ditch. Larvae will congregate in the deeper holes where they maybe crushed (Scott, 2003).

2. Pitfall traps

Make pitfall traps. Pitfalls are the best means of collecting crawling insects.

3. Plastic

A small piece of plastic, slit to the middle, wrapped around the plant stem and overlapped, can be taped or covered with soil. Another method uses 2 pieces of plastic about 12 inches square, pulled together around the plant from opposite sides and held down with soil.



4. Protective collars

Protective collars made of plastic or paper cup, plastic drink bottles with torn-out bottom, sturdy cardboard, and milk cartons. Place the collar around the young plant and push into the soil to prevent the cutworm from attacking the stem.

5. Sticky substances

Molasses, saw dusts, or crushed eggshells are place around the base of each plant. When cutworm emerges to feed, it will come in contact with the trap, get stuck, harden, and die.

6. Tarpaper

A square of tarpaper (or other heavy, flexible paper) measuring 9-12 cm wide placed at the base of each transplant will prevent adult flies to lay eggs near the plant. Make a cut from the edge to the center making a small hole (in the center). Make sure that the paper will fit around the stem but will lie flat on the ground. During transplanting, place the disc on the soil around each plant so that the stem is in the middle of the disc.

7. Yellow pan traps

Fill half the yellow pan or basin with soapy water. Place the pan close to the plant but expose enough that moth can see it. Trapped moths sink and drown because soap breaks the surface tension of the water.

Sticky board trap

Flying insects are attracted to bright yellow, blue, and white colors. Traps, consisting of square pieces of cardboard or hard plastic coated with sticky substances placed throughout the growing area among the plants, attract them. Strips of yellow or blue sticky plastic can also be used around or inside the growing ranges. The procedure on how to prepare a sticky card is from eHow. (Source: eHow. How to make your own yellow sticky traps. http://www.ehow.com/how_9839_make-own-yellow.html)

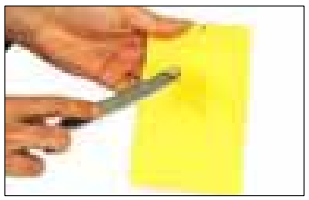
How to make?

1. Cut plywood or sturdy cardboards, 3 inches wide x 5-7 inches long.
2. Make experimentations on the sizes and forms of your board traps.
3. Paint boards with yellow or blue or white depending on the pests you want to monitor and trap

How to use?

1. Fasten boards to stakes with nails or staples or papers clips or hang them from wire supports.

2. Spread used-motor oil, or plant resin, or mustard, or vegetable oil, or petroleum jelly directly on your board. Leave a small space uncoated for easy handling.



3. Place traps near the plants, preferably 25 cm away from the plant to ensure that the leaves will not stick to the board, but not facing direct sunlight.

4. Hang and position the traps at 50-75 cm zone above the plants.
5. As a general rule, place 1 to 2 sticky cards per 100 square meter growing area. Replace traps at least once a week. It is difficult to determine the population of newly trapped flies/moths on a sticky card to those previously trapped ones.

Pests monitored and controlled

Yellow sticky traps

Bright yellow sticky traps are used for monitoring/controlling of the following pests:

1. Aphids
2. Cabbage root maggot
3. Carrot rust fly
4. Cabbage white butterfly
5. Cucumber beetle
6. Fungus gnat
7. Onion fly
8. Thrips
9. Whiteflies

Blue sticky traps

Bright blue traps are for monitoring thrips.

White sticky traps

Bright white traps are for monitoring flea beetles and tarnished plant bugs.

Trap cropping

Trap cropping is the planting of a trap crop to protect the main cash crop from a certain pest or several pests. The trap crop can be from the same or different family group, than that of the main crop, as long as it is more attractive to the pest. There are two types of planting the trap crops; perimeter trap cropping and row intercropping. Perimeter trap cropping is the planting of trap crop completely surrounding the main cash crop. It prevents a pest attack that comes from all sides of the field. It works best on pests that are found near the borderline of the farm. Row intercropping is the planting of the trap crop in alternating rows within the main crop.

Advantages of trap cropping

1. Lessens the use of pesticide
2. Lowers the pesticide cost
3. Preserves the indigenous natural enemies
4. Improves the crop's quality
5. Helps conserve the soil and the environment

Table 3: Examples of trap cropping practices			
Trap crop	***Main crop***	***Method of planting***	***Pest controlled***
Alfalfa	**Cotton**	Strip intercrop	Lygus bug
Basil and marigold	**Garlic**	Border crops	Thrips
Castor plant	**Cotton**	Border crop	Bollworm
Chinese cabbage, mustard, and radish	**Cabbage**	Planted in every 15 rows of cabbage	Cabbage webworm, flea hopper, and mustard aphid
Beans and other legumes	**Corn**	Row intercrop	Leafhopper, leaf beetles, stalk borer, and fall armyworm
Chick pea	**Cotton**	Block trap crop at 20 plants/ sq m (Brown, 2002)	Bollworm
Collards	**Cabbage**	Border crop	Diamondback moth
Corn	**Cotton**	Row intercrop, planted in every 20 rows of cotton or every 10-15 m	Bollworm
Cowpea	**Cotton**	Row intercrop in every 5 rows of cotton	Bollworm
Dill and lovage	**Tomato**	Row intercrop	Tomato hornworm
Horse radish	**Potato**	Intercrop	Colorado potato beetle
Hot cherry pepper	**Bell pepper**	Border crop	Pepper maggot
Indian mustard	**Cabbage**	Strip intercrop in between cabbage plots	Cabbage head caterpillar
Medic, Medicago litoralis	**Carrot**	Strip intercrop in between carrot plots	Carrot root fly
Okra	**Cotton**	Border crop	Flower cotton weevil
Onion and garlic	**Carrot**	Border crops or barrier crops in between plots	Carrot root fly
Napier grass	**Corn**	Border crop	Corn stem borer
Sesbania	**Soybean**	Row intercrop at a distance of 15 m apart	Stink bug
Sunflower	**Cotton**	Row intercrop in every 5 rows of cotton	Bollworm
Sudan grass	**Corn**	Border crop	Corn stem borer
Tansy	**Potato**	Intercrop	Colorado potato beetle
Tobacco	**Cotton**	Row intercrop, planted in every 20 rows of cotton	Bollworm
Tomato	**Cabbage**	Intercrop (Tomato is planted 2 weeks ahead)	Diamondback moth
Soybean	**Corn**	Row intercrop	Corn earworm
Sickle pod	**Soybean**	Strip intercrop	Velvet bean caterpillar, green stink bug
Rye	**Soybean**	Row intercrop	Corn seedling maggot
Green beans	**Soybean**	Row intercrop	Mexican bean beetle

Tips for successful trap cropping

- Make a farm plan. This will guide you on where the trap crops are to be sown or planted.
- Learn to know and identify the pests.
- Select a trap crop that is more attractive to the pest than the main crop.
- Monitor your plants regularly.
- Immediately control the pests that are found in the trap crop. Prune or remove the trap crops once the pest population is high, otherwise they will serve as the breeding ground and the pests will attack the rest of your farm.
- Be ready to sacrifice your trap crop as an early crop and destroy them once pest infestation is high.
- Always keep farm records.

III. 2. Biological control

III. 2. 1. Beneficial insects

Braconid

Common Name
Bracon

Scientific name
Bracon spp.

Type
Eggs, larvae, pupae, and adult parasitoid

Hosts
Ants, aphids, armyworms, beetle's larvae, bollworms, cabbageworms, caterpillars, codling moths, corn borers, cutworms, imported tent caterpillars, leafhoppers, leafminers, maggots, midges, plant bugs, scales, tomato hornworms, weevils

Description

Eggs and larvae of Bracons are found inside the hosts' bodies.

The larvae are tiny, cream-colored grubs that feed in or on other insects. Larvae molt five times and undergo 5 **instars**.

Pupae of some **species** live and pupate within the host until they mature; others pupate in silken cocoons on the outside of the body of the host, while others spin silken **cocoons** away from the host.

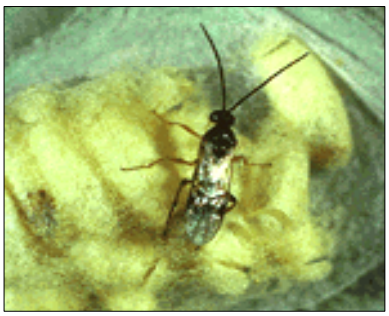
Adult wasps are tiny, about 2.5 mm in size, slender black or brown with threadlike waists. Female wasps lay eggs into the eggs of hosts' pests but prefer caterpillars' bodies.

In cases where aphids are the host pests, aphids are not killed instantly. Aphids continue to feed on plants tissues until the Braconid larvae inside their bodies completely consume them. The fully-grown Braconid larvae cement the dead aphids to the leaf surface making aphids' shells black and mummified. About a week later, the adult Bracon wasps cut round holes in the **mummies** and emerge. The empty mummies remain on the leaf. The presence of mummies in a colony of aphids is a sign that Bracons are present.

Cotesia

Common Name Cotesia wasp, Cotesia

Scientific name
Cotesia spp.



Type
Larva parasitiods

Hosts
Armyworm, bollworm, cabbage looper, cabbageworm, celery looper, corn earworm, cutworm, diamondback moth, gypsy moth, hornworm, stem borer, tobacco budworm, webworm

Description

Eggs are ovate, clear, and shiny and increase in size after they are laid. They hatch 2 days later.

The first instar parasitoid larvae begin feeding internally after 3-4 days. The immature parasitoids develop through three larval instars in the host body, and then emerge from the host by chewing through the skin. After emergence from the host, the last instar larvae immediately spin cocoons and pupate.

Pupae vary according to species; some are either in an irregular mass of yellow silken cocoons attached to the host larva or to plant leaves, and some in white cocoon, about a size of rice grain. The cocoons are usually found inside host feeding tunnels in

leguminous plants. Pupation takes 4-6 days after which adults emerge.

Adults are small wasps, about 3-7mm in length. They are dark-colored and look like flying ants or tiny flies. They have two pairs of wings and chewing-lapping mouthparts. They have curved antennae, the males having much shorter antennae than the females. A female abdomen has a downward curve extension, called the ovipositor- with which she lays her eggs. The adult female looks for hosts in leaves and in tunnels of crops. Some species lay about 15-65 eggs in the body cavity of the host while some lay a single egg. A single wasp can parasitize 200-300 host caterpillars during its 10 to 14-day life. The life cycle, from egg to adult, is approximately 15-30 days, depending on the species and the temperature.

Damsel bug

Common Name Nabids

Scientific name *Nabis ferus, N. aternatus, N. capsiformis*

Type

Generalist predator

Hosts

Aphids, armyworms, asparagus beetle, Colorado potato beetle eggs and nymphs, corn earworm, corn borer, imported cabbageworm, leafhoppers, mites, moth eggs, sawfly larvae, and tarnished plant bug nymphs. Although they can survive for about two weeks without food, they will eat each other if no other prey is available.

Description

Eggs are deposited in soft plant tissues where they are so difficult to find. Nymphs resemble adults and develop through 5 nymphal stages in about 50 days.

Adults are tiny, about 2-4 mm long, with slender bodies and are yellowish or gray or reddish-brown in color. They have piercing-sucking mouthparts, a 4-segmented beak, elongated heads, and 4 long segmented antennae. They are fast runners with long slender back legs and enlarged forelegs for grasping prey. They are commonly found in most agricultural crops, especially legumes, throughout the year. Adults begin laying eggs soon after emergence.

Damsel fly

Common Name Bog dancer, Damselfly, Damsel, Narrow wing

Scientific name *Agriocnemis femina femina, A. pygmaea*

Type Generalist predator

Hosts

Leafhoppers, moths and butterflies, plant hoppers (Shepard; Barrion; Litsinger, 1987: p. 127)

Description

Eggs are laid in emerging plants, in floating vegetation, or directly in the water. The hatched eggs do not go through the larval and pupal stages.

A naiad (nymph of damselfly) lives in water, has an elongated body, long legs, and three leaf-like appendages or gills on its tail. These appendages are used for oxygen transport. A naiad molts several times before emerging. At this stage, naiads are very good predators. They prey aquatic insects and other arthropods within their reach. They grab their prey with their modified lower jaw. At the last stage, a naiad swims out of the water and clings to a plant to dry its skin. After a few minutes of drying in the sun, its outer skin splits open at the head and the adult damselfly strains to pull itself out of its old skin. The new legs harden to hold onto the plant. Its wings slowly expand and are pumped open by fluid from its abdomen.

An adult damselfly has a long thin body which is green, blue, red, yellow, black, or brown and is often brightly colored. It has an oblong head with bulging eyes and very short antennae. When resting, it holds its four large membranous wings of nearly equal size vertically rather than horizontally. It is a delicate and weak-flying insect. Its wings are usually clear except for a spot at the end of the wing called a stigma. The male sex organ is located at the front part of the abdomen. Damselflies commonly fly in pairs during mating. Damselfly adults use their hind legs, which are covered with hairs to capture prey as they fly. They hold the prey in their legs and devour it by chewing. Adults are usually found flying near plants, usually in irrigated rice fields during the daytime throughout the year.

The damselfly's mating pattern is unusual. The male deposits sperm by bending the abdomen forward and then clasping the female behind the head with its

claspers on the tip of his abdomen. The female then loops her abdomen forward and picks up the sperm from the male. The mating pairs are seen flying and clinging in tandem. Most species have one generation per year depending on the species, although they complete their life cycle from 1-2 years.

Diadegma

Common Name Diadegma wasp, Diadegma

Scientific name *Diadegma semiclausum, D.insulare, D. mollipla, D. fenestral*

Type Larva parasitioids

Hosts

Cabbage diamondback moth, potato tuber moth, cabbage webworm

Description

The egg is found inside the body of the host larva - where the larva is then hatched.

It eats the contents of the host larva. After the host larva spins its cocoon, the Diadegma larva eventually kills it and spins its own cocoon inside that of the host. The Diadegma kills its host only at the stage when the host larva stops feeding and starts to pupate. The pupa is the black colored developing wasp which can be seen inside the cocoon, in place of the light colored diamondback moth pupa.

The adult Diadegma wasps are very small about 6 mm to 1 cm long. They are found in cruciferous crops and herbaceous plants. Their population is dependent on the population of their hosts. They are the most important natural enemies of DBM and can parasitize up to 90% of their larvae. They can parasitize both exposed and hidden larvae as some species have short ovipositors while others have long ones that can reach hidden larvae. The total development period from egg to adult is about 2-3 weeks under temperate conditions (Philippine German Plant Protection Project, 1996: pp. 1-17).

The following practices are suggested when introducing Diadegma in the field:

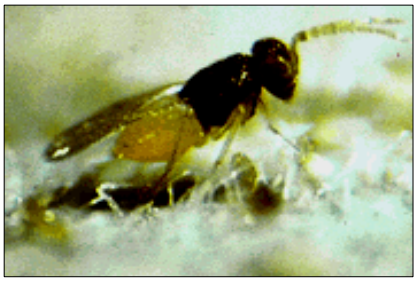
1. Make sure that the field environment is pesticide-free.
2. Release Diadegma wasps at their adult stage at a ratio of 200 females to 100 males or an optimal sex ratio of 2 females to 1 male. The presence of too many males disturbs the females, which in turn affects their reproductive behavior.
3. 300 per release is the recommended number to avoid an overcrowded population. The female has the tendency to lay unfertilized eggs or more male offspring once there is an overpopulation.
4. Releases should be done at weekly intervals for at least 5 times, good enough for the insects to be well-established.
5. The temperature should be low enough; about 18-25 degrees C, and field location should be 600 m or more above sea level, to allow them to reproduce successfully.
6. Monitor insect parasitism regularly. Black cocoons mean a parasitized DBM larva or Diadegma wasp is developing inside the cocoon (Philippine German Plant Protection Project, 1996: pp. 1-17).

The introduction of Diadegma wasps into the field is to reduce the DBM population to a level below the economic threshold and to establish Diadegma as an integral part of the local insect fauna. It takes about ½ - 1 year to build-up its population naturally in Brassica fields (Fitton; Walker, 1992).

Encarsia

Common Name Encarsia, Whitefly parasite

Scientific name *Encarsia spp.*



Type Larva parasitoids

Hosts Various whitefly species

Description

Eggs are found inside the body of the host larva.

The larvae develop within the whitefly larvae passing through four larval stages. The host pupa turns black when Encarsia pupates inside the whitefly. Adult wasps emerge from the parasitized pupae by chewing a hole in the top of the scale.

Adults are very tiny wasps, about 1 mm in size. These parasitic wasps can look actively and effectively for whiteflies. They can cover distances of 10-30 m looking for hosts. Adult females attack young whitefly larvae by stinging and laying eggs inside them. An adult female wasp can lay 60-100 eggs. The life cycle is completed within 2-4 weeks depending on the climatic conditions. Adults can live for 30 days but are active for about 10 days.

Adult wasps feed on honeydew and the body fluids of whitefly larvae. They also feed directly on the scales.

However, honeydew restricts their movements so that it is difficult for them to have a wider feeding coverage.

With the exception of the adult, all stages of Encarsia occur inside the whitefly host.

Ground beetle

Common name Carabid

Scientific name *Calosoma spp., Cicindela spp., Megacephala spp.*

Type

Generalist predator

Hosts

Cabbage root maggots, cutworms, snails, slugs, leaffolder and planthoppers larvae

Description

Eggs are normally laid singly in the soil.

Larva is elongated and tapered toward the end, worm-like in appearance and have a large head directed forward.

Pupa is brownish black, small and found in the soil.

Adult ground beetles or Carabids are about 2-6 cm long, dark shiny brown to metallic black, blue, green, purple, or multi-colored. They vary in shapes,- from elongated to heavy-bodied, - tapered head end with threadlike antennae, and have a ringed wing cover. Some species do not use their wings however, like many other insects they are also attracted to light. They use their wings to fly at night to be near to the source of light. Their heads are usually smaller than their thorax. Both adults and larvae have strong pincher-like mandibles. They have prominent long legs, which make them fast moving insects.

Most species are nocturnal and they hide during the day in soil crevices, under rocks and stones, decaying logs, leaf litter, or composting materials. When disturbed or when other vertebrates prey upon them, they emit an odor or gas, as a type of defense mechanism, preventing them from being eaten by other predators. Ground beetles live on or below the ground, hence the name. Development from the egg to the adult stage takes about a year, although adults may live 2 to 3 years or longer.

Hoverfly

Common name Flower fly, Syrphid fly, Syrphidae

Scientific name *Eristalis spp., Volucella spp.*

Hoverfly larvae eating aphids

Type

Generalist predator

Hosts

Aphids, thrips, psyllids, scale insects, small caterpillars, and larvae of Heliotes

Description

Eggs are tiny, about 1mm in size, ovate-shaped, and glistening-white. These are found laid singly and close to the developing aphid colony in the leaves, shoots, or stems of the plants. They hatch within 2-3 days.

The larvae, known as Syrphids, are legless slug like maggots, about 1-13 mm in length depending on their larval stages. They usually have a mottled-gray, beige, or light-green color. They lift their pointed heads to look for preys. Once preys are located, their mouth-parts suck out the contents of the preys. Larvae are frequently found feeding on aphids in the sheltered and curled portion of leaves. They blend well with their habitat and therefore they must be looked for closely to locate them.

Pupae are teardrops shaped and are found in the soil surface or in the plant's foliage.

Adult hoverflies are true flies with only two wings instead of four which most insects have. Adults are large and beautiful insects about 13 mm long. They have a dark head, a dark thorax, and a banded yellow and black abdomen. They closely resemble bees or wasps rather than flies. Their habit of hovering like humming birds gave them the names hoverflies or flower flies. They are expert hoverers, able to remain absolutely stationary in midair. In some species, males will hover in certain spots to attract the attention of females while other species patrol a wider area of up to 100 yards to feed and mate. They dart from flower to flower making them easy to distinguish from the bees and wasps. They feed on pollen, nectar, and honeydew. They are good pollinators.

Lacewing

Common name Brown lacewing, Green lacewing, Aphid lion

Scientific name *Chrysoperla carnea, Chrysopa rufilabris*

Type

Generalist predator

Hosts

Aphids, leafminer, mealybugs, thrips, whitefly (Ellis; Bradley, 1996: p. 449), armyworms, bollworms, cabbage worm, codling moths, corn borer, cutworm, DBM, fruitworm, leafhopper nymphs and eggs, potato beetle, scale insects, spider mites, and caterpillars of most pest moths. If given the chance, they can also prey on adult pests.

Description

Eggs are found on slender stalks or on the underside of leaves. Each egg is attached to the top of a hair-like filament. Eggs are pale green in color.

Larvae are known as aphid lions. Newly hatched, they are grayish-brown in color. Upon emerging, larvae immediately look for food. They grow to about 1 cm in length. They attack their prey by taking them with their large sucking jaws and injecting paralyzing poison, and then sucking out the body fluids of the pest. A larva can eat 200 or more pests or pest eggs a week. An older larva can consume 30-50 aphids per day. It can consume more than 400 aphids during its development. The larvae resemble alligators with pincers like jaw. However, they become cannibalistic if no other prey is available. They feed for 3 to 4 weeks and molt three times before pupation. They cover their bodies with prey debris.

Pupae are cocoons with silken threads. These are found in cracks and crevices. The pupal stage lasts for approximately 5 days.

Adults are green to yellowish-green with four, delicate transparent wings that have many veins and cross veins. Adults are about 18 mm long, with long hair-like antennae and red-gold eyes. Each adult female may deposit more than 100 eggs. Many species of adult lacewings do not prey on pests. They feed on nectar, pollen, and honeydew. An adult will live for about four to six weeks depending on the climatic conditions.

Ladybird beetles

Common name Ladybird beetles, Ladybugs, Lady beetles, Coccinellid, Coccinellid beetles

Scientific name *Harmonia conformis, H. axyridis, Hippodamia convegens*

Type

Generalist predators ´

Hosts

Aphids, leaffolders, leafhoppers, mealybugs, planthoppers, scales, spider mites, whiteflies, and other leaf feeding insects.

Description

Eggs are yellow to orange in color, football-shaped, and are laid in circular clusters of 10 -50 eggs on the underside of leaves or near the aphid colony. Newly hatched larvae are gray or black and less than 4 mm long. They emerge as dark alligator-like flightless creatures with orange spots. Adult larvae can be gray, black, or blue with bright yellow or orange markings on the body. They are usually patterned with colors similar to their parents, and many are adorned with spines. They have long sharp mandibles and feed on small insects like their adults. The larvae are elongate and slightly oblong in shape. They undergo four instars before pupating.

The pupae are usually brightly patterned and can be found attached to the leaves and stems of plants where larvae have fed and developed.

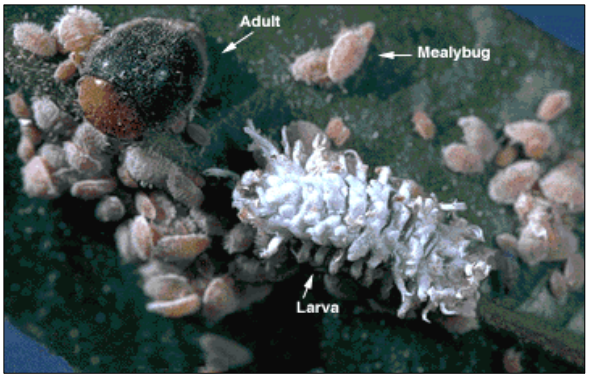
Adults are oval to hemispherical and strongly convex with short legs and antennae. Most species are brightly colored. Body length ranges from 0.8-16 mm. Their colors tell other predators that they are tasteless and toxic. When disturbed, some of them emit a strong smelling yellow liquid as a protection against other predators. Their colors vary from red, orange, steel blue, yellow brown, or yellow **elytra**, frequently spotted or striped with black. They feed on pollen, nectar, water, and honeydew but aphids or other prey are necessary for egg production. They are the best-known predators of aphids and are capable of eating up to 50-60 per day and about 5000 aphids in their lifetime.

Many species are well-known for their use in biological control, and have been distributed to various parts of

the world to combat insect pests of agricultural crops. However, members of the subfamily Epilachninae are foliage feeders and are sometimes pests of several crops.

Mealybug destroyer

Scientific name *Cryptolaemus montrouzieri Coleoptera:Coccinellidae*



Type

Mealybug predator

Hosts

Mealybugs but feed on scales and aphids in the absence of mealybugs.

Description

Eggs are yellow and are laid among the cottony egg sack produced by the mother mealybugs. The eggs develop into larvae in about 5 days.

The larva looks like mealybug. It has woolly appendages of wax but is twice as big as the adult mealybug. It grows up to 1.3 cm in length. It undergoes three larval stages, which lasted for about 12-17 days. The larva feeds on mealybug eggs, young crawlers, and the honeydew produced by mealybugs. It can consume up to 250 mealybugs.

The pupa is found in sheltered stems. The pupal stage lasts for about 7-10 days.

Adult mealybug destroyer is dark brown or blackish beetle. It has orangish head with reddish abdomen. It is small, about 3-4 mm long. A female can lay up to 10 eggs a day in a mealybug colony or in a group of mealybug eggs. It may live up to 2 months.

Conservation

Mealybug destroyers only thrive when there are mealybugs. They feed on mealybugs, which are necessary for their reproduction. Members of carrot (fennel, dill, angelica, tansy) and sunflower families (goldenrod, coreopsis, sunflower, and yarrow) are good habitats for adult mealybug destroyers.

Minute pirate bug

Common Name Minute pirate bugs, Insidious flower bugs

Scientific name *Orius tristicolor, O. insidiosus*

Type

Generalist predator

Hosts

Aphids, bollworm, potato leafhopper nymphs, spider mites, scale insects, insect eggs, small corn borers' larvae, thrips, other small caterpillars, whiteflies

Description

Eggs are elongated, very small, about 0.25 mm, and are clear or milky white in color. The red eyes of the embryo are seen through the shell before hatching. Eggs are laid inside the plant tissues. Incubation takes about 4-7 days.

Nymphs are small, wingless, teardrop-shaped and yellow-orange to brown in color. Nymphs pass through five instars before becoming adult. With each molt, the young closely resemble the adults they will eventually become. The nymphal stage takes about 2 weeks. Adults are also very tiny, about 2 mm long, ovate, and black with white wing patches. Their head and thorax are shiny and black, and their beak extends to between the bases of the first pair of legs. They have flattened bodies that are colored black or brown with lighter markings like pirate flags, hence the name. They possess efficient searching behavior and are voracious general feeders. They are able to aggregate in areas of high prey density and increase their numbers rapidly where food is abundant. They can consume 30 or more spider mites per day. Both nymphs and adults feed on a variety of pests as their primary source of food. Their lifecycle takes about 20 days under optimum conditions to complete. Adults live for about 3 - 4 weeks.

Praying mantis

Common Name Praying mantids (plural)

Some important mantids species

1. African mantis (Sphodromantis spp.) found in Africa
2. Chinese mantis (Tenodera aridifolia sinensis) found in China
3. Devils flower mantis (Blepharoppsis mendica) found in Asia
4. Giant Malaysian shield mantis (Rhombodera basalis) found in Malaysia
5. Giant mantis (Hierodula spp.) found in Asia
6. Ghost mantis (Phyllocrania Paradoxa) found in Africa and Madagascar
7. Indian flower mantis (Creoboter meleagris) found in India
8. Leaf mantis (Deroplatys spp.) found in Asia
9. Madagascan marbled mantis (Polyspillota aeruginosa) found in West Africa and Madagascar, Nigeria and Kenya
10. Malaysian orchid mantis (Hymenopus coronatus) found in Indonesia, Malaysia, and Sumatra
11. Spiny flower mantis (Pseudocreobotra spp.) found in Africa
12. Twig mantis (Popa spurce) found in Africa
13. Wondering violin mantis (Gongylus gongylodes) found in India and Sri Lanka

Type Predator

Hosts

Aphids, fruit flies, grasshoppers, caterpillars, and they eat each other when no food is available.

Description

The eggs are laid in groups. Each group of eggs is encased in a foamy substance that hardens into a tough protective casing called ootheca. Eggs hatch after 3 - 8 weeks, although not all eggs will hatch as young mantids.

The young mantids are hatched as pro-nymphs. They are surrounded by a protective membrane and move like grubs to the surface of the ootheca. In some species, there is a single exit hole at the bottom of the ootheca, where the young emerge individually. In others, the young emerge through the oothecal wall nearest the egg cell and will hang on silken cord from the ootheca until the skin hardens.

The adult praying mantis varies in color depending on the habitat it is living in. It camouflages the leaves, flowers, twigs, barks, trees where it is found. Its size varies depending on the species, from about 3 cm-18cm. It has strong spine-forelegs and usually sits and waits motionless among vegetation for prey, with its forelegs held together in a prayerful manner, hence the name 'Praying mantis'. It has strong mouthparts for chewing, large eyes, well-set on its mobile triangular head, with antennae that are slender and segmented. It has a neck that can rotate its head while waiting for prey.

Some species have powerful forewings for protection and flying. While flying, it can be mistaken as for a small bird. Other species are wingless, odd-looking, flower/leaf-shaped, and others are so thin to be recognizedthat they are hardly recognizable. They will rise up in a threatening manners ready to attack, when disturbed.

A female adult should be well fed prior to mating or else she will kill the male once she is hungry after mating. A female mantis lays up to a few hundred frothy liquid eggs in habitats where mantids live.

Predatory mite

Scientific name *Phytoseiulus spp, Metaseiulus occidentalis, Typhlodromalus aripo. Acari:Phytoseidae*

Type Mite predator

Hosts

Adults, nymphs, larvae, and eggs of spider mites, nymphs of thrips, eggs and nymphs of fungus gnats, small insects and their eggs

Description

Eggs are oblong and slightly larger than the spherical eggs of spider mites.

Nymphs are smaller and lighter in color but look like small adults.

Predatory mites are red, orange, tan, or brown in color, pear-shaped, long-legged, and are approximately 0.5 mm long. They can move around quickly on spider mites colonies (unlike the spider mites that are almost stationary). They can consume about 30 eggs or 20 nymphs a day.

Conservation

Predatory mites feed voraciously on spider mites. They must have spider mites to survive and to reproduce. They do not feed on pollen or plant sap. They are very effective in proper crop and environmental conditions with temperatures ranging from 27-32 degrees centigrade.

Predatory mite (Typhlodromalus aripo) controls cassava green mite (Monoychellus tanajoa). It can reduce the green mite population by ½ and can increase cassava yield by 1/3. This predatory mite species does not require mass breeding in rearing station. It can be transferred to new locations on cassava shoot tips where mites are present. It can spread easily when introduced into cassava fields because of the many food sources such as mites, white flies, corn pollens, and honey dews. But in order to reproduce, it requires mite prey.

In the absence of mites, predatory mite disperses or dies so that it causes no harm to the environment. There are several species of predatory mites which are mass-reared commercially for the management of mites and thrips in greenhouses and field grown crops.

Rove beetles

Common Name Staphylinid

Scientific name *Aleochara bilineata*

Type

Rove beetle larvae are maggots and pupae parasites when they are about to pupate, but both adult and larva are generalist predators

Hosts

Both adults and larvae are predators of root maggots' eggs and larvae, mites, worms, nematodes, and other small insects. Adults tend to be cannibalistic, eating their own eggs and attacking other adults when food supply is low.

Description

Eggs are tiny, about 0.5 mm long and 0.4 mm wide, pear-shaped, pale green in color, and are covered with a gelatin-like material. These are laid by female adults in the soil among the roots of the root-maggot infested plants. The eggs hatch 5-10 days later.

The first instar larvae are pale brown, about 1.5 mm long, slender, segmented, and tapered toward the anterior. They have large heads. The parasitic second and third instar larvae are white, have rudimentary legs, and are found within the host puparium.

Before pupating, a larva will actively search for a host (pupa of maggot) in the surrounding soil. It will pupate in the pupa of the maggot by entering into its cocoon and feeding its contents, and then pupate itself inside for about 3-4 weeks before emerging as an adult. It is possible that two or more larvae enter into one maggot pupa but only one will survive and mature.

Adult rove beetles are brown, reddish-brown, or black or have gray markings on the wings and abdomen, with slender elongate bodies. Their wing covers are shorter than the abdomen where most part of the abdomen is exposed. Both adults and larvae have well-developed 'jaws' cross in front of the head. They live mostly in decaying organic matter but are also found in moist agricultural soils or in habitats where large numbers of fly larvae live. When disturbed, they run very fast, with their abdomen lifted upward, like that of scorpions. Adults are good fliers as well.

Spider

Type

Generalist predator

Hosts

Brown planthoppers, stem borers, leafhoppers, moths, flies, and other agricultural pests they can catch.

Description

1. Crab Spiders (Thomisidae) are colorful crab-like spiders generally found on the blossoms of plants. They have the tendency to camouflage in their habitat so as to catch prey, unaware as they pass by. They are called crab spiders because their first four legs are larger than their hind legs and because of their capability to walk forward, backward, or sideways like a crab (CABI, 2000).
2. Dwarf spiders (Atypena formosana) are very small and are always mistaken for spiderlings (newly

hatched spiders) of other spider species. They measure about 1 to 5 mm in length. Adults have three pairs of spots or gray markings on the dorsal part of their spherical abdomen. They are normally found in groups at the base of a plant. They build webs and catch their prey by trapping them in their webs. However, they can hunt directly and feed on 4-5 leafhopper/planthopper nymphs a day, and also other small insects (IRRI, 2001).

3. Grass spiders are moderately sized, brownish-gray weavers of funnel-shaped webs. Their webs are not sticky and can often be found on low-growing shrubs (CABI, 2000).
4. Jumping spiders (Phidippus sp.) are brown jumping spiders with brown hairs covering their body. They have two bulging eyes and these are arranged in three distinct rows. They have broadly or partly ovoid abdomens with light transverse basal bands. They feed on leafhoppers and other small insects (IRRI, 2001).
5. Long-jawed spiders (Tetragnatha maxillosa) have long legs and bodies, measuring 6 to 10 mm in length. Their eyes are arranged in two distinct rows. Their abdomens are brownish-yellow, with or without markings and are usually four or more times longer than their width. They prey on moths and flies and can consume 2 to 3 preys a day. Once their prey are caught, these are wrapped with silk in their webs (IRRI, 2001).
6. Orb weavers, Argiope spiders (Aranaeus spp.) are large yellow-black garden spiders which produce zigzag stitches in the bottom center of large webs hanging between stems of plants. They have poor vision and can locate their preys by the vibrations and tension on their web threads (IRRI, 2001).
7. Wolf spiders (Lycosa pseudoannulata) have forked or Y-shaped median light bands on their outer coverings. Wolf spiders prey on moths and butterflies. They feed on 5 to 15 preys daily and they eat each other when their population is high (IRRI, 2001).

Some spiders' eggs are laid in a cluster in silken sacs, while some species lay their egg masses covered with silks within folded leaves. Some of these sacs are attached to the mother spiders or mothers stay nearby to guard their egg sacs. Eggs usually hatch into spiderlings within three weeks. The spiderlings may remain attached to the mother for several days on some species, but for some species they are left on their own.

Spiders are not insects. They have 8 legs while insects have 6. They do not have wings whereas insects do. They have two body sections; a united head and thorax and abdomen, while insects have three; head, thorax, and abdomen.

A female can produce 200-400 eggs but only 60-80 spiderlings can hatch from these. Females can survive 2-3 months. In some species, females die after laying eggs.

All spiders are poisonous to insects but only a few species are poisonous to humans, the Black widow and the Brown recluse (CABI, 2000; IRRI, 2001).

Tachinid fly

Common Name Diptera

Scientific name*Bombyliopsis abrupta, Lixophaga sp.*

Type

Larvae and adult parasitoid

Hosts

Aphids, armyworm, beetles, bollworm, bugs, cabbage looper, cotton stainer, cutworm, grasshoppers, horn-worm, leafhoppers, mole crickets, moths, sawflies, scale insects, stem borers, stick insects (CABI, 2000).

Description

Eggs are ovate-shaped and white in color. They are found in the skin of the host insect or in leaves near the host and are hatched when the host ingests them.

The larvae or maggots are worm-like and lack appendages like all other fly larvae. They are greenish-white in color. They have three larval instars and then leave the hosts to pupate in the soil. Before pupation, some mature maggots produce hard cocoons. The larval stage takes about 4 days to 2 weeks depending on the climatic conditions. The newly hatched larvae enter into its host and feed on the content before pupating into the soil. Some tachinid species are hosts' specific, for example for a certain species; it is parasitic only on leaf rolling caterpillars, or only on sugarcane stem borer.

Pupae are oblong, yellowish and turn dark-reddish as they mature.

Adults measure between 3 and 10 mm and have very stout bristles at the tips of their abdomens. They look very similar to the common housefly but are larger with stocky and soft bodies. They vary in appearance from gray black to brightly colored, or sometimes looking like bees. Adult Tachinid flies have only 1 pair of

wings. They feed on honeydews and flower pollen. Different species have varied modified sucking type mouthparts: the cutting sponging, the piercing-sucking, and lapping-sponging. Adult flies are found in almost all crop habitats, either resting on foliage or feeding on nectars and pollen. Additionally for females, they search for hosts to lay their eggs. The female adult lays her eggs near or into the larvae, or on another insect. She can lay as many as 1000-2000 eggs in her lifetime. Adults can live from 3 days to 2 months depending on the species (IRRI, 2001).

However, the Uzi fly (Exorista sorbillans or E. bombycis) is an important pest of the mulberry silkworm and other silkworm species in Asia (CABI, 2000).

Tiphia wasp

Scientific name *Tiphia vernalis, T. koreana, T. popilliavora, T. pygidialis*

Type

Grub parasite

Hosts

Larvae of Japanese beetles and scarab beetles (IRRI, 2001)

Description

The female wasp burrows into the ground in search of a grub. She lays her eggs on a white grub. She stings the grub to temporarily paralyze it and lays a single egg on a specific location (depending on her species). The paralyzed grub recovers from the sting to be the source of food when the egg hatches. The tiny wasp's larva starts to feed by biting the grub's skin. It feeds slowly on the body fluids of the grub.

The larva molts 5 times taking about 2-3 weeks to complete. Before pupating, the larva eats the remainder of its host and then spins a small, fuzzy, brown ovate-shaped cocoon.

Adult Tiphia wasps are shiny dark-colored and about 1cm-2cm long wasps. They are similar to winged black ants. The female wasps' bodies are heavily set built for digging soil in search of beetle grubs. The male wasps are slender and smaller, have tiny hooks at the end of their abdomens which are used for mating.

Tiphia wasps feed primarily on the honeydew emitted by aphids, scale insects, and leafhoppers but they also feed on the nectar of blossoms.

Tiphia wasps are native to Japan, Korea, and North China. They are now found in cooler climates where they have been introduced to control Japanese beetles and other scarab beetles (CABI, 2000).

Trichogramma

Common name
Trichogramma, Tricon

Scientific name
Trichogramma spp.

Type

Egg parasites

Hosts

Trichogramma species parasitize eggs of over 200 species of moth and caterpillars. Among these are; the rice and corn stem borer, cabbageworm, tomato hornworm, Heliotis and Helicoverpa species, codling moth, cutworm, armyworm, webworm, cabbage looper, fruit worms, and sugarcane borer.

Description

Trichogramma adults are extremely small. The female adult lays her eggs on other moths' eggs. First, she examines the eggs by antennal drumming, then drills into the eggs with her ovipositor, and lays one or more eggs inside the moth's eggs. She usually stays on or near the host eggs until all or most of them are parasitized. When the parasitized moth's eggs turn black, the larvae parasites develop within the host eggs. The larva eats the contents of the moth's eggs. Adults emerge about 5-10 days later depending on the temperature. Adults can live up to 14 days after emergence. Female adults can lay up to 300 eggs.

Trichogramma species differ in their searching behavior, host preferences, response to environmental conditions, and suitability in biological control uses. The timing of Trichogramma releases in the field is important. Non-parasitism could be due to the use of less suitable Trichogramma strains to the host pests, environmental conditions, and untimely release of parasitoids. It is best to release of parasitoids at the beginning of a pest infestation (when moths are first seen in the field), followed by regular releases until a

natural breeding population of Trichogramma is established.

An example of this approach is the corn borer control. The first release should be during the first appearance of moths and corn borers' eggs in the cornfields. Weekly releases thereafter are to ensure the Trichogramma population build-up and parasitism occurrence. The build-up of the parasitoids depends on the presence of the pest or alternative hosts and food for adults. It is important to regulary monitor pest population, egg parasitism (parasitized eggs are black in color), and the larval infestation. Trichogramma are released as pupae in parasitized host eggs. The pupae can be pasted on cards or put in various containers. To be successful in the field, food, host eggs and shelter must be available.

III. 2. 2. Homemade solutions

III. 2. 2. 1. Plants used in Pest Control

Aloe

Scientific name *Aloe barbadensis*
Family *Aloeaceae*

Plant parts used Leaves, rhizomes
Mode of action Larvaticidal
Formulations look table 4 below

Table 4: Formulations for the Use of Aloe

Materials	*Methods of preparation*	*How to use*	*Target pests*
Aloe, vitex extract			
5 kg of vitex leaves 2 kg of aloe leaves 50-60 ml of soap 60-70 liters of water Cooking pot Pail *This formulation is good enough to spray 0.4 ha area.*	Soak vitex leaves in 10 liters water. Then bring to boil for 30 minutes. Cool and then strain. Remove the outer part of the aloe leaves and grind in water to get the extract. Strain. Mix the 2 extracts.	Dilute 50-60 liters of water to the extract. Add soap. Stir well. Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	Armyworm Hairy caterpillar Rice leaf folder Rice stem borer Semi-looper caterpillar Bacterial and fungal diseases
Aloe moth attractant			
½ liter of aloe extract 1 kg of castor cake Wide-opened containers Plant latex or resin *6 traps are good enough for ½ ha.*	Mix aloe and castor cake. Add the latex as adhesive material.	Put mixture in wide-opened containers. Place containers in strategic locations of the field.	**Moths**

Effect on humans

Aloe is a popular house plant due to its reputation as a healing plant for burns, cuts, and other skin problems, contact dermatitis can occur on sensitive individuals.

Effect on non-target organisms

None

Andrographis

Common Name King of bitters
Scientific name *Andrographis paniculata*

Plant parts used Whole plant
Mode of action Repellent
Formulation look table 5 below

Table 5: Formulation for the Use of Andrographis

Materials	*Methods of preparation*	*How to use*	*Target pests*
Plant extract			
2 kg of fresh plant 10 grams of well-crushed dried chili pods 1 liter of cow's urine Water Grinder Pail	Grind plants in 250 ml of water. Add cow's urine and chili. Dilute filtrate with 10 liters of water. Allow this solution to stand for sometime. Strain.	Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	**Aphids** **Melon worms** **Thrips** **Whiteflies**

Effect on humans
None

Effect on non-target organisms

Basil

Common names
Basil, Black basil, Holy basil, Sweet basil, Tulasi
Scientific name *Ocinum spp.*

Plant parts used Leaves, stems, whole plant
Mode of action Repellent, insecticidal, oviposition inhibiting

Formulation look table 6 next page

Table 6: Formulation for the Use of Basil			
Materials	***Methods of preparation***	***How to use***	***Target pests***
Basil leaf extract			
50 grams of basil leaves 2-3 liters of water 8-12 ml of soap Grinder Pail	Grind leaves. Soak overnight in water. Strain. Add soap. Stir well.	Spray early in the morning on infested plant parts.	**Caterpillars** **Fruit flies** **Red spider mites** **Red scales** **Spotted leaf beetles** **Fungal diseases** **Nematodes**

Effect on humans
None

Effect on non-target organisms
None

Butterfly bush

Scientific name *Buddleia lindleyana*

Plant parts used Leaves
Mode of action Insecticidal

Formulation look table 7

Table 7: Formulation for the Use of Butterfly bush			
Materials	***Methods of preparation***	***How to use***	***Target pests***
Leaf extract			
5 kg of Butterfly bush leaves ¼ liter of water 10-15 ml soap Mortar and pestle Pail	Pound leaves. Add water. Squeeze out the sap. Strain.	Dilute 1 liter of filtrate with 10-15 liters of water. Add soap. Stir well. Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	**Black bean aphids** **Caterpillars in cabbage** **Plant hoppers**

Effect on humans
None

Effect on non-target organisms
None

Chili

Common Names Chili, Red peppers

Scientific name *Buddleia lindleyana*

Plant parts used Fruit, seeds

Mode of action Insecticidal, repellent

Formulations look table 8

Table 8: Formulation for the Use of Chili

Materials	*Method of preparation*	*How to use*	*Target pests*
All purpose insect pest spray			
1 tsp powdered red hot pepper 1 garlic bulb 1 small onion 1 liter of water 1 tbsp of soap Knife Strainer Basin/pail	Chop onion and garlic. Add powdered red pepper. Mix the above ingredients into the water. Soak for 1 hour. Strain. Add soap. Stir well.	Fill-in the sprayer. Spray through plants. If no sprayer is available, make soft straw brush and wet plants with the extract. Repeat spraying when necessary.	**Leaf eating pests**
Chili spray			
4 cups of ripe hot peppers or 5 cups chili seeds 30 grams of soap Cooking pot Strainer	In a pot, boil ripe pods or chili seeds in water for 15-20 minutes. Take the pot from the fire and add 3 liters of water. Cool and strain. Add soap. Stir well.	Spray on infested plants.	**Ants** **Aphids** **Caterpillars** **Flies** **Mealy bugs**
Chili and neem leaves extract			
10-20 pieces of hot pepper 2-2.5 kg fresh neem leaves 21 liters of water 2 tbsp of powdered soap Mortar and pestle Basin/pail	Pound hot pepper and neem leaves. Add to 1 liter of water. Soak the mixture overnight. Strain.	Add 20 liters of water and the powdered soap to the filtrate. Stir well. Fill-in the sprayer. Spray on infested plants. Spray early in the morning or late in the afternoon.	**Armyworm** **Whitefly** **Mosaic virus**
Chili and neem seeds extract			
12 pieces chopped hot chili 200 grams fully dried and shelled neem seeds 4 liters of water Basin/pail Grinder and knife	Grind the neem seeds. Soak the grounded neem seeds in water overnight. Add the chopped hot chili. Strain.	Fill-in the sprayer Spray on the infested plants thoroughly.	**Aphids** **Diamondback moth** **Sucking and chewing insects** **Whitefly**

Chili, custard apple, neem extract			
25 grams of dried chili pods 100 grams of custard apple leaves 50 grams of crushed neem fruits 20 ml of soap Grinder Wide-mouth bottles Pail	Grind dried chilies and soak overnight in 100 ml of water. Soak crushed neem fruits overnight in 200 ml of water. The next day filter both extracts. Grind the custard leaves. Add 500 ml of water. Strain. Mix all 3 filtrates.	Add 5-6 liters of water to the filtrate. Add soap. Stir well. Spray on infested plant parts, preferably early in the morning or late afternoon.	**Aphids** **Leafrollers** **Red scales** **Spotted beetles**

Effect on humans

Chili irritates nose, eyes, and skin. Extra care should be taken when handling the extracts.

Effect on non-target organisms

None; however, when the pepper extract concentration is so strong, it can burn the leaves and eventually kill the plants. It is important to **do some tests first** on small portion of the plant before going into large scale spraying.

Coriander

Scientific name *Coriandrum sativum*

Plant parts used Leaves, seeds
Mode of action Repellent
Formulation Look table 9

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Table 9: Formulation for the Use of Coriander

Materials	*Method of preparation*	*How to use*	*Target pests*
Coriander spray			
200 grams of seeds 1 liter of water Cooking pot Mortar and pestle Pail	Crush seeds. Boil in water for 10 minutes. Cool. Strain.	Dilute extract with 2 liters of water. Spray early in the morning on infested plant parts.	**Spider mites**

Effect on humans

None.

Effect on non-target organisms

None.

Custard Apple

Common Names Custard apple, Soursop, Sweetsop
Scientific name *Annona spp.*

Plant parts used Root, leaf, fruit, seeds
Mode of action Insecticidal, antifeedant, repellent

Formulations Look table 10

Table 10: Formulations für the Use of Custard Apple

Materials	*Method of preparation*	*How to use*	*Target pests*
Custard apple leaf extract			
500 grams of fresh Custard apple leaves 12-17 liters of water Pail Bolo/knife Cooking pot Strainer	Boil leaves in 2 liters of water until the remaining liquid is about ½ liter. Strain.	Dilute filtrate with 10-15 liters of water. Fill the sprayer. Spray on infested plants thoroughly.	**Aphids** **Brown plant hopper** **Coffee green scale** **Cotton stainer** **Diamondback moth** **Grasshopper** **Green bugs** **Green leaf hopper** **House fly**
Custard apple seed extract			
500 grams of finely ground Custard apple seeds 20 liters of water Pail/basin Strainer	Add powdered seeds in water. Let the extract stand for 1-2 days. Strain the extract.	Spray on infested plants thoroughly.	**Ants** **Aphids**
Custard apple seed oil extract			
Seeds from unripe fruit Grinder Water Pail	Grind seeds to extract oil.	Dilute 1 part of oil in 20 parts of water. Spray on the infested plants thoroughly. Powdered seeds (from dried mature seeds) can be dusted directly to the infested plants.	**Diamondback moth pupae**

Effect on humans

The hard seeds are toxic, but can be swallowed whole with no ill effects (Morton, 1987: pp. 80-83). Powdered seeds cause painful irritation when in contact with the eyes. Take extra precaution while handling the extract.

Effect on non-target organisms

None

Eupatorium

Common Names Christmas bush, Siam weed
Scientific name *Eupatorium odoratum*

Plant parts used Whole plant
Mode of action Insecticidal and repellent

Formulation look table 11

Table 11: Formulations for the Use of Eupatorium

Materials	*Method of preparation*	*How to use*	*Target pests*
Leaf extract			
400 g of dried leaves 10 liters of water 10-15 ml soap Cooking pot Pail	Boil leaves in water for 10 minutes. Cool. Strain.	Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	**Aphids** **Diamondback moth** **Snails** **Sweet potato weevil**

Effect on humans
None.

Effect on non-target organisms
Plant is poisonous to fish.
Leaf meal is used as chicken feed.

Garlic

Scientific name *Allium sativum*

Plant parts used Whole plant, bulbs, leaves, flower
Mode of action Repellent, insecticidal, nematicidal, fungicidal, antibiotic

Formulations look table 12, next page

Table 12: Formulations for the Use of Garlic			
Materials	***Method of preparation***	***How to use***	***Target pests***
Garlic bulb extract			
85 grams of chopped garlic 50 ml of mineral oil (kerosene) 10 ml of soap 450 ml of water Strainer Bottle container	Add garlic to kerosene. Allow this mixture to stand for 24 hours. Add water and stir-in the soap. Store in bottle container.	Dilute 1 part of the emulsion with 19 parts of water (for example, 50 ml of emulsion to 950 ml of water). Shake well before spraying. Spray thoroughly on the infested plant, preferably early in the morning.	**American bollworm** **Armyworm** **Cotton stainer** **Onion thrips** **Potato tuber moth** **Root knot nematode** **Sugarcane shoot borer** **Bacterial diseases** **Antrachnose** **Downy mildew** **Rice blast**
Garlic oil spray			
100 grams of garlic 2 tbsp of mineral oil 10.5 liters of water 10 ml of soap Covered container	Chop garlic finely. Soak garlic in mineral oil for a day. Add ½ liter water and soap. Blend well by stirring thoroughly. Strain.	Dilute the filtrate with 10 liters of water. Fill the sprayer. Shake sprayer from time to time to avoid oil from floating. Spray on the infested plant thoroughly.	**Imported cabbage worm** **Leafhoppers** **Squash bugs** **Whitefly**
Garlic oil emulsion			
50 ml of garlic oil 950 ml of water 1 ml of soap	Add soap to oil. Blend well by stirring thoroughly. Add water. Stir.	To avoid oil from floating, immediately spray extract on infested plants and shake sprayer from time to time. Spray early in the morning or late afternoon.	**American bollworm** **Potato tuber moth** **Rice brown leaf spot** **Root knot nematode**

Effect on humans

None.

Effect on non-target organisms

Garlic oil spray has broad-spectrum effect. It is non-selective so it can kill beneficial insects as well. This is not recommended for aphid control since it kills the natural enemies of aphids. It should be limited to home and garden applications where natural controls are rarely.

Ginger

Scientific name *Zingiber officinali*

Plant parts used Rhizome
Mode of action Repellent, insecticidal,

Formulations look table 13

Table 13: Formulations for the Use of Ginger

Materials	*Method of preparation*	*How to use*	*Target pests*
Ginger rhizome extract			
50 grams of ginger 12 ml of soap 3 liters of water Grinder Strainer Pail *4 kg of ginger are needed to spray 0.4 ha*	Grind ginger and make into paste. Mix with water. Add soap. Stir and strain.	Spray on infested plants thoroughly. If there is no sprayer, make soft brushes out of plant straw or twigs and wet infested plant.	**Aphids** **Plant hoppers** **Thrips** **Nematodes** **Brown leaf spot on rice** **Mango anthracnose** **Yellow vein disease**
Ginger, garlic, and chili extract			
25 grams of ginger 50 grams of garlic 25 grams of green chili 10 ml of kerosene 12 ml of soap 3 liters of water Grinder Pail *1 kg garlic, ½ kg ginger, and ½ chili are needed for 0.4 ha*	Soak garlic in kerosene overnight. Grind and make into a paste. Add 50 ml water to chili, grind, made into a paste. Grind ginger and make into a paste as well. Mix all ingredients into the water and add soap. Filter the extract. Stir well before spraying.	Spray on infested plants thoroughly.	**Aphids** **Armyworm** **Bollworm** **Caterpillars** **Fruit borer** **Leaf miner** **Shoot borer** **Thrips** **Whiteflies**
Ginger powder extract			
20 g of ginger powder 1 liter of water	Add powder to water Stir well	Spray on infested plants	**Powdery mildew** **Root rot** **Fungal leaf blight**

Effect on humans

Ginger has no side effects on human beings; however, chili is irritating to the skin and causes pain when it is in contact with the eyes.

Effect on non-target organisms

None.

Gliricidia

Common names Kakawate, Madriado, Madre de cacao

Scientific name *Gliricidia sepium*

Plant parts used Leaves and bark

Mode of action Insecticidal, repellent, and rodenticidal

Formulations look table 14

Table 14: Formulations for the Use of Gliricidia

Materials	*Method of preparation*	*How to use*	*Target pests*
Madre de cacao leaf extract			
½ kg leaves Grinder or mortar and pestle Pail or basin Strainer	Grind or pound leaves. Soak overnight in water. Strain.	Add 20 liters of water to the filtrate. Spray on infested plant thoroughly.	**Armyworm** **Cabbage looper** **Caseworm** **Tobacco budworm** **Whorl maggots**
Madre de cacao & neem			
1 kg of Madre de cacao leaves 1 kg of neem leaves Knife Pail Strainer Water	Shred the leaves. Soak leaves in 5 liters of water for 3 days. Strain.	Add water to make up 20 liters of filtrate. Spray on infested plants. Spraying interval is 4-5 days.	**Aphids** **Blister beetles** **Fall armyworm** **Termites** **Whitefly** **White grubs**
Madre de cacao & chili			
2 kg of Madre de cacao leaves 12 pieces of chili Grinder Pail Strainer	Grind Madre de cacao leaves and chilies. Soak in water overnight. Strain	Add water to make up 20 liters of filtrate. Spray on infested plants.	**Bean pod weevil** **Various insect pests in tomato seedlings**
Madre de cacao, chili & onion			
½ kg of Madre de cacao 7 pieces chili 3 onion bulbs Grinder Pail Strainer	Grind all the ingredients. Soak overnight in water. Strain.	Add water to make up 20 liters of filtrate. Spray on infested plants.	**Caterpillars in tomatoes and pepper**

Effect on humans

None.

Effect on non-target organisms

None; foliage is used as feeds for livestock and as fertilizer.

Guinea hen weed

Common names Anamu

Scientific name *Petivaria alliacea*

Plant parts used Roots

Mode of action
Antifeedant (Prakash; Rao, 1997: p. 237)

Formulation look table 14

Table 14: Formulation for the Use of Guinea hen weed

Materials	*Method of preparation*	*How to use*	*Target pests*
Root extract			
10 kg of roots 3 cowpats 3 dessertspoonfuls of salt Grinder Pail Strainer	Grind roots. Add cowpat and salt. Soak in 30 gallons of water for 8 days. Strain.	Mix 1 liter of the filtrate with 20 liters of water. Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	**Fall armyworm** **Leaf-cutting ants** **Whiteflies**

Effect on humans
None, however pure root extract is abortive and toxic once taken internally in high doses.

Effect on non-target organisms
None.

Horsetail

Scientific name *Equisetum arvense*

Plant parts used Leaves

Mode of action Insecticidal

Formulation look table 15

Table 15: Formulation for the Use of Horsetail

Materials	*Method of preparation*	*How to use*	*Target pests*
Horsetail spray			
½ cup finely crushed dried horsetail leaves. 4 gallons of rain water cooking vessel Strainer	Put ingredients in cooking vessel. Boil in water for 30 minutes. Cool. Strain.	Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	**Wide-range of plant pests and diseases**

Effect on humans
None.

Effect on non-target organisms
Plant is poisonous to horses.

Lansones

Other name Longkat

Scientific name *Lansium domesticum*

Plant parts used Seeds

Mode of action Insecticidal

Formulation look table 16

Table 16: Formulation for the Use of Lansones

Materials	*Method of preparation*	*How to use*	*Target pests*
Lansones seed extract			
500 grams of seeds 20 liters of water Mortar and pestle Pail	Finely pound seeds. Soak in water for 1 day. Strain.	Spray early in the morning on infested plants.	**Armyworm and other leaf eating caterpillars**

Effect on humans

None.

Effect on non-target organisms

None.

Lemongrass

Common names Citronella, Lemongrass

Scientific name *Cymbopogon marginatus, C. nardus, C. citratus*

Plant parts used Leaves, roots

Mode of action Insecticidal, repellent

Formulations Look table 17

Table 17: Formulations for the Use of Lemongrass

Materials	*Method of preparation*	*How to use*	*Target pests*
Lemongrass leaf extract			
50 g of grounded lemongrass 2 liters of water	Soak lemongrass with water.	Spray unto tomatoes, lettuce and carrots	**Bacterial leaf blight**

Lemongrass, chili, bitterwood extract			
Whole plant of lemongrass Chili pods Bitterwood leaves 4 ml of soap Mortar and pestle Strainer Basin	Pound each plant (of desired amount) to get the plant juice. 5-7 tbsp of plant juices are needed from each plant. Mix the all the plant juices.	Dilute the mixture of plant juices with 4 liters of water. Spray on infested plants thoroughly preferably early in the morning or late in the afternoon.	**Rice pests**
Citronella grass. Madre de cacao, chili, tobacco and Tinospora extract			
25 kg of citronella grass 25 kg of fresh Madre de cacao leaves 1 kg of chilies 10 kg of tobacco leaves 5 kg of Tinospora Drum Soap Bolo or knife	Chop these plant materials. Put in a drum full of water. Set aside for 1 month to allow fermentation.	Dilute 1 liter of stock solution with 10-12 liters of water. Add soap. Stir well. Spray on infested plants thoroughly.	**Most agricultural pests**

Effect on humans

None; however extracts are possible irritants to sensitive skins or when used in strong dilution. Do not use on damaged skin.

Be careful, leaves have sharp edges and can inflict razor cuts in the skin.

Effect on non-target organisms

None.

Mammey

Common names Mammey apple

Scientific name *Mammea americana*

Plant parts used Root, bark, branch, leaves, and fruits

Mode of action Insecticidal, repellent

Formulations look table 18

Table 18: Formulations for the Use of Mammey

Materials	*Method of preparation*	*How to use*	*Target pests*
Mammey spray			
1kg of mammey seeds 100 liters of water 100 ml of soap Mortar and pestle Pail	Pound ripe mammey seeds. Add powder into soapy water. Stir well.	Spray on infested plants thoroughly including the undersides of the leaves.	**Diamondback moth Larvae of cabbage worm**

Mammey seed powder dust			
Mammey seeds Grinder or mortar and pestle Sawdust or ground dried leaves Basin or pail	Grind or pound seeds. Mix with sawdust or ground dried leaves.	Dust into cabbage plants early in the morning when the dews are on the plants for the powder to stick well. Approximately 8-9 grams are needed for each plant.	**Aphids** **Armyworm** **Cabbage worm** **Bean beetle** **Diamondback moth** **Melon worm**

Effect on humans

None; however proper handling of the extracts is advised as they may irritate skin and eyes.

Effect on non-target organisms

None.

Marigold

Scientific name *Tagetes spp.*

Plant parts used Flowers, leaves, and roots

Mode of action Insecticidal, repellent, fungicidal, nematocidal

Formulations look table 19

Table 19: Formulations for the Use of Marigold

Materials	***Methods of preparation***	***How to use***	***Target pests***
Marigold water extract			
Mexican marigold leaves Soap Hot water Mortar and pestle Strainer Pail	Pound the leaves. Soak the pounded leaves in hot water. Leave to stand for 24 hours. Strain.	Dilute the filtate with water at a ratio of 1:2 Add 1 tsp soap in every liter of the extract	**Ant** **Aphid** **Grasshopper**
Fermented marigold extract (Stoll: p. 132)			
Whole flowering plant Soap Water Strainer Drum	Fill-in drum with 1/2-3/4 full of flowering plants. Leave to stand for 5-10 days. Stir occasionally. Strain before use.	Dilute the filtate with water at a ratio of 1:2 Add 1 tsp soap in every liter of the extract	**Coffee berry disease** **Rice blast** **Tomato blight** **Root knot nematodes**
Marigold and tomato extract			
1 kg of marigold leaves 1 kg of tomato leaves 20 liters of water Grinder Soap Strainer	Grind the leaves. Add enough water. Strain.	Add 20 liters of water to the filtrate. Add 1 tsp soap in every liter of the extract. Spray on the target pests.	**Aphid** **Bean pod borer** **Leaf beetle**

Marigold and chili extract			
500 g of whole plant 10 hot chili pods 15 liters of water Knife Soap Strainer Pail	Finely chop the plant and the chilies. Soak them in water overnight. Strain.	Dilute the filtate with water at a ratio of 1:2 Add 1 tsp soap in every liter of the extract	**Most agricultural pests**
Marigold, chili, garlic, and onion spray			
2 handfuls of marigold leaves 2 pieces chili 3 garlic cloves 2 large onions Cooking pan Pail Strainer	Chop 2 handfuls of marigold leaves, 2 pieces chili, 3 gloves garlic, and 2 large onions. Place in a pan of water and bring to boil. Let it cool. Strain.	Add four times amount of water to the extract. Spray or sprinkle on affected plant parts.	**Against most insect pests**

Effect on humans

None; however plant extract can cause irritation to sensitive skin.

Effect on non-target organisms

None; however, the aroma attracts bees so be careful that you do not have the smell of marigold when dealing with bees.

Pyrthrins have a quick knockdown effect on insects and can be applied a day before harvest because these are quickly destroyed by sunlight (Cremlyn, 1978: pp. 39-49). Marigold is most effective when mix with other pesticidal plants because of lack of persistence to sunlight.

Neem

Common name Margosa tree
Scientific name *Azadirachta indica*

Plant parts used Leaves and seeds

Mode of action Repellent, insecticidal, antibacterial, anti-fungal, antifeedant, oviposition and growth inhibiting, and crop and grain protectant (Prakash; Rao, 1997: pp. 35-103)

Formulations look table 20

Table 20: Formulations for the Use of Neem

Materials	*Methods of preparation*	*How to use*	*Target pests*
Neem leaf extract			
1-2 kg of neem leaves Mortar and pestle Used cotton cloth Pot Soap Strainer String *10-12 kg of neem leaves are needed for 0.4 ha*	Pound neem leaves gently. Place in a pot. Add 2-4 liters of water. Cover the mouth of the pot securely with the cloth and leave it as such for 3 days. Strain to get clear extract.	Dilute 1 liter of neem leaf extract with 9 liters of water. Add 100 ml of soap. Stir well. Spray on the infested plants.	**Aphids** **Beetles** **Grasshoppers** **Grubs** **Leafhoppers** **Locusts** **Planthoppers** **Scales** **Snails** **Thrips** **Weevils** **Whiteflies**

Water seed powder extract			
Matured, dried neem seeds Mortar and pestle Basin, pail Muslin pouch Strainer Soap (5 ml/10 l of water) Water	Remove shells and pulps from seeds of desired amount. Then pound seeds gently in such a way that no oil comes out. Once done, take the desired amount of powder in a pail of water. Stir well for about 10 minutes and steep for at least 6 hours but not more than 16 hrs. Stir it again for another 10 minutes. Strain. Add soap. Stir well.	***Refer to Table 21on the next page for the neem powder and water ratio for the control of specific pest.*** Spray on the infested plants thoroughly. Spray early in the morning or late afternoon.	**Cotton bollworm** **Aphids** **Cotton leaf roller** **Cutworm** **Diamondback moth** **Fall armyworm** **Grasshopper** **Leaf miner** **Leaf hopper** **Locust** **Mexican bean beetle** **Whiteflies**
Neem seed oil suspension in water			
5 kg of finely ground neem seeds ½ liter of hot water Soap Basin	Put the finely ground seeds into a basin. Add hot water little by little until it is possible to knead the mixture. Knead and press the mixture to get the oil. *Approximately 650-750 ml oil is extracted from this mixture.*	***Refer to Table 22 on the next page for the oil and water ratio.*** Take desired amount of neem oil and mix with soap before adding water. Stir thoroughly to prevent oil separation. Fill-in the knapsack sprayer. Spray thoroughly on infested plants.	**Aphids** **Brown planthopper** **Flea beetle** **Leafhopper** **Potato tuber moth** **Psyllid** **Scale insects** **Whitefly** **Whorl maggot**

Effect on humans

None; the proper use of neem has never been associated with any side effects.

Effect on non-target organisms

Azadirachtin is relatively harmless to butterflies, bees, ladybugs, and wasps since these beneficials feed on nectar and pollen. Azadirachtin must be ingested to be effective so that pests that feed on plants are affected by its content. However, constant spraying of highly concentrated neem products to flowering plants affect bees since they carried contaminated pollen and nectar to the hives (National Research Council, 1992).

A study was conducted on neem products and their effects on mortality, growth, and reproduction on 7 species of earthworms. Various neem products were incorporated in the upper 10cm soil layer of tomato plots. None of the materials had negative side effects on earthworms. Positive effects on weight and survival were found in soil treated with ground neem leaves and ground seed kernels under greenhouse conditions. Reproduction was slightly favored over a period of 13 weeks in a neem-enriched substrate in rearing cages (Rossner; Zebitz, 1986: pp. 627-632).

Azadirachtin has no side effects on birds and other animals (Martineau, 1994). There is no toxic residue left to contaminate the environment and insects do not develop resistance to neem (Prakash; Rao, 1997: pp. 35-103).

Notes:

1. *Neem seed extract should be milky white in colour and not brownish. If pounded with the seed coat on, 1 ½ times the amount of seeds are required. The seeds should be 3 -8 months old to be effective pest control materials.*
2. *It is very important to add the soap with the oil before adding water. It should be used immediately otherwise oil droplets will start floating. A knapsack sprayer is better for neem oil spraying because it has the tendency to mix the extract while in the process of spraying.*

Table 21: Recommended powdered kernels and water ratio for various pests
(Singh; Singh, 2000: pp. 5-7)

Pests	***Powdered kernels in grams per liter of water***	***Powdered kernels in kilograms per 600 liters of water per hectare (ha)***
Desert locust	5	3
Hairy caterpillar **Giant looper** **Gypsy moth** **Migratory locust**	10	6
Leaf miners	15	9
Cabbage aphid **Japanese beetle** **Tobacco caterpillar**	20	12
Chafer beetle **Colorado potato beetle** **Flea beetle**	30	18
Corn earworm	40	24
American bollworm **Aphids** **Cotton leaf roller Diamondback moth** **Grasshopper** **Leaf hopper** **Leaf miner** **Red locust** **Mexican bean beetle** **Mustard aphid** **Whiteflies**	50	30
Fall armyworm	60	36
Pod fly	80	48
Citrus leafminer	100	60

Table 22: Recommended neem oil in water suspension for various pests (Singh; Singh, 2000: pp. 5-7)

Pests	***Neem oil in milliliter per liter water***	***Neem oil in liter per 600 liters of water per hectare***
Potato tuber moth **Red and yellow scales** **Tortoise beetle**	10	6
Psyllid **Whitefly**	15	9
Midge **Whorl maggot**	20	12
Cotton aphids **Flea beetle** **Gall midge** **Leafhopper**	30	18
Brown planthopper	100	60

Onion

Common name Onion, Shallot
Scientific name *Allium sepa*

Plant parts used Bulbs
Mode of action Insecticidal and repellent

Formulations look table 23

Table 23: Formulations for the Use of Onion

Materials	*Methods of preparation*	*How to use*	*Target pests*
Onion bulb extract #1			
85 grams of chopped onion 50 ml of mineral oil (kerosene) 10 ml of soap 450 ml of water Strainer Bottle container	Add chopped onion to kerosene. Allow this mixture to stand for 24 hours. Add water and stir-in the soap. Store in bottle container.	Dilute 1 part of the emulsion with 19 parts of water (for example, 50 ml of emulsion to 950 ml of water). Shake well before spraying. Spray thoroughly on the infested plant, preferably early in the morning.	**Whiteflies**
Onion bulb extract #2			
1 kg of bulb onions 1 liter of water Cooking pot Pail Strainer	In a pot, bring 1 liter of water to boil. Chop the onions, then place in a covered container. Pour the boiling water into the container. Let it stand for 24 hours.	Dilute the 1 liter extract with 10 liters of water. Spray thoroughly on the infested plant, preferably early in the morning or late afternoon.	**Ants** **Scales** **Spider mites** **Thrips**
Onion bulb extract #3			
50 g of bulb onions 1 liter of distilled water Pail	Finely chop onion and add water.	Spray on infested plants	**Alternaria** **Anthracnose** **Fusarium wilt** **Fungal leaf blight**

Effect on humans

None.

Effect on non-target organisms

None.

Papaya

Scientific name *Carica papaya*

Plant parts used Leaves, seeds, unripe fruit
Mode of action Repellent, insecticidal, rodenticidal, fungicidal

Formulation look table 24

Table 24: Formulations for the Use of Papaya

Materials	*Methods of preparation*	*How to use*	*Target pests*
Papaya leaf extract			
50 grams of finely shredded papaya leaves 8-12 ml of soap Muslin cloth Pail Water	Soak shredded leaves in 100 ml of water. Stir vigorously. Let it stand overnight. Squeeze the extract using the muslin cloth.	Dilute the extract with 2-3 liters of water. Add soap. Stir well. Spray thoroughly on infested plant parts.	**Leafy caterpillars**

Effect on humans
None.

Effect on non-target organisms
None.

Pepper tree

Common name Brazilian pepper tree, Christmas berry tree
Scientific name *Schinus molle, S. terebinthifolius*

Plant parts used Leaves, fruits
Mode of action Repellent,

Formulation look table 25

Table 25: Formulations for the Use of Pepper tree

Materials	*Methods of preparation*	*How to use*	*Target pests*
Leaf extract			
3 kg of leaves 15 ml of soap 15 liters of water Pail	Soak leaves in water for 3 days. Strain. Add soap. Stir well.	Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	Aphids

Effect on humans
None.

Effect on non-target organisms
None.

Pyrethrum

Common name Chrysanthemum
Scientific name *Chrysanthemum spp.*

Plant parts used Flowers, leaves, and roots
Mode of action Insecticidal, repellent, fungicidal, nematocidal

Formulations look table 26

Table 26: Formulations for the Use of Pyrethrum

Materials	*Methods of preparation*	*How to use*	*Target pests*
Pyrethrum extract			
1 cup of fresh pyrethrum daisy flower heads 30 ml of rubbing alcohol (70% isoprophyl alcohol) Pail Strainer	Soak flowers in alcohol overnight. Strain through a cheesecloth.	Add 3 liters of water to the filtrate. Stir well. Spray on infested plants	**Aphids** **Cabbage loopers** **Codling moths** **Mexican bean beetles** **Stink bugs** **Thrips** **Tomato pinworms** **Whiteflies**
Pyrethrum water extract			
1-1.5 kg of dried pyrethrum 3 kg of liquid soap 100 liters of water Drum	Finely shred dried pyrethrum. Add into the drum with water. Stir vigorously. Strain. Add soap. Mix well.	Spray on the target pests preferably in the evening.	**Aphid** **Bean fly** **Cabbage white butterfly** **Coffee bugs** **Colorado beetle** **Diamondback moth** **Eggplant fruit and shoot borer** **Flea beetle** **Gall midge** **Grasshopper** **Green leafhopper** **Locust** **Thrips**
Pyrethrum powder extract			
3 g of pyrethrum powder 1 liter of water 1 tsp of soap Pail	Add the pyrethrum powder and soap to water. Stir well.	Immediately apply on infested plants preferably in the evening.	**Flea beetles**

Effect on humans

None, however plant extract can cause irritation to sensitive skin.

Effect on non-target organisms

None; however, recent studies show that phyrethrin-based chemical products are harmful to natural enemies, fishes and crustaceans, and pose environmental risks.

Quassia

Scientific name *Quassia amara*
Family Simarubaceae

Plant parts used Wood and bark
Mode of action Insecticidal

Formulation look table 27

Table 27: Formulations for the Use of Quassia

Materials	*Methods of preparation*	*How to use*	*Target pests*
Pyrethrum extract			
4 tbsp of bark chips Water Grinder Pail Strainer	Grind the bark chips. Add powder to 2 liters of boiling water. Cool. Strain. Soak overnight bark chips in 1-2 liters of cold water. Strain.	Spray on pests infected plants.	**Aphids** **Caterpillars** **Colorado potato beetles larvae** **Sawflies** **Several species of flies**

Effect on humans

None; in fact, Quassia is used as hops substitute for making beer and has been long used as medicinal herb.

Effect on non-target organisms

None; it goes easy with bees and ladybugs.

Red cedar

Scientific name *Toona ciliata*

Plant parts used Leaves
Mode of action Insecticidal

Formulation look table 28

Table 28: Formulations for the Use of Red cedar

Materials	*Methods of preparation*	*How to use*	*Target pests*
Leaf extract for seed treatment			
1 kg of leaves Water Mortar and pestle Basin	Pound leaves. Soak overnight in equal amount of water.in 1-2 liters of cold water. Strain.	100 ml of filtrate is good enough to treat a kilo of seeds. Plant seeds immediately.	**Pod borer of groundnuts** **Termites** **Wireworms** **White grubs**

Effect on humans

None.

Effect on non-target organisms

None.

Spanish needle

Common name Farmer's friend

Scientific name *Bidens pilosa*

Plant parts use: Seeds, whole plant

Mode of action Insecticidal

Formulations look table 29

Table 29: Formulations for the Use of Spanish needle

Materials	*Methods of preparation*	*How to use*	*Target pests*
Seed extract			
1 teacup of mature seeds Water Soap Cooking pot Pail Strainer	Pour seeds in a cooking pot with water. Bring to boil for 5 minutes. Strain.	Dilute filtrate with 1 liter of water. Add a small piece of soap. Stir well. Spray on infested plants. Pour on termite infested soil.	**Aphids** **Cutworm** **Termites**
Plant extract			
1 whole plant 2 liters of water Soap	Pound plant. Soak in water overnight. Squeeze out the plant sap. Strain. Add a small piece of soap. Stir well.	Spray on infested plants. Pour on termite infested soil.	**Aphids** **Cutworm** **Termites**

Effect on humans

None.

Effect on non-target organisms

None.

Stemona

Scientific name *Stemona tuberosa*

Plant parts used Tubers

Mode of action Insecticidal

Formulation Look table 30 on the next page

Table 30: Formulation for the Use of Stemona			
Materials	***Methods of preparation***	***How to use***	***Target pests***
Tuber extract			
200 grams of dried roots 1 liter of tap water or coconut water Mortar and pestle Pail Strainer	Pound roots. Soak pounded roots overnight in water. Strain.	Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	**Caterpillars** **Crickets** **Flies** **Screw worm** **Weevils**

Effect on humans

None.; however take extra precautions while handling the extract.

Effect on non-target organisms

None.

Sweet flag

Scientific name *Acorus calamus*

Plant parts used Rhizome
Mode of action Insecticidal, oviposition inhibiting

Formulations Look table 31

Table 31: Formulations for the Use of Sweet flag			
Materials	***Methods of preparation***	***How to use***	***Target pests***
Rhizome extract			
Sweet flag rhizome, dried 2 liters of water 8 ml of soap Mortar and pestle Pail *½ kg of powder is needed for 0.4 ha.*	Pound rhizome. Take 20 grams of rhizome powder and add to water. Let it stand for 1 day. Strain. Stir-in soap.	The following early morning, spray on infested plant parts.	**Aphids** **Leafy caterpillars**
Rhizome powder and cow's urine for seed treatment			
50 grams of powdered rhizome 2.5 liters of water 1 liter of cow's urine Cooking pot Basin *This amount is good for treating 1 kg of seeds.*	In a pot, bring water to boil. Cool. Mix the cow's urine with water. Add the rhizome powder. Stir well.	Add seeds to this solution. Discard seeds that float. Let it stand for 15 minutes. Seeds are ready for sowing.	**Pests on seeds and seed pathogens**

Effect on humans

None.

Effect on no-target organisms

None.

Thundergod wine

Scientific name *Tripterygium wilfordii*

Plant parts used Roots

Mode of action Insecticidal

Formulation Look table 32

Table 32: Formulations for the Use of Thundergod wine

Materials	*Methods of preparation*	*How to use*	*Target pests*
Root extract			
1 kg powdered roots 200 liters of water	Dissolve powdered roots in water. Strain.	Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	**European corn borer**

Effect on humans

None; however the leaves and flowers are highly toxic when eaten. The roots have been used medicinally in China for over 400 years. A root extract of this plant was shown to safely and effectively reduce pain and inflammation in a small group of people with treatment-resistant rheumatoid arthritis.

Effect on non-target organisms

None.

Tinospora

Common names Makabuhay, Boraphet

Scientific name *Tinospora rumphii*

Plant parts used Roots and stem

Mode of action Insecticidal

Formulation Look table 33 on next page

Table 33: Formulations for the Use of Tinospora			
Materials	***Methods of preparation***	***How to use***	***Target pests***
Tinospora water extract			
200 grams of mature vines 1 liter of water Mortar and pestle Knife Pail Tap water *10-15 kg chopped vines are sufficient to treat rice seedlings needed to plant 1 ha.*	Chop vines into small pieces. Pound thoroughly. Add 1 liter of water. Stir with bamboo or wooden stick.	Soak rice seedlings into the water extract overnight before transplanting or spray seedlings before transplanting.	**Diamondback moth** **Rice blackbug** **Rice green leafhopper** **Rice stemborer**
Tinospora, Madre de cacao, hot red pepper extract			
1 kg of Makabuhay vines 5 kg of Kakawate 2 cups of hot red pepper Soap 1 tbsp alcohol 3 glasses of coconut milk Knife Pail Strainer	Pound the first 3 ingredients. Add 4 liters of water. Soak and strain. Add the alcohol, coconut milk, and soap as sticker. Stir thoroughly	For every liter of the extract, add enough water to fill-up a 20 liters calibrated sprayer. Spray on rice plants at weekly interval. Spray early in the morning or late in the afternoon.	**Rice pests**

Effect on humans

None.

Effect on non-target organisms

None.

Tomato

Scientific name *Lycopersicon esculentum*

Plant parts used Leaves, branches, stems

Mode of action Insecticidal, repellent

Formulations Look table 34 on next page

Table 34: Formulations for the Use of Tomato			
Materials	***Methods of preparation***	***How to use***	***Target pests***
Tomato leaf spray #1			
1-2 cups of tomato leaves 2 cups water Basin or pail Knife Strainer	Finely chop tomato leaves. Soak overnight in 2 cups of water. Strain and add 2 more cups of water.	Spray to cover infested plant parts thoroughly.	**Aphids** **Corn earworm**
Tomato leaf spray #2			
1kg of tomato leaves 17 liters of water 17 ml of soap Mortar and pestle Pail Strainer *This quantity is good for 1000 plants.*	Pound leaves, mix with water, and allowed to stand for some time. Filter. Stir-in soap.	Start application when larvae start to infest plants.	**Diamondback moth**

Effect on humans

None; however, avoid contact with your eyes.

Effect on non-target organisms

None. Avoid using spray to other nightshade crops (tobacco, pepper, eggplant, potato) because of the risk of spreading mosaic virus.

Turmeric

Common name Indian saffron, Yellow Ginger

Scientific name *Curcuma domestica*

Plant parts used Rhizome

Mode of action Repellent, insecticidal, antifungal

Formulation Look table 35

Table 35: Formulation for the Use of Turmeric			
Materials	***Methods of preparation***	***How to use***	***Target pests***
Turmeric rhizome extract			
20 gram of shredded rhizome 200 ml cow's urine 2-3 liters of water 8-12 ml of soap Pail	Soak shredded rhizome in cow's urine. Strain.	Dilute mixture with 2-3 liter of water. Add soap. Stir well. Spray on infested plant parts thoroughly, either early in the morning or late in the afternoon.	**Aphids** **Caterpillars** **Red spider mites** **Powdery mildew**

Effect on humans

None.

Effect on non-target organisms

None.

Vitex

Common name Chaste tree, Indian privet tree, Lagundi
Scientific name *Vitex negundo*
Family Verbenaceae

Plant parts used Leaves
Mode of action Antifeedant, , repellent

Formulation Look table 36

Table 36: Formulation for the Use of Vitex

Materials	*Method of preparation*	*How to use*	*Target pests*
Vitex leaf extract			
2 kg of vitex leaves 15 liters of water 10 ml of soap Cooking pot Strainer Pail	Soak leaves overnight in 5 liters of water. The next day, boil the mixture for 30 minutes. Cool then strain.	Add 10 liters of water, then the soap to the filtrate. Stir well. Spray thoroughly on infested plants.	**Armyworm** **Diamondback moth** **Hairy caterpillar** **Rice leaf folder** **Rice stem borer** **Semi-looper**

Effect on humans
None.

Effect on non-target organisms
None.

Wormseed

Common names Epazote, Mexican tea, Skunkweed
Scientific name *Chenopodium ambrosioides*

Plant parts used Leaves

Mode of action Repellent

Formulation Look table 37 next page

Table 37: Formulation for the Use of Wormseed

Materials	*Method of preparation*	*How to use*	*Target pests*
Leaf extract			
1-6 kg of leaves Water Grinder Pail	Grind leaves. Soak in sufficient amount of water for 24 hours. Strain.	Dilute filtrate with 20 liters of water. Spray on infested plants thoroughly. Spray early in the morning or late in the afternoon.	**General pesticide**

Effect on humans
None.

Effect on non-target organisms
None.

Wormwood

Common names Artemisia
Scientific name *Artemisia absinthium*

Plant parts used Whole plant
Mode of action Repellent

Formulations Look table 38

Table 38: Formulations for the Use of Wormwood

Materials	*Methods of preparation*	*How to use*	*Target pests*
Warmwood extract # 1			
1 kg of dried plant 10 liters of water 10 ml of soap Cooking pot Mortar and pestle Pail	Boil wormwood in water for 20 minutes. Set aside for 1 day. Strain. Add soap. Stir well.	Spray early in the morning on infested plant parts.	**Aphids** **Bugs** **Slugs** **Worms**
Warmwood extract # 2			
150 grams of fresh plant 1 liter of water 1 ml of soap Pail	Soak wormwood in water for a day. Filter. Add soap. Stir well.	Spray early in the morning on infested plant parts.	**Aphids** **Caterpillars** **Spider mites** **Weevils**
Warmwood extract # 3			
1 kg of fresh leaves 10 liters of water Knife Pail	Chop leaves. Soak in water for 1 day. Filter.	Spray early in the morning on infested plant parts.	**Turnip aphids**

Effect on humans
None.

Effect on non-target organisms
None.

Yam bean

Common names Jicama, Mexican Potato, Singkamas
Scientific name *Pachyrrhizus erosus*

Plant parts used Seeds
Mode of action Insecticidal, antifeedant

Formulations Look table 39 on next page

Table 39: Formulation for the Use of Yam bean			
Materials	***Method of preparation***	***How to use***	***Target pests***
Seed extract			
500 grams of seeds 20 liters of water Grinder Pail	Grind seeds. Soak in water for 1-2 days. Strain.	Spray early in the morning on infested plant parts.	**Aphids** **Flea beetles** **Stink bugs** **Leaf eating caterpillars**

Effect on humans

None.

Effect on non-target organisms

None.

III. 2. 2. Homemade solutions

III. 2. 2. 2 Other homemade solutions

Alcohol

Rubbing alcohol that contains 75% isopropyl can control several plant pests that are having waxy covering.

To control **mealybugs** and **scales** on a few infested plants, soak a cotton ball or dip a cotton swab in rubbing alcohol to wipe-off and kill the pests. Alcohol dissolves the wax that is covering the insect's body and its egg masses. Regularly monitor the plants to control the newly hatched nymphs and adults that you initially failed to control.

Table 40: Formulations for the Use of Aloe		
Method of preparation	***How to use***	***Pest controlled***
Rubbing alcohol spray		
Dilute 1 cup of rubbing alcohol with 4 cups of water.	Make a test on a few infested plants first. Wait for 3 days for damage **symptoms** to appear, such as burnt leaves. Make adjustment and do some experimentations on the alcohol and water ratio. When all goes well, proceed with the spot application- only treat the infested plant parts.	**Aphids** **Flea beetles** **Mealybugs** **Scale insects** **Thrips** **Whiteflies**

Ammonia Spray

Table 41: Formulation for the Use of Ammonia		
Method of preparation	***How to use***	***Pest controlled***
Ammonia spray		
Mix 1 part ammonia with 7 parts water.	Make a Spray on few infested plants first. Some plants have leaves that are sensitive to ammonia solution. Do not apply on hot weather. Do not apply on drought-stressed plants.	**Aphids** **Flea beetles** **Mealybugs** **Scale insects** **Thrips** **Whiteflies**

Flour spray

Flour, like soap, has been used as an old remedy for pest control. It has a sticky substance called 'dextrin', which is a sugar extracted from the plant starch by the action of heat. When applied as spray, dextrin adheres to the leaf surface and traps the pests until they die. It is important not to apply the filtrate during a cloudy day and/or when rain is expected.

Table 42: Formulations for the Use of Flour spray		
Methods of preparation	**How to use**	**Pest controlled**
Flour spray #1		
Add 2 cups of fine white flour into 5 -10 liters of water. Stir well.	Apply on the infested plants early in the morning, during sunny weather.	**Aphids** **Spider mite**
Flour spray #2		
Add 2 - 4 tbsp of wheat or potato or any baking flour into 4 cups of warm water. Stir well.	Add 1 tsp of soap as sticker. Stir the filtrate again prior to application.	**Aphid** **Spider mite** **Thrips** **Whitefly**
Flour spray #3		
Add 4 cups of white flour and 1/2 cup of buttermilk into 25 liters of water. Stir vigorously to mix the filtrate.	Apply immediately on the infested plants, preferably in the morning.	**Spider mite**

Plant ash

Ash is the residue of burned plant parts like; bark, wood, sawdust, leaves, woody debris, pulp, husk, hulls, fronds, and other plant debris. Ash has been used for soil liming and for traditional pest control to some crawling pests.

Table 43: Formulations for the Use of Plant ash

Method of preparation	*How to use*	*Pest controlled*
Ash-chili powder		
Sieve ash to remove the big particles. Grind finely dried pepper fruits. Mix 2 kg of ash with 50 g of powdered pepper.	Apply a pinch of pepper powder and ash mixture to the funnel of the plant when pinholes on the corn leaves are found. This formulation is good enough for a 0.4 ha area.	**Corn stalk borer**
Method of preparation / How to use		***Pest controlled***
Corn cob ash		
Place ash around the base of a young bean plant. A teacup full of ash is good enough for 5 plants.		**Ants**
Method of preparation / How to use		***Pest controlled***
Rice hull ash - or - Eucalyptus/cypress wood ash		
Sprinkle ash around the young plants or surround the whole plot with a shallow trench (8-10 cm wide) and fill it up with ash.		**Cutworm** **Snail** **Slug** **Turnip moth**
Method of preparation / How to use		***Pest controlled***
Plant ash		
Lay a thick layer of ash around the plants. This will prevent flies and moths laying their eggs near the stems.		**Cutworm** **Fly maggot**
Method of preparation / How to use		***Pest controlled***
Wood ash - lime		
Add ½ cup of wood ash and ½ cup of lime into 4 liters of water. Leave to stand for some hours. Strain to have a clear filtrate. Make a test on few infested plants first to make adjustment of the strength before going into large scale spraying.		**Cucumber beetle and maggots on cucurbits**

Soap spray

Soap has been used as an old remedy to control pests. Salts and fatty acids are found in many soaps which act as selective pesticides.

Table 44: Formulations for Soap spray

Method of preparation	*How to use*	*Pests controlled*
Method #1: Mix 2 teaspoons mild detergent with 4 liters of water.	1. Add soap to water. Use mild soap or potash-based soap. 2. Start with a lower concentration and make adjustments of the strength after testing on few infested plants. 3. Always try on few infested plants before going into full scale spraying. Soaps can cause burnt leaves on sensitive plants, like cole crops and certain ornamentals. Several applications in short periods can aggravate drying of leaves. 4. Apply on the infested plants thoroughly, including the undersides of the leaves. Spray early in the morning or late afternoon.	**Ants** **Aphid** **Fruit fly** **Leafhoppers** **Mealybug** **Psyllids** **Scales** **Spider mite** **Thrips** **Whitefly** **Black spot** **Canker** **Leaf spot** **Powdery mildew** **Rust**
Method #2: Mix 2 teaspoons mild detergent with 4 liters of water.		
Method #3: Mix 3 tablespoons of soap flakes (not detergent) with 4 liters of water.		
Method #4: Mix 1 tablespoon of dishwashing detergent with 1 cup of cooking oil, to make a stock solution. For a gallon of spray, add 5 to 8 tablespoons of stock solution to a gallon of water.		
Method #5: Mix 2 1/2 tablespoons of liquid soap to a gallon of water. Stir well		

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V. Appendix

V. 1 List of crops wherein Endosulfan is mostly used

Vegetable

- Cabbage and other crucifers
- Carrot
- Eggplant
- Garlic
- Lettuce
- Onion
- Pepper
- Squash and other cucurbits
- Tomato, etc

Grains/cereals

- Corn
- Rice
- Sorghum
- Sesame
- Wheat, etc

Root crops

- Cassava
- Sweet potato
- Potato, etc.

Pulses

- Cowpea
- Mungbean
- Peanut
- Pigeon pea
- Soybean
- String bean, etc

Fruits

- Banana
- Citrus
- Mango, etc.

Economic crops

- Coffee
- Cotton and other fiber crops
- Tea, etc

Forest trees

Forage crops

Oil crops

Ornamentals

IV. 2 List of pests wherein Endosilfan is mostly applied

Endosulfan is mostly applied to kill boring, chewing, and sucking insect pests, mites, and slugs and snails.

Insect pests

- **A**nts
- Aphids
- Armyworm
- **B**ean fly
- Bean pod borer
- Brown plant hopper
- **C**abbagehead caterpillar
- Cabbage looper
- Cabbage root maggot
- Cabbage webworm
- Cabbage white butterfly
- Carrot root fly
- Coffee berry borer
- Colorado beetle
- Corn borer
- Corn earworm
- Corn stalk borer
- Cotton bollworm
- Cotton boll weevil
- Cotton stainers
- Cutworm
- **D**iamondback moth
- **E**ggplant fruit and shoot borer
- **F**lea beetles
- Fruit fly
- **G**reen leafhopper
- Grasshopper
- **H**ornworm
- **J**apanese beetle
- **L**eafminer
- Leafhoppers
- Locusts
- Lygus bug
- **M**ango shoot caterpillar
- Mango tip borer
- Mealybugs
- **O**nion fly
- **P**otato tuber moth
- Psyllids
- **R**ice black bug
- Rice bug
- Rice caseworm
- Rice gall midge
- Rice leaffolder
- Rice stem borer
- Rice seedling maggot
- Rice whorl maggot
- **S**cales
- Seedcorn maggot
- Sorghum midge
- Squash bug
- Squash vine borer
- Stink bug
- Sweet potato vine borer
- Sweet potato weevil
- **T**ea mosquito bug
- Termites
- Tea tortrix
- Thrips
- Tomato fruitworm
- **W**hitefly

Mites

Snails and slugs

V. 3 Index of pests corresponding the pages they are mentioned

V. 4 List of photo credits

01 **Titelbild** S. Böthling, Montage: Reginald Bruhn

19 **Pheromone trap** Jewel Bissdorf

21 **Pitfall trap (graphic)** University of Wisconsin. Source: How to make a pitfall trap? http://www.entomology.wisc.edu/mbcn/pitfall.jpg

22 **Sticky board trap in the field** DANIDA**.** http://www.ipmthailand.org/en/Components/traps.htm (This site is no longer available.)

22 **Blue Sticky board trap** Ontario, Ministry of Agriculture and Rural Affairs http://www.omafra.gov.on.ca/english/crops/facts/03-075.htm

Beneficial insects

24 **Braconid**: IRRI & University of Queensland

24 **Cotesia**: Cornell University

25 **Damsel bug**: University of Georgia. http://www.cpes.peachnet.edu/lewis/1nabid.jpg

25 **Damsel fly**: IRRI and University of Queensland

26 **Diadegma**: Cornell University

26 **Encarsia**: Mark Hoddle, University of California

27 **Ground beetle**: IRRI and University of Queensland

27 **Hoverfly**: Photo source: Texas A&M University http://insects.tamu.edu/images/insects/color/sorghum/sor067.jpg

28 **Lacewing**: Clemson University http://entweb.clemson.edu/cuentres/cesheets/benefici/ce171.htm

28 **Ladybird beetles**: L. T. Kok

29 **Mealybug destroyer**: Photo source: Cornell Universityhttp://www.nysaes.cornell.edu/ent/biocontrol/ predators/cryptolaemus_m.html

29 **Minute pirate bug**: Texas A&M University

30 **Praying mantis**: R. Bessin, Univerity of Kentucky

31 **Rove beetles**: Jim Kalisch & Barry Pawson, UNL Entomology

31 **Spider**: IRRI and University of Queensland

32 **Tachinid fly**: IRRI and University of Queensland

33 **Tiphia wasp**: The Ohio State University

33 **Trichogramma**: Sylvie Chenus

Homemade solutions

34 **Aloe**: HEAR. http://www.hear.org

35 **Andrographis**: K. Vasisht, http:www.ics.trieste.it/MedicinalPlant/MedicinalPlant.aspx?id=6

35 **Basil** Jewel Bissdorf

36 **Butterfly bush** Sarasota Extension http://sarasota.extension.ufl.edu/FHLC/Inv/images/Butterfly_Bush.JPG

37 **Chili** Jewel Bissdorf

38 **Coriander** Wikipedia. http://en.wikipedia.org/wiki/Coriander

39 **Custard apple** Jewel Bissdorf

40 **Eupatorium** Albert Perdeck. http://www.csdl.tamu.edu/FLORA/imaxxast.htm

40 **Garlic** Jewel Bissdorf

42 **Ginger** Wikipedia. http://en.wikipedia.org/wiki/Ginger

43 **Gliricidia** HEAR. http://www.hear.org/starr/hiplants/images/600max/html/starr_070111_3221_gliricidia_sepium.htm

44 **Horsetail** Wikipedia. http://en.wikipedia.org/wiki/Equisetum_arvense

45 **Lansones** Jewel Bissdorf

45 **Lemongrass** Les Bohm

46 **Mammey** CIRAD. http://ecofog.cirad.fr/FLG/Plante.aspx?id=1

47 **Marigold** Jewel Bissdorf

48 **Neem** Manuel Parami

51 **Onion** Jewel Bissdorf

52 **Papaya** Jewel Bissdorf

52 **Pepper tree** HEAR. http://www.hear.org/starr/hiplants/images/600max/html/starr_070313_5608_schinus_molle.htm

53 **Pyrethrum** Wikipedia. http://en.wikipedia.org/wiki/Chrysanthemum

54 **Quassia** Wilkipedia. http://en.wikipedia.org/wiki/Quassia

54 **Red cedar** JB Friday, College of Tropical Agriculture and Human Resources. http://www.ctahr.hawaii.edu/forestry/Data/Species_Pages/Page_T.html

55 **Spanish needle**Michael Hassler, Karlsruhe University. http://www.rz.uni-karlsruhe.de/~db50/FOTO_-_Archiv/Bidens%20pilosa%20BotKA%20S1.jpg

55 **Stemona** Harald Greger, http://www.phytochemie.botanik.univie.ac.at/herbarium/living%20plants/stemona/tuberosa/pages/stemtub.htm

56 **Sweet flag** Wikipedia, http://en.wikipedia.org/wiki/Sweet_flag

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57 **Tinospora** Filipino Herbs Healing Wonders. http://www.filipinoherbshealingwonders.filipinovegetarianrecipe.com/

58 **Tomato** Jewel Bissdorf

59 **Turmeric** Kazou Yamasaki. http://home.hiroshima-u.ac.jp/shoyaku/photo/Thai/021207Curcuma.jpg

60 **Vitex** Kazou Yamasaki. http://home.hiroshima-u.ac.jp/shoyaku/photo/Phil/Vitex.jpg

60 **Wormseed** Forest and Kim Starr http://www.hear.org/starr/hiplants/images/hires/html/starr_030628_0154_chenopodium_ambrosioides.htm

61 **Wormwood** Botanischer Garten Ruhr-Universität Bochum http://www.boga.ruhr-uni-bochum.de/html/Artemisia_absinthium_Foto.html

61 **Yam bean** Philippine Medicinal Plants, http://www.stuartxchange.org/Sinkamas.htm

PAN Germany
Pestizid Aktions-Netzwerk e.V.

For more information on non-chemical pest management see:

www.oisat.org

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