Crops/ fruits/ vegetables

Pests/ diseases/ weeds

Medicinal plants

Fruit and vegetable processing

Natural pest control

Bio-pesticide: Bt

Images

(Bacillus thuringiensis)

Bio-pesticides: Copper, Sulfur

Biofumigation

Flour preparation

©

Mar 24, 2010 - Disclaimer

Search

Publications About us

Limit to Publications: TOF

Home Help Contact

You are here: Home > Plant Health > Natural pest control

Back

Print

Crops/ fruits/ vegetables

Pests/ diseases/ weeds

Medicinal

Images

plants

Fruit and vegetable processing

Natural pest control

Bio-pesticide: Bt (Bacillus thuringiensis)

Crops/ fruits/ vegetables

Pests/ diseases/ weeds

Images

Mexican marigold (Tagetes minuta)

- Medicinal plants
- Fruit and vegetable processing
- Natural pest control
  - Bio-pesticide: Bt (Bacillus thuringiensis)
  - Bio-pesticides: Copper, Sulfur
  - Biofumigation
  - Flour preparation
  - Hot-water treatment
  - Natural

© Ellis RP, Courtesy of EcoPort, www.ecoport.org

Mexican marigold has been successfully used in biofumigation against root-knot nematodes by a Kenyan farmer.

enemies

Mar 24, 2010 - Disclaimer

Images

Soil solarization

pesticide: Bt (Bacillus thuringiensis)
Bio-pesticides: Copper, Sulfur
Biofumigation
Flour preparation
Hot-water treatment
Natural enemies
Plant

- vegetables
- Pests/ diseases/ weeds
- Medicinal plants
- Fruit and vegetable processing
- Natural pest control
  - Bio-pesticide: Bt (Bacillus thuringiensis)
  - Bio-pesticides: Copper, Sulfur
  - Biofumigation
  - Flour

Images

© A. M. Varela

Homemade yellow sticky trap in a tomato field.

Homemade sticky trap to monitor thrips in French beans.

- preparation
- Hot-water treatment
- Natural enemies
- Plant extract: Garlic
- Plant extract: Neem
- Plant extract: Pyrethrum
- Soap spray
- Solarisation
- Traps and Bagging

Cultural practices

© B. Loehr

Homemade yellow sticky trap in a tomato field.

Yellow sticky trap


ISCA

- weeds
- Medicinal plants
- Fruit and vegetable processing
- Natural pest control
  - Bio-pesticide: Bt (Bacillus thuringiensis)
  - Bio-pesticides: Copper, Sulfur

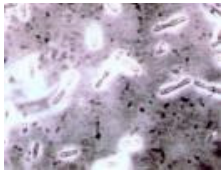
© Merle Shepard/Coastal Research & Education Center, Charleston, USA

sexmaculata) feeding on aphids. The adults are pink and black.

Mar 24, 2010 - Disclaimer

Print

- Crops/ fruits/ vegetables
- Pests/ diseases/ weeds
- Medicinal plants
- Fruit and vegetable processing
- Natural pest control
  - Bio-pesticide: Bt (Bacillus thuringiensis)
  - Bio-pesticides: Copper, Sulfur



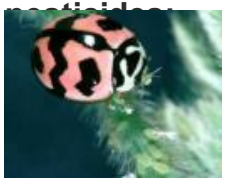
Bio-pesticide: Bt (Bacillus

Bio-pesticides:

Biofumigation

Flour preparation

Hot-water treatment



Natural enemies

Plant extract: Garlic

Plant extract: Neem

Plant extract: Pyrethrum

Soap spray

Solarisation

Traps and Bagging

Mar 24, 2010 - Disclaimer

Information of www.infonet-biovision.org

Biofumigation
Flour preparation
Hot-water treatment
Natural enemies
Plant extract: Garlic
Plant extract: Neem
Plant extract: Pyrethrum
Soap spray
Solarisation
Traps and Bagging
Cultural practices

neem

Plant extract: Neem
Scientific name: *Azadirachta indica*
Neem can be used against the following pests (clicking on underlined pests takes you to pests' page): African armyworm, African bollwom, Aphids, Banana weevil, Cabbage looper, Cabbage moth, Cabbage webworm, Coconut mite, Cutworms, Diamondback moth, Giant coreid bug, Giant looper, Grasshoppers, Jassids, Larger grain borer, Leafminers, Legume pod borer, Lima bean pod borer, Mealybugs, Nematodes, Onion-fly, Pod-fly, Pod-weevils, Riptortus bugs, Root-knot nematodes , Spider mites, Spiny bollworm, Spotted bollworm, Stink bugs, Thrips, Whiteflies

nation on Neem in Pest Control

The neem tree has over 100 compounds with pesticidal properties. The best known is azadirachtin. This substance is found in all parts of the tree, but it is much more concentrated in the fruit, especially in the seeds.

Neem is unique among plants with pesticidal properties since it has


Neem trees
© A.M. Varela

so many different effects on pests: It acts as a broad-spectrum repellent, insect growth regulator (it causes deformities in the insects' offspring) and insect poison. It discourages feeding by making plants unpalatable to insects or suppresses the insect's appetite (anti-feedant effect); if they still attack, it inhibits their ability to moult and lay eggs. Unlike most botanical insecticides, neem also has a somewhat "systemic" effect. This means that plants can take up neem extracts through their roots and leaves, spreading the material throughout the plant tissues. For this reason neem can help control pests like leafminers, which feed within leaves and are normally not affected by sprays that only cover the outsides of the plant.

Farmers and scientists have also observed a certain preventive effect of neem oil or seed extract against plant diseases such as mildews and rusts.

Neem products are effective against a wide range of pests; about 400 species of crop pests are known to be affected by neem extracts. In spite of its broad-spectrum action, neem products generally, would not harm natural enemies (like wasps, ladybird beetles, spiders, etc.). This is explained by the special mode of action of neem compounds, and by the feeding behaviour of natural enemies as well as the relatively low contact effect of neem products. The degree of effects on natural enemies is largely dependent on the type of formulation, and time, frequency and methods of applications.

Adults of predatory insects are apparently not affected by dosages of neem products recommended for effective pest control. However, their activity, fecundity and longevity may be negatively affected with high dosages. Hover flies are one of the most sensitive groups to neem applications. Parasitoids are in general less sensitive to neem products than predators. However, especially in very small species of parasitic wasps, treatment of the developmental stages of the host (for instance eggs or puparia of whiteflies) may have negative effects on the emergence rate, walking ability, searching ability, longevity and fecundity of the natural enemy.

In general, neem products based on neem oil or with high oil content have more or stronger side effects on non-target organisms than oil-free preparations. Thus, their application should be avoided or restricted on crops where natural enemies play an important role in pest control.

Some neem products, especially the ones with high oil content, are phytotoxic to some plants, this means plants may be burned when neem extract is used at a high dosage. Therefore, the extracts should be tested on few plants before going into full scale spraying.

Neem based pesticides are suitable for organic farming and for use in developing countries because leaf or seed extracts can easily be prepared without the use of expensive and complicated equipment. However, neem extracts are rapidly

'destroyed' when exposed to sunlight (UV, ultra-violet rays), which means they will loose their power. For this reason, commercial products usually contain a sunscreen, which protects the extract from sunlight, allowing a longer exposition to sunlight.

The effect of neem as a pesticide depends on the concentration of the active principles, on the formulation, on the pest type and on the crop.

Neem pesticides can be prepared from the leaves or from the seeds. The leaves or seeds are crushed and steeped in water, alcohol, or other solvents. For some purposes, the resulting extracts can be used without further refinement. Ground neem seeds or neem kernel powder (before or after oil extraction) is used as a soil amendment, and it is effective for control of nematodes. It is also used for control of stalk borers, and to prepare water extracts, which are then spray onto plants. (See more information on stemborer datasheets).

Neem has also been used to protect stored roots as well as tubers against the potato moth. Small amounts of neem powder are said to extend the storage life of potatoes for three months. (See more information on the potato datasheet).

Neem oil, extracted from the seed kernels, gives effective protection to stored beans, cowpeas, and other legumes.

In recent years, there have been a number of studies conducted to investigate the

particular effects of neem extracts on malaria-transmitting mosquitoes. There are indications that the most effective way to use neem is to apply seed extract to breeding sites when population numbers are low, during the dry season, in order to eradicate as many immature mosquitoes as possible and reduce the population available for breeding when conditions become more favourable. Once the rainy season commences, regular applications of seed extract should continue to prevent immature mosquitoes from emerging as adults (Gianotti et al, 2008).

Use as an insecticide: The seeds are the primary source of insecticides. They can be used in the form of simple aqueous extracts or as a basic raw material for formulated pesticides. The leaves are also used as simple aqueous (water) extracts.

Use as a nematicide: The neem cake, a by-product of oil extraction from the seeds, worked into the soil has shown to reduce to a considerable extent the reproduction and population density of numerous pathogenic nematode species.

Use as a fungicide: One of the latest discoveries is neem's potential application in the control of fungi that cause diseases to plants. Neem oil based emulsions have proven to be the most effective.

Use as a molluscicide and acaricide (miticide): These pests are only controlled on to a limited extent with neem. Neem showed deterrent effects on land snails. Alcoholic extracts, in particular, have a negative effect on the reproduction of spider mites.

The susceptibility of different groups of pests to neem products is shown on the table below.

Pests	Level of control	Recommended neem formulation
Beetle larvae, butterfly and moth caterpillars	excellent	aqueous neem extracts
Stalkborers	good	aqueous neem extracts and neem cake, neem powder
True bugs, plant- and leaf-hoppers Grasshoppers	good	neem oil, neem kernel extracts
Grasshoppers	good	neem oil
Adult beetles	good/ fair	aqueous neem extracts, neem cake powder, leaves, neem oil
Thrips, fruit flies, scale insects, mealybugs	fair/ poor	neem oil, aqueous neem extracts
Mites	fair/ poor	alcoholic extracts
Aphids and whiteflies	good/ fair	neem oil

Plant parasitic nematodes	**good**	**neem cake, neem leaves**

Standard Procedures for the Preparation and Application of Neem Extracts

- **Select healthy neem leaves that are free from diseases.**
- **When storing the 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 moulds before using them.**
- **Use utensils for the extract preparation that are not used for your food preparation and for drinking and cooking water containers. Clean all the utensils properly before and after use.**
- **Do not have direct contact with the crude extract while in the process of the preparation and during the application.**
- **Make sure that you place the neem extract out of reach of children and house pets while leaving it overnight.**

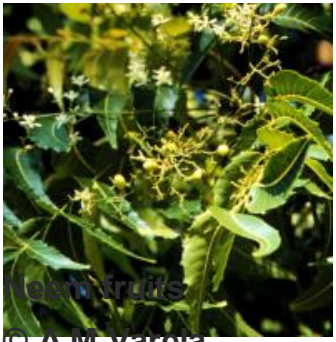
- **Harvest all the mature and ripe fruits on the crop to be sprayed before neem application.**

- **Always test the plant extract formulation on a few infested plants first before going into large scale spraying. When adding soap as an emulsifier, use a potash-based one such as gun soap (Kenya).**

- **Wear protective clothing while applying the extract.**

- **Wash your hands after handling the plant extract.**

How to Prepare Neem Water Extracts



© A.M.Varela

How to prepare neem water extracts from neem seeds:

- Grind 500 grams (g) of neem seed kernels in a mill or pound in a mortar.
- Mix crushed neem seed with 10 litres of water. It is necessary to use a lot of water because the active ingredients do not dissolve easily. Stir the mixture well.
- Leave to stand for at least 5 hours in a shady area.
- Spray the neem water directly onto vegetables using a sprayer or straw brush.

Neem water can be stored and will remain effective for 3 to 6 days if it is kept in the dark.

1. Collect allen neem fruitsfrom underneath the trees.
2. Remove the flesh from the seeds and wash away any remaining shreds washed away. In some regions in Africa such as the Indian Ocean Coast in Kenya and

Tanzania the seeds need not be taken off the tree or pulped when collected, as large colonies of fruit bats pluck the ripe fruit off the tree, during the night, suck off the sweet outer skin and then spit out the seed, which can be found lying under the trees the next morning.

3. Dry the seeds in airy conditions (in sacks or baskets) to avoid formation of mould.

4. When needed, shell the seeds, grate them finely, and soak them overnight in a cloth suspended in a barrel of water. Dosage: 50g of neem powder per litre of water. This solution is then sprayed on infested plants.

Removing pulp

© A.M.Varela

Detailed recipe to prepare 10 litres of Neem Seed Kernel Extract (NSKE):

1. Grind 500 grams (g) of neem seed kernels in a mill or pound in a mortar.

2. Mix crushed neem seed with 10 litres of water. It is necessary to use a lot of water because the active ingredients do not dissolve easily. Stir the mixture well.

3. Leave to stand for at least 5 hours in a shady area.

4. Spray the neem water directly onto vegetables using a sprayer or straw brush.

It has been estimated that 20 to 30kg of neem seed (an average yield from 2 trees), prepared as neem water can treat one hectare of crop.

Neem seeds ready for processing

Neem pesticides available in Kenya

- Neemros® and Neemroc® : Locally produced pesticides. Produced by Saroneem Biopesticides Limited. Babadogo road, opposite Catholic Church. P. O. Box 64373-00620 Nairobi. Contact: Mr. Dorian Rocco, Mobile: 0728592478, Email: saroneem@yahoo.com

- Achook: Manufactured in India and available in most Agrovet shops.

Precautions for using Neem Extracts/Formulations:

- Neem is almost non-toxic to mammals and is biodegradable. It is used in India as an ingredient in toothpaste, soap, cosmetics, pharmaceuticals and cattle feed. The leaves are used for tea. (Link to datasheet on neem as a medicinal plant for more information). However, the seeds and extracts of both neem and chinaberry trees are poisonous if consumed. Neem trees are very often confused with the Persian lilac or

chinaberry tree a relative of neem, which thrives a high altitudes, whereas neem thrives at low altitudes (up to 1200m).

- Because neem's chemical structure is so complex (the tree has many different compounds, many functioning quite differently and on different parts of an insect's life cycle and physiology), scientists believe it will take a long time for insects to develop resistance to it. However, to minimise the chance of affecting beneficials (natural enemies) and discouraging development of pest resistance, use neem sprays only when absolutely necessary, and only on plants you know are affected by pests.

- Neem extracts do not kill insect pests immediately. They change the feeding behaviour and life cycle of the pests until they are no longer able to live or reproduce. Effects are often not visible before 10 days after application. Consequently, severe pest attacks will not be controlled within time. For a reliable and satisfying control, neem extracts must be applied at an early stage of pest attack.

- Neem products break down fairly quickly - usually within 5 to 7 days - in sunlight and in the soil, so you may need to repeat the application during the growing season to deal with new pests that arrive from outside during this time.

- Neem work fastest during hot weather. Heavy rains within a few days of application may wash off the protective cover of neem on plants. Reapply if pests are a problem.

- If crops have to be watered, water should be targeted to the soil because water running over the leaves of sprayed plants may wash off the neem water extract.

Information Source Links

- **Ellis, B.W. and Bradley, F.M. (1992). The Organic Gardener's Handbook of Natural Insect and Disease Control. Rodale Press. ISBN:0-87596-753-1**
- **HDRA. Leaflet The Neem tree, see also online under http://www.gardenorganic.org.uk**
- **Hellpap, C. (1995). Practical results with neem products against insect pests, and probability of development of resistance. Pest of selected field crops. Corn. In The Neem tree- Source of Unique Natural Products for Integrated Pest Management, Medicine, Industry and Other Purposes. Ed. by H. Schmutterer. pp 385-389. ISBN: 3-527-30054-6.**
- **Lemmens, R.H.M.J., Soerianegara, I., Wong, W.C. (1995). Plant resources of Southeast Asia No. 5 (2). Timber trees: minor commercial timbers. Leiden, Netherlands: Backhuys Publishers.**
- **Maundu, M. and Tangnas, B. (2005). Useful trees and shrubs for Kenya. World Agroforestry Center.**
- **Schmutterer, H. (Ed.) (1998). The Neem tree- Source of Unique Natural Products for Integrated Pest Management, Medicine, Industry and Other Purposes. pp 385-389. ISBN: 3-527-30054-6.**
- **Siddiqui, K.M. (1995). Neem, its occurrence, growth and uses. Peshawar, Pakistan: Pakistan Forest Institute.**
- **Tewari D.N. (1992). Monograph on neem (*Azadirachta indica* A. *Juss.*). Dehra Dun, India: International Book Distributors.**
- **Gianotti, R. L.; Bomblies, A.; Mustafa Dafalla, M. Issa-Arzika,I., Duchemin, J-B and Eltahir, E. AB. (2008). Efficacy of local neem extracts for sustainable malaria vector**

control in an African village. Malaria Journal 2008, 7:138 doi:10.1186/1475-2875-7-138. http://www.malariajournal.com

Local Reference Address for Neem Products

- **Health products and Neemros® and Neemroc®, locally produced pesticides. Produced by Saroneem Biopesticides Limited. Babadogo road, opposite Catholic Church P. O. Box 64373-00620 Nairobi. Contact: Mr. Dorian Rocco Mobile: 072 8592478, email: saroneem@yahoo.com saroneem@yahoo.com**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Bio-pesticide: Bt (Bacillus thuringiensis)

Bio-pesticide: Bt (Bacillus thuringiensis)
Scientific name: *Bacillus thuringiensis*
Bt can be used against the following pests (clicking on underlined pests takes you to pests' page): African armyworm / African bollworm / Bean armyworm / Beet armyworm / Cabbage webworm / Cabbage moth / Cabbage looper/ Cotton leafworm / Diamondback moth / Giant looper / Green looper / Spiny bollworm / Spotted bollworm / Pod

borers / Tomato looper

General information on Bt

Bt is a naturally occurring soil bacterium that causes disease on insect pests. It is accepted in organic farming and is considered ideal for pest management due to its low cost, ease of application, high virulence and narrow host specificity. Thus, Bt is regarded as environmentally friendly with no toxic effects on natural enemies and humans. The activity of Bt is due to toxins produced by this bacterium.

Bt is commercially available in most agricultural suppliers. It is sold in various formulations (spray, dust, and granule) and strains (Bt *tenebrionis*, Bt *kurstaki*, Bt *israelensis*, Bt *aizawai*, Bt *san diego*). Bt products in Kenya are sold under the following commercial names: Dipel, Javelin, Thuricide and Xentari. Note that not all Bt can be used for control of caterpillars. Bt *israelensis* is used for control of mosquitoes and Bt *tenebrionis* for control of beetles.

How does it work?

Bt must be ingested by a susceptible host to be effectiv. When ingested, Bt produces proteins that react with the cells of the stomach lining. These (proteins) poison and paralyze the insect's digestive system causing the insect to stop feeding within hours. Bt-infested insects will live for several days but will cause no further damage

to the plant. They will die eventually from starvation.

How to use Bt

1. Spray thoroughly, covering all the plant surfaces.
2. Apply when larvae are less than 5 mm long or when the eggs begin to hatch. Bt works best on young larvae.
3. In the hot tropics, it is more effective to spray Bt in the late afternoon as there are longer and cooler hours ahead. This enables Bt to remain longer on the leaves' surfaces. Bt survives better in cooler temperature. Whereas, spraying in the morning provides a shorter and hotter environment.
4. Do not mix the Bt concentrate with alkaline water (pH 8 or higher). Alkalinity reduces its effectiveness. To make the water acidic, add a few tablespoons of white vinegar in a gallon of water before adding Bt.

Information Source Links

- **ICIPE: www.icipe.org**
- **OISAT: Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Plant extract: Pyrethrum

Plant extract: Pyrethrum
Scientific name: *Chrysanthemum cinerariaefolium* and *C. coccineum*, *Tanacetum cinerariifolium*
Pyrethrum flower extracts can be used against the following pests and diseases (clicking on underlined pests takes you to pests' page): African armyworm, African bollworm, Aphids, Cutworms, Spider mites, Thrips, Whiteflies, Maize stalk borers, Potato jassids

General Information on Pyrethrum, Pyrethrins and Pyrethroids

Pyrethrum and Pyrethrins

Pyrethrum is a natural insecticide derived from 100% African *Chrysanthemum cinerariaefolium* flowers, but also in *C. coccineum* and *C. marshalli* flowers (members of the daisy or aster family). They are perennial plants with a daisy-like appearance and white flowers. The flowers possess insecticidal properties. Pyrethrum has been used for centuries as an insecticide and as a lice remedy. Because it decomposes rapidly in the environment, pyrethrum has been approved for a wide range of indoor and outdoor uses, including homes, restaurants, broad-scale spraying operations, and organic farms.

Considered nonsynthetic, Pyrethrum is allowed in some countries for organic home gardens. Preventive, cultural, mechanical and physical methods must be first choice for pest control, and conditions for use of a biological or botanical material must be documented in the organic system plan.

Pyrethrum is most productive at altitudes of above 1600 meters and ideally in semi-arid conditions where winters are cool. On richer soils the insecticidal properties are reduced. The content of the active substances increases with altitude and cooler average temperatures.

You will often find pyrethrum mixed with a synergist such as piperonyl butoxide (PBO). PBO gives pyrethrum an added "kick" that makes it more effective against insects. Only a few are approved for organic production.

Formulations and Application guidelines:
Pyrethrum is sometimes available blended with rotenone to increase the range of pests controlled (i.e. flea beetles) and perhaps efficacy. However, mixing insecticides against a specific target insect is not recommended because it will promote the development of resistance. Currently, none of these mixtures is approved for organic-farming.

Liquid formulations typically contain 0.1-6 % pyrethrum and up to 60% PBO (not

permitted); dusts contain 0.2-0.4 % pyrethrum.

Application tips:
Care should be taken not to mix pyrethrum with lime, sulfur, or soap solutions, since pyrethrum is broken down by both acid and alkaline conditions.

Pyrethrum is rapidly broken down by sunlight. Use of UV-inhibiting adjuvants may allow for a longer period of control. Growers should decide whether the advantage of having a longer activity period for pyrethrum to protect the crop from reinfestations is appropriate for their management system, or would be a concern for its impact on beneficial species.

Since pyrethrum is a contact poison the target pest must be present and hit by the spray. Flighty insects such as cucumber beetle should be sprayed early in the morning when they are sluggish and bee pollinators have not begun.

Pyrethrins

Pyrethrins are the six constituent compounds with insecticidal properties that occur in these Chrysanthemum species. The pyrethrum daisy is native to southwest Asia. Kenya is the leading producer of pyrethrum followed by Australia.

In Kenya, the active ingredients from the pyrethrum plants, are commercially available

in most places under different commercial names such as "Flower-DS". They are broad spectrum insect nerve poisons approved for controlling pests on flowers, fruits and vegetables in the garden and greenhouse. They can be used to control most *aphids, cabbage loopers, leafhoppers, spider mites, stink bugs, thrips* and *whiteflies*.

Pyrethrins are effective in controlling weevil and normally recommended, but not accepted if sales are planned under organic systems.

Py-Mack, is a byproduct of the pyrethrin manufacturing industry, and is used as cattle feed. Most of the pyrethrins have been extracted, but enough remains that py-mack can be used as cutworm bait, and in treating early attacks of maize stalk borer. Feeding livestock py-mack is also said to reduce incidents of intestinal worms.

Efficacy
Older studies: Pyrethrum is a broad-spectrum insecticide used to control true bugs, caterpillars, beetles, aphids, flies, mites, whiteflies, thrips and leafhoppers (Casida 1973). Within these groups, pests may have a greater or lesser susceptibility to pyrethrum products. Specific pest species controlled by pyrethrum as noted in the older literature include potato leafhopper, beet leafhopper, cabbage looper, celery leaf tier, Say's stink bug, twelve-spotted cucumber beetle, six-spotted leafhopper, lygus bugs on peaches, grape thrips, flower thrips, grape leafhopper, and cranberry fruitworm. It was not considered particularly effective against flea beetles, imported cabbageworm, diamondback moth, aphids on spinach, or lygus bugs on alfalfa

(Casida 1973).

Recent studies: A summary of recent university field trials of pyrethrum products on vegetable crops commonly grown in the Northeast was compiled. These university-based trials typically test products with untreated buffer rows and other conditions that create unusually severe pest pressure.

The level of pest control is likely to be higher on fields in which a good program of cultural controls has been implemented.

Pyrethroids

Note: In contrary to the above mentioned natural extracts, Pyrethroids are of the worst and most persistent pesticides!
Pyrethroids are synthetic compounds whose structure and mode of action are similar to pyrethrins but they are not approved for use in organic production. There are many pyrethroids including Ambush®, Ammo®, Aztec®, Pounce® and Warrior ®.

Standard Procedures for the Preparation and Application of Pyrethrum Extracts

1. Pick the flowers on a warm day when they are fully open. Select healthy, non-

mouldy pyrethrum flowers.

2. Pile them up into small heaps in the sun to warm through. Then spread out to dry on thick mats in a shady area.

3. If they are to be stored 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. Light breaks down the active ingredients of the flowers, reducing effectiveness.

4. Make sure that flowers are free from moulds before using them.

5. Do not store pyrethrum for long periods. The active ingredients in pyrethrum flowers break down with time. Farmers get the best price for pyrethrum at the factory gate if delivered within three months of harvesting. After that, the active ingredients start breaking down. A six month old dried flower may only have half the amount of active ingredients compared to a freshly dried flower.

6. Use utensils for the extract preparation that are not use for your food preparation and for drinking and cooking water containers. Clean properly all the utensils every time after using them.

7. Avoid direct contact with the crude extract while in the process of the preparation and during the application.

8. Make sure that you place the plant extract out of reach of children and house pets while leaving it overnight.

9. Harvest all the mature and ripe fruits of the crops to be sprayed before treating with pyrethrum.

10. Always test the plant extract formulation on a few infested plants first before going into large scale spraying.

11. When adding soap as an emulsifier, use a potash-based one. Liquid dish soap is easier to use.

12. Wear protective clothing while applying the extract.

13. Wash your hands after handling the plant extract.

14. Observe withholding period. Pyrethrum and pyrethrins has a one-day withholding period, as the active ingredients break down quickly in sun light.

Precautions:

- **Pyrethrin and pyrethrum insecticides are mildly to toxic to mammals. Prolonged contact with the skin can produce a rash, and inhaling dust or spray can cause headaches and sickness.If you suffer from hay fever, avoid contact with pyrethrum flowers or py-mack. Some people have allergic reactions to them.**
- **Pyrethrins and related products tend to work best at lower temperatures and cloudy conditions. The efficiency is reduced when sprayed at midday on a hot day.**
- **Pyrethrin and pyrethrum insecticides will kill lady beetles, but do not appear to be harmful to bees.**
- **Though the effect of pyrethrum is as a nerve poison, the insects can sometimes**

recover from the amounts required to produce a knock down effect within 24 hours (especially if the extract is made from slightly older flowers). Close observation is required to ensure complete death of the targeted pests. If they recover it means a higher concentration is needed.

Recipes for Pyrethrum in Pest Control

Pyrethrum is used in two ways: as a powder or dust and as a spray.

Pyrethrum powder:
Grind flowers to a dust. Use pure or mix with a carrier like talc, lime or diatomaceous earth (DE). Sprinkle over infested plants. Py-mack can be used in a similar manner.

Pyrethrum spray:
1. Mix 20g pyrethrum powder with 10 litres water. Soap can be added to make the substance more effective but it is not vital. Strain and apply immediately as a spray. For best effects this should be applied in the evening.

2. The active ingredients can also be extracted by alcohol. Mix one cup powdered pyrethrum flowers with1/8 cup of isopropyl alcohol (the blue alcohol used in house

cleaning) or kerosene. Cover the container and let it sit overnight. Strain through a clean cotton cloth, then store the extract in a tightly sealed and labeled container. When you need to use it, add three liters of water to the extract and spray.

3. Dofour preparation (for large scale spraying): 1 to 1.5 kg dried pyrethrum is mixed into 100 Litres of water and 3 litres of liquid dish soap. Strain and spray. The addition of soap is supposed to increase the efficacy four-fold.

Information Source Links

- **Cornell University. Ressource guide to organic insect management. www.nysaes.cornell.edu/**
- **Ellis B.W. and Bradley, F.M. (1992). The Organic Gardener's Handbook of Natural Insect and Disease Control. Rodale Press 1992. ISBN:0-87596-753-1**
- **Herb Herbert Fact Sheet on Pyrethrum: http://www.herbherbert.com/pdf/pyrethrum.pdf**
- **OISAT: Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Plants For a Future Database: http://www.pfaf.org/database/plants.php?Tanacetum+cinerariifolium**
- **Stoll, G. (1988). Natural Crop Protection in the Tropics. A CTA publication from**

AGRECOL, Switzerland.

- **Casida, J. E. and G. B.Quistad, eds. 1995. Pyrethrum Flowers?Production, Chemistry, Toxicology, and Uses. Oxford University Press, Oxford**
- **Casida, J. E., ed. 1973. Pyrethrum, The Natural Insecticide. Academic Press, New York. Cox, C. 2002. Pyrethrins/Pyrethrum Insecticide Factsheet. Journal of Pesticide Reform 22(1) 14-20.**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Plant extract: Garlic

Plant extract: Garlic
Scientific name: *Allium sativum*
Garlic can be used against the following diseases (clicking on underlined diseases takes you to diseases' page): African bollworm, Downy mildew, fruit rots, rusts, blights, African armyworm, onion thrips, root knot nematodes, anthracnose, rice blast

Standard Procedures for the Preparation and Application of the Plant Extracts

Botanicals are derived from plants. Many plant products are said to have pesticidal

properties. They are natural products and most of them break down quickly on the leaves or in the soil. However, there is very little information on their effective dose rates, their impact on beneficial organisms or their toxicity to humans.

Garlic is widely cultivated and easy to grow in field, garden or backyard. It is appreciate as a seasoning or condiment for cooking and due to its medicinal properties. Its value as a pesticide is also appreciated particularly in organic farming and cultivation in the backyard garden. There are commercial pesticides containing garlic as an active ingredient, and homemade extracts are widely used.

Garlic has anti-feedant (insect stop feeding), bacterial, fungicidal, insecticidal, nematicidal and repellent properties.
Garlic is reportedly effective against a wide range of disease-causing pathogens and insects at different stages in their life cycle (egg, larvae, adult). This includes ants, aphids, armyworms, diamondback moth and other caterpillars such as the false codling moth, pulse beetle, whitefly, wireworm, khapra beetle, mice, mites, moles, Epilachna beetles, and termites as well as fungi bacteria and nematodes.

Garlic is non-selective; it has a broad-spectrum effect and can kill beneficial insects as well. Therefore it should be used with caution. It is not recommended for aphid control since it kills the natural enemies of aphids. Adult ladybird beetles seem not to be affected by garlic sprays (Ellis et al. 1992) (Brooklyn Botanic Garden, 2000: p. 98). Drenching with garlic extracts to control soil nematodes, although effective, should

be avoided since it may also kill many beneficial soil bacteria and insects.

When growing garlic for pest control, it has been recommended avoiding use of large amounts of fertilisers. This is because heavy doses of fertiliser reduce the concentration of the effective substances in the garlic (HDRA).

General recommendations for preparing and using garlic extracts:

1. Select plant parts of garlic that are free from diseases.

2. Store garlic bulbs in a cool, dry shady place. The most common practice for storing garlic is to braid the dry tops and let the bulbs cure while hung up in the tops. Another method is storing in a single layer in a well-ventilated shady and dry place as practised for onions.

3. Use clean utensils and make sure they are cleaned again directly after use

4. Do not have a direct contact with the crude extract while in the process of the preparation and during the application.

5. Make sure that you place the plant extract out of reach of children and house pets while leaving it overnight.

6. The taste of garlic will remain on sprayed plants for some time after spraying so it may be best to avoid spraying near harvest time, or to harvest all the mature and ripe fruits on the crop to be sprayed before plant extract application.

7. Try out different strengths of the garlic extract to determine effective dosages for specific pests.

8. Always test the plant extract formulation on a few infested plants first before going into large scale spraying. When adding soap as an emulsifier, use a potash-based one like laundry soap (e.g gun soap).

9. Wear protective clothing while applying the extract.

10. Wash your hands after handling the plant extract.

Garlic Bulb Extract

Garlic bulb extract is used against downy mildew, fruit rots, rusts and blights.

Materials:

2 garlic bulbs
Few drops of soap
4 cups of water
Grinder or knife
Strainer
Bottle container

Methods of preparation:

Grind garlic. If you do not have a grinder, chop garlic.
Allow mixture to stand for 24 hours.
Add water and stir in the soap.
Store in bottle container.
Strain before using.

How to use:

Dilute one part of the emulsion with 9 parts of water.
Shake well before spraying.
Spray thoroughly on the infested plant, preferably early in the morning.

Effect on humans: None

Effect on non-target organisms: Garlic oil spray has a 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 present.
Adult lady beetles seem not to be affected by garlic sprays (Ellis et al. 1992).
(Brooklyn Botanic Garden, 2000: p. 98)

Garlic Bulb Extract II

Garlic Bulb Extract II

Used against the following pests and diseases:

African bollworm, African armyworm, onion thrips, root knot nematodes, anthracnose, downy mildew, rice blast.

Materials:

85 grams of chopped or crushed garlic
50 ml of mineral oil (vegetable oil)
10 ml of liquid dish soap
950 ml of water
Strainer
Bottle container

Methods of preparation:

Add garlic to vegetable oil.
Allow mixture to stand for 24 hours.
Add water and stir in the soap.
Store in bottle container.

How to use:

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.
(adapted from Vijayalakshmi et *al*. 1999; Ellis et *al.* 1992)

Garlic Bulb Extract III

Ingredients:
100 g garlic cloves
0.5 litres of water
10 gm soap
2 teaspoons mineral oil

Steep the finely grated garlic for 24 hours in the mineral oil. Dissolve the soap in the water, mix the infusion of garlic and mineral oil, stir well together and filter through a fine cloth. Before use dilute this solution with 20 parts of water.

The following preparation is successful against caterpillars in fruit trees:
Two finely grated garlic bulbs and two spoon chilli peppers are stirred into four litres of hot water in which a nut-sized piece of soap has been dissolved.

Information Source Links

- **Brooklyn Botanic Garden. (2000). Natural disease control: A common-sense approach to plant first aid. Handbook # 164. Brooklyn Botanic Garden, Inc. 1000 Washington Avenue, Brooklyn, NY.**
- **Ellis, B. W. and Bradley, F.M. (1992). The Organic Gardener's Handbook of Natural Insect and Disease control. Rodale Press. ISBN 0-87596-753-1**
- **HDRA - the organic organisation. How to Use Garlic as a Natural Pesticide. www.hdra.org.uk**
- **OISAT: Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Vijayalakshmi, K., Subhashini, B., Koul, S. (1999). Plants in Pest Control: Garlic and onion. Centre for Indian Knowledge Systems, Chennai, India.**
- **wwbota.free.fr**
- **www.howtopedia.org**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Hot-water treatment

Hot-water treatment

Hot-water treatment of seeds is used against the following diseases (clicking on underlined diseases takes you to diseases' page): Anthracnose / bacterial blight / bacterial leaf streak / bacterial spot / black rot / black leg / black scurf / black spot / common blight / powdery scab / ring spot / early blight / septoria spot / Phytophtora (pineapple)

Hot-water treatment of seeds can be used for the following crops: Spinach / brussels sprouts / cabbage / pepper / tomato / eggplant / broccoli / cauliflower / carrot / collard / kale / kohlrabi / turnip / mustard / cress / radish / lettuce / celery / celeriac / banana / mango / pineapple / potato

Hot-water treatment can be used against the following pests: Fruit flies (on mango fruits) / Banana weevil (on banana suckers) / Mealybugs (cassava and pineapple) / Nematodes (banana suckers and pineapples)

Hot-water treatment for seeds

Hot water treatment of own seed to prevent seed borne diseases such as black rot, black leg, black spot and ring spot of crucifers is recommended. This treatment helps reduce the seed-borne pathogens such as *Alternaria* spp., *Colletotrichum* spp.,

Phoma spp., _Septoria_ spp., and bacterial pathogens (_Pseudomonas_ spp., and _Xanthomonas_ spp). However, specified temperature and time interval must be strictly followed in order to maintain seed viability. Use a good thermometer or better ask for assistance from qualified personnel from your local extension office. To make sure that the seed is not damaged it is advisable to test the germination of 100 heat-treated and 100 untreated seeds.

For potato tubers heat treatment of 10 min in water at 55°C was used. The same treatment of naturally or artificially contaminated seed tubers gave complete absence of blackleg infection in the field and decreased the amounts of powdery scab (_Spongospora subterranea_) and black scurf (_Rhizoctonia solani_) on progeny tubers.

Procedure:

1. In a large pot put plenty of water, heat the water to the required temperature.
2. Place seeds in loose cotton bag and submerge it in water. Follow strictly the recommended temperature and the time required. It is important that the water is maintained at a uniform temperature throughout the container. Constantly stir the water while soaking the bag. Suspend the bag and do not let it touch the bottom of the pot.
3. Remove the bag and cool it in clean cold water to stop the heating.
4. Spread the seeds on a clean dry paper to cool and dry.
5. Preferably do not store treated seeds. Sow them immediately on well-prepared

seedbeds.

Storing seeds:

If treated seeds cannot be sown immediately, a good way to store the seeds is as follows:

- **Dry the seeds in the indirect sun until they are completely dry.**
- **Take a clean jar, pot or bottle of clear non-coloured glass and place a clean piece of cloth with warm ashes in the bottom. You should be able to touch the ashes without burning yourself. Close the container well and let the ashes cool. By adding ashes, any water that gets in the container will be absorbed by the ashes and will prevent the seeds from moulding and rotting**
- **After an hour or so, the ashes should be cool and you can then place the seeds, loose or wrapped in a transparent plastic bag, in the container. Close the container with a piece of plastic (in case of a bottle with a cork). Spread about 2 mm layer of grease or vaseline over the plastic or cork so that the edges are covered to prevent moisture getting into the container.**
- **Store the container in a cool, dry place.**
- **Check regularly if mould has formed on the seeds. If the seeds were dried well, the chance that mould would develop is very small. However, should you see mould, dry the seed again.**

Heat treatment recommendations:

Potato tuber: 55°C for 10 min
Spinach, brussels sprouts, cabbage, pepper, tomato, eggplant: 122°F/50°C: 30 minutes
Broccoli, cauliflower, carrot, collard, kale, kohlrabi, turnip: 122°F/50°C: 20 minutes
Mustard, cress, radish: 122°F/50°C: 15 minutes
Lettuce, celery, celeriac: 118°F/47°C: 30 minutes
(Nega et al, 2003)

Hot-water treatment for mango fruit

Hot water treatment (HWT) is also recommended for mango fruits as an effective post harvest treatment to minimise fruit fly damage and anthracnose.
For large commercial enterprises it is possible to immerse mango fruits in a water bath with constant temperature of 48°C for 45-60 minutes. According to Joshi et al. (1995) this gives 100 % control of fruit fly eggs. Temperature control is very important as fruit can be damaged by hot temperatures.

For smaller operations, immersing mango fruits in water bath of 50°C for 5 minutes is recommended.
Caution: Do not use this method without a good thermometer to measure the temperature, as fruits can be damaged by too hot temperatures.

Hot-water treatment for banana suckers

Hot-water treatment of suckers helps against banana weevil. Recommendations suggest immersing clean trimmed suckers in a bath with hot water at 52-55°C for 15-27 minutes before planting. There have been reports of hot water treatment killing remaining eggs and a high percentage of grubs. For example, Gettman et al. (1992) reported over 99% mortality of weevil eggs and grubs when suckers of dessert bananas were placed in a water bath of 43°C for 3 h. However, other sources indicate that hot baths are very effective in eliminating nematodes, but kill only a third of the weevil grubs. Thus, clean planting material is likely to provide protection against weevil for several crop cycles (Gold and Messiaen, 2000).

Hot-water treatment for pineapple plantlets for transplanting

Hot water treatment (50°C for 30 min to 2 hours) of planting material is efficient and

can control both mealybugs, *Phytophthora* and nematodes on pineapple plantlets. After this treatment it is important to drip dry the planting material to avoid fungus attack and deterioration.

How can the temperature be controlled?

A simple method for farmers to control temperature has been developed in Kenya. It consists of a pith block (of about 3 cm3) or a small piece of wood tied to an iron plate (3 x 3 cm and weighing about 10 g) covered with a thin film of candle wax. This device is allowed to sink in a half-empty oil drum with water, in which the banana material to be treated is placed. Wood is burnt underneath the drum, when the temperature rises to 55°C the wax melts releasing the pith or piece of wood, which then floats to the surface. At this moment the firewood is removed. (Prasad and Seshu Reddy, 1994).

Information Source Links

- **Mackay, J. M., Shipton, P. J. (1983). Heat treatment of seed tubers for control of potato blackleg (Erwinia carotovora subsp. atroseptica) and other diseases. Plant Pathology 32, 385-393. Published online under http://www3.interscience.wiley.com/**
- **Nega, E., Ulrich, R., Werner, S. und Jahn, M. (2003). Hot water treatment of**

vegetable seed - an alternative seed treatment method to control seed borne pathogens in organic farming. Journal of Plant Diseases and Protection 110(3):pp. 220-234. http://orgprints.org/7672/

- **Prasad, J.S., Seshu Reddy, K. V. (1994). Hot water treatment for banana planting material made easier. In: Infomusa, Vol. 3 (2), 16.**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Bio-pesticides: Copper, Sulfur

Bio-pesticides: Copper, Sulfur
Copper can be used against the following pests/diseases: Alternaria fruit spot / Anthracnose / Armillaria root rot / Bacterial black spot / Bacterial blight of coffee / Bacterial spot / Brown spot / Coffea leaf rust / Common blight / Downy mildew / Early blight / Leaf blight / Late blight / Phaeoramularia fruit and leaf spot / Phytophthora blight
Sulfur can be used against following pests/diseases: Powdery mildews, Rusts, Leaf blights, Fruit rots, Spider mites, Psyllids and Thrips

Some Pesticides Permitted in Organic Gardening

If we think organic gardening means vegetables free of any chemical pesticides, we don't have the story quite right.

Organic gardeners can use certain pesticides -- chemicals that are derived from botanical and mineral-bearing sources. These chemicals may be highly toxic, but they break down more rapidly than common chemicals, such as the Sevins, Malathions and 2,4,Ds.

The use of botanical and mineral-bearing pesticides, even though some are toxic, also can be incorporated into an Integrated Pest Management (IPM) approach to growing crops. IPM relies on a variety of pest control means rather than on one product or method. The pesticides discussed below are appropriate to include in IPM programs.

Just as the more common chemicals are given toxicity ratings -- CAUTION, WARNING or DANGER -- so are chemicals from botanical and mineral-bearing sources. "CAUTION" means low toxicity or completely free from danger; "WARNING" means moderately toxic and "DANGER" means highly toxic. The toxicity rating for each pesticide is provided in the paragraphs below.

General information on copper

There are many copper compounds used as fungicides. Recommended is Bordeaux mix which is a combination of copper sulphate and hydrated lime. Other compounds include Copperoxychloride.

Copper fungicides were formerly accepted in organic farming provided that the number of applications was strictly followed and a proper soil amendment is observed to prevent copper accumulation in the soil, and can still be accepted with permission from the certifying authority. (Other fungicides such as Sulphur (Thiovit) are being tested by CIP).

In wet weather fungicide sprays should be applied as soon as the disease is observed or as soon as local experience suggests that weather conditions are favourable for disease development.

Crop scouting should be used as a guide in making a decision on whether to apply a fungicide. And when applying fungicides, safety procedures in application must be complied with, particularly, in use of protective clothing. Observe right dosage and prescribed pre-harvest intervals. Ask your local agricultural extentionist on locally registered fungicides.

Bordeaux mixture is primarily a fungicide that controls bacterial leaf spots, blights, anthracoses, downy mildews and cankers. It also repels many insects. The compound is labeled for use on many vegetables, tree fruits and nut crops.

Bordeaux, as with sulfur and lime sulfur, can be phytotoxic to plants. If applied in cool, wet weather, it may burn leaves or cause russeting of fruit.

Bordeaux mix spray

Materials needed to make a gallon mixture

- **3 ½ tbsp of copper sulphate**
- **10 tbsp of hydrated lime**
- **1 gallon of water (4 liters of water)**
- **Wooden stick**
- **Plastic bucket**

How to prepare?

1. **Add copper sulphate and hydrated lime in water. Make sure to use plastic container**
2. **Stir well using a wooden sick or ladle**
3. **Protect self from direct contact with the solution**

How to use?

1. Spray plants thoroughly preferably early in the morning, in a dry and sunny day. In this way, the plants have the time to dry and the solution can not penetrate into the leaves' tissues
2. Constantly shake the sprayer while in the process of application to prevent the solution from clogging

Pest controlled

1. Flea beetles on tomatoes and potatoes
2. Anthracnose
3. Bacterial blight
4. Bacterial wilt
5. Black spot
6. Downy mildew
7. Late blight on solanaceous crops
8. Powdery mildew
9. Rust
10. and many other disease causing pathogens

General information on sulphur

Sulphur probably is the oldest known pesticide in use. The Greek poet, Homer, described the benefits of "pest-averting sulfur" 3,000 years ago.

Sulfur can be used as a dust, wettable powder, paste or liquid. Its primary use is to control powdery mildews, certain rusts, leaf blights and fruit rots. Spider mites, psyllids and thrips also are susceptible to sulfur. Most pesticidal sulfur is labeled for vegetables such as beans, potatoes, tomatoes, peas and fruit crops such as grapes, apples, pears, cherries, peaches, plums and prunes.

Sulphur has the potential to cause plant injury in dry hot weather (above 32°C). It's also incompatible with other pesticides. Don't use sulfur on plants within 20-30 days of applying spray oils. Sulphur reacts with the oil to create phytotoxicity.

While copper fungicides were formerly accepted in organic farming in many countries provided that the number of applications was strictly followed and a proper soil amendment is observed to prevent copper accumulation in the soil, and can still be accepted with permission from the certifying authority. Other fungicides such as Sulphur (Thiovit) are currently being tested by CIP.

Sulfur is non-toxic to mammals, but it may irritate eyes and skin. It has been given a CAUTION rating.

Lime Sulfur

Lime sulfur is made by boiling lime and sulfur together. The mixture is used as a dormant spray on fruit trees to control diseases such as blight anthracnose, powdery mildew and some insects including scales, thrips and eriophyid mites. Its drawbacks include its rotten-egg smell, its potential to burn exposed skin and eyes and to injure plants if applied when temperatures exceed 26°C. Lime sulfur has been assigned a DANGER rating.

Standard procedures for the preparation and application of homemade copper extracts

1. Monitor plants regularly and spray only when necessary.
2. Read and follow the label instructions carefully, particularly, dosage, pre-harvest intervals and safety measures. Ask for assistance from your local extension agriculture office, if unsure.
3. Spray in the early morning or late afternoon.
4. Wear protective clothing when handling pesticides and during application. Wash your hands after handling of pesticides and application. Do not eat, drink or smoke when handling and during application of synthetic pesticides including copper.
5. Do not have a direct contact with the crude extract while in the process of the preparation and during the application.
6. Make sure that you place the extract out of reach of children and house pets while

leaving it overnight.
7. Harvest all the mature and ripe fruits before extract application.
8. Always test the extract formulation on a few infected plants first before going into large scale spraying. When adding soap as an emulsifier, use a potash-based one. Gun soap (Kenya) is recommended.

Information Source Links

- **OISAT: Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Soap spray

Soap spray
Local names: Sabuni (Swahili)
Soap spray can be used against the following pests (clicking on underlined pests takes you to pests' page): Aphids / Mealybugs / Spider mites / African armyworm / Leafminers / Thrips / Whiteflies

General Information on Use of Soap

Soft soaps made from potassium compounds are preferable because they can add useful minerals to the soil. Avoid using strong powder detergent soaps because they contain caustic soda which can scorch plant leaves and, if used frequently, will reduce soil fertility. Liquid soap and soft soap solutions can also burn leaves if their concentration is too strong or if applied too frequently.
Among pests controlled by soap solutions are: aphids, armored crickets, armyworm, caterpillars, leafminer, mites, small beetles, slugs and snails, thrips and whiteflies (Elwell and Maas, 1995).

In general, soaps will kill aphids and small caterpillars at concentrations of 5-8 g per litre of water. Concentrations of 8 g per litre will kill beetles and larger caterpillars, while concentrations of 10 g per litre can kill plants and are sometimes used as herbicides. Soap solutions are effective only when wet, once dried out, they lose their insecticidal properties (Rappaport, 1992).

Standard Procedures for the Preparation and Application of Homemade Extracts

1. Use utensils for the extract preparation that are not use for your food preparation and for drinking and cooking water containers. Clean properly all the utensils every

time after using them.
2. Do not have a direct contact with the crude extract while in the process of the preparation and during the application.
3. Make sure that you place the extract out of reach of children and house pets while leaving it overnight.
4. Harvest all the mature and ripe fruits before extract application.
5. Always test the extract formulation on a few infected/ infested plants first before going into large scale spraying. When adding soap as an emulsifier, use a potash-based one.
6. Wear protective clothing while applying the extract.
7. Wash your hands after handling the extract.

How to Prepare Soap Spray

Use mild soap or potash-based soap.

1. Mix 1 tablespoon of dishwashing soap or 3 tablespoons soap flakes (non detergent) with 4 litres of water
2. Start with a lower concentration and make adjustments of the strength after testing on few infested plants.
3. Precaution: Soap spray may injure foliage. Always try on few infested leaves before going into full scale spraying. Soaps can burn leaves on sensitive plants, like kale

crops and certain ornamentals. Several applications in short periods can aggravate drying of leaves. It may take 2 days for damage symptoms to appear.

Apply on the infested plants thoroughly, including the undersides of the leaves. Spray early in the morning or late afternoon.

Information Source Links

- **Elwell, H. and Maas, A. (1995). Natural Pest and Disease Control. The Natural Farming Network, P.O. Box 301, Causeway, Harare, Zimbabwe**
- **Lowell, J. F. (1998). Producing Food Without Pesticides. Local solutions to crop pest control in West Africa.. Technical Centre for Agricultural and Rural Cooperation, The Netherlands and Church World Service, Senegal**
- **OISAT: Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Rappaport, R. (1992). Controlling Crop Pests and Diseases. The Macmillan Press Ltd., Hong Kong**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Flour preparation

Flour preparation

Flour preparation can be used against the following pests (clicking on underlined pests takes you to pests' page): Aphids / Spider mites. The method 3 can also be used against Thrips / Whiteflies / Downy Mildew on Cucumbers in greenhouses.

General Information on Flour Preparation

Flour mixed in water is said to be very effective against aphids and spider mites. It should be applied in the morning taking care to spray underside of leaves. As the heat of the sun increases, the mixture dries out and the insects are left encrusted in flour, shrivel and die. The coating of flour falls off the leaves so that their ability to photosynthesise is not essentially affected (Stoll 1988).

According to Ellis & Bradley (1992) starch like ordinary baking flour is an old pest control remedy, whereas numerous products made as non poisonous insect control from potato starch, are currently on the market in the US and India. Reportedly potato starch apart from killing aphids, red spider mites, white flies and thrips also acts as an inhibitor to downy mildew on cucumbers in glasshouses.

Recipes for Flour/ Starch Preparations

Flour preparation I:
A spray made from 2 cups of fine white flour well stirred into 5-10 litres of water is said to be very effective against aphids and spider mites.

Flour Preparation II:
Stir together vigorously 1 cup of buttermilk with 8 cups of fine white flour and 50 litres of water. Spray this onto the affected crop taking care to treat the underside of the leaves. This mixture destroys eggs, larvae and adult mites. Four applications have been shown to kill 95 % of red spider mite infestation (Stoll 1988).

Flour and Soap III:
- Add 2 - 4 tablespoons of wheat or potato or any baking flour into 4 cups of warm water.
- Stir well.
- Add 1 teespoon of soap as sticker.
- Stir the filtrate again prior to application.

Recipe for potato starch remedy

Commercial potato flour is not on the market in Kenya, but it is very easy to produce at home:

Finely shred a few Irish potatoes and mix in a bowl of water. Leave to stand for some hours, then stir the mixture and sieve out the potato flesh. Remaining in the bottom of the bowl will be a white layer of potato starch. If not to be used right away, the water can be decanted, and the starch dried for later use.

Potato starch spray: mix 2-4 tablespoons of potato starch in 1 litre of water and add 2-3 drops of liquid dish soap. Shake the mixture and spray to cover the leaves well. Very close to recipe for flour and soap III.

Information Source Links

- **Ellis, B. W. and Bradley, F.M. (1992). The Organic Gardener's Handbook of Natural Insect and Disease control. Rodale Press. ISBN 0-87596-753-1**
- **OISAT: Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Stoll, G. (2000). Natural crop protection in the tropics. Margraf Verlag. Weikersheim**

Information of www.infonet-biovision.org

Biofumigation

Biofumigation

Biofumigation can be used against the following pests (clicking on underlined pests takes you to pests' page): Root-knot nematodes / Rice root-knot nematodes / Bacterial wilt.

General Information on Biofumigation

Bio-fumigation is based on incorporating soil amendment (fresh plant mass, manure) into the soil, which will release several substances, known as isothiocyanates (ITC's), able to suppress soil-borne pests, plus a soil heater to enhance biological activities. Plants from Cruciferae family (Cabbage, radish, cauliflower etc.) release large amount of these toxic substances in the soil and are considered the best material for biofumigation.

How to do it:

- **Incorporate the fresh mass into the soil. This can be done directly if the mass is coming from grown crop or with mass taken from other side and brought into the plot or field. If the mass is transported to the field, the soil should be well prepared before the incorporation. During transportation and storage of these organic**

materials in the field, care must be taken not to lose the gases produced from biodegradation, by covering the piles of the biofumigant with plastic until the time of application.

A dose of 50 t / ha is recommended, although when problems with nematodes or fungi are very serious, 100 t / ha should be applied, a dose that can be reduced by chosing a cultivation techniques such as application in furrows.

The biofumigant should be distributed uniformly, so that no concentration of pathogens will appear that could create problems for the crop. Once the biofumigant is distributed, it should be incorporated immediately into the soil.

- **Water the field, if possible by sprinkling, until the soil is saturated, although watering can be done by flooding, or drip irrigation can be installed.**
- **Cover the soil surface tightly with a transparent plastic film for at least two weeks to retain the gases produced from the biodegradation of the organic matter. This could be the same plastic as the one used for soil solarization.**
- **The film is removed 3-4 weeks after and the soil slightly removed in order to permit the gases to escape from soil.**
- **Planting of the interested crop can be done 24 hours later.**

Using Biofumigation against Nematodes

Different mustards (e.g. *Brassica juncea var. integrifolia* or *Brassica juncea var. juncea*) should be used as intercrop on infested fields. As soon as mustards are flowering they are mulched and incorporated into the soil. While incorporated plant parts are decomposing in a moist soil, nematicidal compounds of this decomposing process do kill nematodes. Two weeks after incorporating plant material into the soil a new crop can be planted or sown (it takes about 2 weeks for the plant material to decompose and stop releasing phytotoxic substances = chemicals poisonous to plants). (Eric Wyss, Personal communication)

Mexican marigold, also known as Tagetes, has been successfully used in the control of root-knot nematode in roses by a Kenyan Farmer (Report on ToT for Alternatives to the Use of Methyl Bromide for Soil Fumigation in Brazil and Kenya).

It is recommended to alternate the use of agricultural residues with green manure, especially from brassicae, using 5-8 kg m2 of green matter, although combinations of legumes and grass can be applied. In the case of the use of green manure cultivated in the same field, fast growing plants should be used to be incorporated at least 30 days after having been planted, to avoid the increase of pathogen populations. Planting brassicae after biofumigation can serve as bio-indicators of possible phytotoxicity, because the germination of these seeds is sensitive to phytotoxic substances. At the same time they are very sensitive to nematodes and permit the detection of areas in the crop where biofumigation is not effective. They act like trap

plants, and like biofumigants when incorporated into the soil.

In Spain, successful application of biofumigation was achieved in strawberries, peppers, cucurbits, tomato, brassicae, cut flowers, citrus and banana. Biofumigation has also been recently applied to Swiss chard and carrot crops. The most utilized biofumigants have been goat, sheep and cow manure, and residues from rice, mushroom, brassicae and gardens.

The effectiveness of biofumigation in controlling nematodes, fungi, insects, bacteria, and weeds is nearly the same as with the use of conventional pesticides. Biofumigation may also regulate viral problems by controlling vector organisms.

(FAO, Global report on validated alternatives to the use of methyl bromide for soil fumigation)

Biofumigation against Bacterial Wilt

From 1999 research on using biofumigation in control of bacterial wilt has been carried out in Australia and the Phillippines by the Autralian Center for International Agricultural Research (ACIAR). The Center with collaborators have been working to

identify suitable brassicas for tropical environments and to evaluate them in the field, initially on experimental farms and more recently on commercial farms and smallholder farmers? fields. There are many varieties and they differ enoumously in the level of disease-suppressing chemicals they produce.

In recent years Australian banana growers have started growing brassica green manures for nematode control, and in the US farmers are using mustard green manure crops to replace synthetic fumigation for potatoes with huge savings on costs.

Growing of radish, mustard and broccoli have reduced bacterial wilt significantly (50-60%) in most of the experiments, though researchers believe the treatment is more effective on sandy soil than on heavy clay soil.

How do we get the useful chemicals out of the plant tissue? The most effective according to researchers is to disrupt the plant cells, by freezing or complete maceration. This will give the best biofumigation effect, but equipment to do this is not always available. A field rotavator used for chopping the plant material and incorporating it into the soil is second best. The rotavation effect can be duplicated by hand chopping the plant material before digging it into the soil but this is very labour demanding.

The project also discovered that other large incorporations of green manure will

suppress bacterial wilt. An example is mentioned of sweet potato leaves giving good control as well.
In Northern Australia, results in some field trials have been excellent. A paddock with a high level infection of bacterial wilt was planted with tomatoes. An untreated block yielded less than 2 tons of tomatoes/ha, while the area where brassica green manure had been applied yielded up to 20tons/ha of tomatoes and had correspondingly lower levels of bacterial wilt.

Information Source Links

- **FAO: Global report on validated alternatives to the use of methyl bromide for soil fumigation. online-version click here**
- **Taylor, Robin. Mustard Cuts the Bacterial Wilt. Article in 'Partners in Research for Development' summer 2005-06 ACIAR. www.aciar.gov.au**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Solarisation

Solarisation
Solarisation can be used against the following pests (clicking on

underlined pests takes you to pests' page): Cowpea seed beetles / Late blight / leafminers / damping-off diseases / Storage pests of seeds and grains (Grain borers, Grain weevils, Grain moths)

General Information on Soil Solarization

Soil solarisation is a method of controlling soil-borne pests (soil-borne fungi, bacteria and nematodes) without application of pesticides by placing plastic sheets on moist soil during periods of high ambient temperature. The plastic sheets allow the sun's radiant energy to be trapped in the soil, heating the upper levels. Transparent plastic allows a more effective heating of the soil than black or coloured one. Also, the thinner the plastic the greater the heating will be, though the plastic should be resistaent to wind and or puncture by animals should be avoided.
Soil solarisation is most applicable and viable in arid and semi-arid conditions where hot temperatures prevail during day time. However, poor-resourced smallholders may not have financial resources to invest in buying plastic mulches nor leaving their restricted land units for a month without cropping.

Solarisation during hot months can increase soil temperature to levels that kill many disease-causing organisms (pathogens), nematodes, and weed seed and seedlings. It

leaves no toxic residues and can be easily used on a small or large scale. Soil solarisation also improves soil structure and increases the availability of nitrogen (N) and other essential plant nutrients. (Elmore et.al., 1997)

How to prepare the soil:
Soil to be solarised must be well prepared by tilling and should be crumbled to a depth of 30 to 40 cm. Solarisation is effective only if done in moist soil. The field must therefore be irrigated until a depth of 50 to 60 cm before mulching. Solarisation is most effective if the plastic is laid as close to the soil surface as possible. Remove weeds, stones and other debris that could puncture the plastic.

Laying the plastic sheet:
Sheets can be laid by hand. The edges of the sheet should be buried in small trenches around the field. Plastic can be laid either in complete coverage where the entire field to be planted is covered or strip coverage where only beds or parts of the field are treated.

Strip coverage effectively kills most pests and eliminates the need for deep cultivation after solarisation. It is especially effective against weeds, since the furrows are cultivated. Strips should be a minimum of 75 cm wide; beds up to 1.5 m wide. Strip coverage can be more economical because less plastic is needed. With strip coverage, however, longterm control of soil pathogens and nematodes may be lost because pests in the untreated soil in the rows between the strips can

contaminate and reinfest treated areas.

Duration of treatment:
The plastic sheets should be left on the soil for 4-6 weeks to allow the soil to heat up to the greatest temperature possible. Then, the plastic can be removed. If the soil must be cultivated for planting, the cultivation must be shallow, less than 5 cm, to avoid moving untreated soil to the surface.

Solarisation of Seeds and Grains

Dry grain and seed that has been attacked by grain weevils, borers or moths can be treated as follows:
1. Put affected grain in a black plastic bag and close tightly, closing in at least 50% air space
2. Put the bag in the sun. If the seeds are to be used for planting, insert a thermometer to be sure temperature inside the bag does not exceed 50°C (above this temperature the seeds will quickly loose capacity to germinate)
3. Leave for a day
4. Check at the end of the day if any insects are still alive.If the sun has been hot enough the insects will have died at the end of the day. If a few are still alive repeat

the treatment. The grain can then be stored using good storage practices as described under storage pests

For further information on storage pests click here.

Information Source Links

- **Elmore, C.L., Stapelton, J.J., Bell, C.E. and Devay, J.E. (1997). Soil Solarization - A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds. University of California, Vegetable Research and Information Center.**
- **Soil Solarization Home http://www.agri.huji.ac.il/~katan/applic.html**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Traps and Bagging

Traps and Bagging
Sticky traps can be used against the following pests (clicking on underlined pests takes you to pests' page): Thrips, Whiteflies, Aphids, Leafminers

Introduction

Insect traps for monitoring and control

Insect traps are useful tools for monitoring insect populations to determine the need for control or the timing of control practices. In some instances, attractants and traps also can be used to control insect populations directly by mass trapping or mating disruption. Mass trapping is most likely to be effective when the density of the target pest is low and immigration into the trapped area is minimal, as is the case in restricted environments (e.g. greenhouses).

Insect traps consist of a visual (colour, shapes and light) and/or chemical (scent) attractant to attract the target insect, plus a device to capture the insect once it arrives. Most insect traps either use glue to immobilise insects or have funnel structures to prevent them from escaping.

Coloured sticky traps (blue, yellow or white) or water traps

They are useful for monitoring adult insects in the nursery or field.

- **Yellow sticky traps and water traps have been used for monitoring adult**

leafminers, whiteflies, aphids (winged forms) and thrips among other insect pests. Thrips are also attracted to white and blue. As the yellow colour attracts many insect species, including beneficial insects, use yellow sticky traps only where necessary. Coloured traps can be easily made at home (see below).

- **Water traps are also useful for trapping thrips and leafminer immatures that drop to the soil to pupate. Sticky and water traps need to be checked regularly; the trapped insects should be identified and counted and the traps serviced.**

The sticky boards have to be changed, or the water replenished, once they are covered by insects, dust and/or debris, since then they are not effective.

Light traps

They can be used to catch moths such as armyworms, cutworms, stemborers and other night flying insects. Light traps are more efficient when placed soon after the adult moths start to emerge but before they start laying eggs. However, light traps have the disadvantage of attracting a wide variety of insects. Most of the attracted insects are not pests. In addition, many insects that are attracted to the area around the light traps (sometimes from considerable distances) do not actually fly into the trap. Instead, they remain nearby, actually increasing the total number of insects in the immediate area.

Pheromone traps

A scent lure may smell like food to an insect pest or, more frequently, like pheromones. Many insects, release an odour to signal their readiness for mating, specially the females (sex pheromones), or to attract other insects (male and females) from the same species (aggregation pheromones). These odours can be reproduced in a laboratory. This material is then applied to a rubber cap or other device and the scent is released slowly over several weeks, attracting the insects to the collection device.

Several types of pheromones traps have been developed for monitoring and mass trapping African bollworms, cutworms, fruit flies, etc. and are widely used. However, in East Africa pheromone traps are, in the rule, not locally available, and imported ones are not affordable to smallholder growers.
Because pheromone traps are so effective and specific, they are useful for mass trapping pests. For that purpose, numerous traps have to be placed throughout a pest's environment, so that enough insects are trapped to substantially reduce the local population and limit the damage it causes. When aggregation pheromones are used to attract adult beetles of both sexes, traps may reduce the feeding damage caused by the adult insects and reduce reproduction by capturing adults before they lay eggs. When sex pheromones are used to capture moths, success depends upon capturing males before mating occurs. Pheromone lures must be changed on a

regular schedule.

Colour and water traps for thrips and blister beetles

Adult thrips can be monitored and in some cases be reduced by mass trapping with coloured (blue, yellow or white) sticky traps or water traps in the nursery or field. Research in California, has shown that hot-pink sticky cards attract more thrips than blue-coloured traps. The colour spectrum of the boards is important for the efficacy of the sticky traps. Bright colours attract more thrips than darker ones.

The location of the traps varies depending on the crop and on the developmental stage of the crop. Sticky traps with cylindrical surfaces are more efficient that flat surfaces. They are best placed within a metre of crop level; traps should not be placed near the borders of fields or near shelterbelts.

Water traps should be at least six cm deep with a surface area of 250 to 500 cm2, and preferably round, with the water level about two cm below the rim. A few drops of detergent added to the water ensure that thrips sink and do not drift to the edges and escape; a drop of formaldehyde prevents algal and fungal growth. They are best used at vegetation level but not where leaves and debris can fall into them because this

discolours the water. A coarse wire-netting guard may be necessary to prevent birds bathing in them (Lewis, 1997).

Blister beetles are attracted to blue (and possibly pink, purple and red) colours. This fact can be utilised to create traps for them:

- **Take any light blue container, fill with soapy water and place around susceptible crops like beans, cowpeas and pigeon peas. The beetles fall in and drown.**
- **Dig holes, line them with blue plastic bags and place soapy water in the bottom.**

Yellow sticky traps for whiteflies, aphids and leafmining flies

- **Yellow plastic gallon containers mounted upside down on sticks coated with transparent automobile grease or used motor oil. These should be placed in and around the field at about 10 cm above the foliage. Clean and re-oil when traps are covered with flies.**
- **Yellow sticky boards. To use, place 1 to 4 yellow sticky cards per 300 square meter field area. Replace traps at least once a week. It is difficult to determine the population of newly trapped insects on a sticky card from those previously trapped**

ones. To make your own sticky trap, spread petroleum jelly or used motor oil on yellow painted plywood, 6 cm x 15 cm in size or 30 cm x 30 cm. Place traps near the plants but faraway enough to prevent the leaves from sticking to the board. Traps when hung should be positioned 60 to 70 cm zone above the plants. Yellow sticky traps are mainly used to monitor, whiteflies, winged aphids and leafmining flies.

- **Yellow plastic trapping sheets. A two m long x 75 cm wide yellow plastic sheet coated with motor oil, both ends attached to bamboo or wooden poles and carried by two persons through the field to mass capture adult flies.**
- **Yellow plastic drinking cups coated with adhesives and stapled on stakes above plant canopies to trap flies**

Note: the yellow colour attracts many insect species, including beneficial insects, so use yellow traps only where necessary.

Traps for house flies and fruit flies

Fruit flies and house or barn flies are attracted to fermenting fruit juice. The top of a plastic bottle can be cut off and inverted as shown in above sketch. A little sugar water or honey can be smeared around the rim of the bottle to further attract the flies, who will then enter the bottle containing sweet/fermenting fruit juice and be

trapped.

Fruit fly traps can be made locally using an ordinary jar with a lid, 'Kimbo' or 'Blue Band' tubs or similar plastic containers or plastic bottles, in which holes have been cut. They can be used with food baits such as protein hydrolysates, yeast or sweet/fermenting fruit juice.

Homemade fruit fly trap

© A.M.Varela, icipe

Fruit fly trap (Lynfield or bucket trap)

The Lynfield trap is cheap and easy to make. It is made of a cylindrical plastic container with 4 holes evenly spaced on its sides, a lid, a wire hanger and a bait basket (if it is to be used with a dry attractant). Similar traps can be made locally using 'Kimbo' or 'Blue Band' tubs or similar plastic containers or plastic bottles.

They can be used with either specific attractants such as methyl eugenol or food baits such as protein hydrolysates or yeast or a peace of fruit (banana, mango). Also vinegar is a very good attractant. (Methyl eugenol attracts males of *Bactrocera* species and of a few *Dacus* species). Food baits attract both males and female fruit flies, they are not species specific, and also attract other insects, including natural enemies.

Several types of commercial fruit fly baits exist but are not locally available or registered.

Use food baits that attract a whole range of fruit fly species in the orchard such as protein hydrolysate (for example, Nulure®, Buminal®, Solbait®). An alternative is waste brewers' yeast at a rate of 45 ml per litre water. Use about 250 ml of the mixture in each trap. Add 1 tablespoonful of borax (di-sodium tetraborate) to each trap to prevent rotting of the flies caught.

A simple fruit fly trap is as follows:
- Take a plastic bottle
- As bait, use 1/2 cup vinegar, mix with water,
- add 4-6 drops liquid dish soap (it heavies down the wings and the fruit flies drown), don't stir
- Then take a pen or pencil and poke 4 to 5 holes in the plastic, just big enough for a fruit fly to fit into, about 7mm. Once a fruit fly crawls in, it can't get out. You would

think they would just fly back out through the holes, but they won't! If you see fruit flies crawling around on the surface of your plastic container but not going inside, make the holes larger

- Hang the bottle in an area where you have seen the most fruit flies. Depending on the amount of fruit flies you have, you can expect to start seeing the bottle fill up within just a few hours.

Fruit fly trap

The trap is filled with bait and hanged on the tree about 2-4 m above the ground within the canopy layer, in a semi-shaded spots, preferably in the upwind part of the canopy. The trap should be hanged in such a manner that branches and leaves are nearby, but not touching the trap. Traps should be hanged 10-50m apart, depending on the bait used. Collect catches weekly and sieve them.

© A.A. Seif, icipe

Fruit bagging

Bagging prevents fruit flies from laying eggs on the fruits. In addition, the bag

provides physical protection from mechanical injuries (scars and scratches). Although laborious, it is cheap, safe, and gives a more reliable estimate of the projected harvest. Bagging not only protects fruit from fruit fly damage but protect the fruit from physical damage improving the market appearance of fruits. However, it is only practicable on small trees.

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

How to bag a fruit?
Blow in the bag to inflate it. Remove some of the fruits, leaving one on each cluster. Insert one fruit per bag then close the bag using coconut midrib or firmly tie top end of bag with string or wire. Push the bottom of the bag upwards to prevent fruit from touching the bag. Use a ladder to reach as many 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.

Mango fruit bagging in an orchard in Kenya to prevent infestation by fruit flies.

© M. K. Billah, icipe

Reminders

Bagging works well with melon, bitter gourd, mango, guava, star fruit, and banana. Whole banana bunches may be bagged inside banana leaves. Start bagging the mango fruit 55 to 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 dispose of them properly.

Light traps

How to make a light trap:

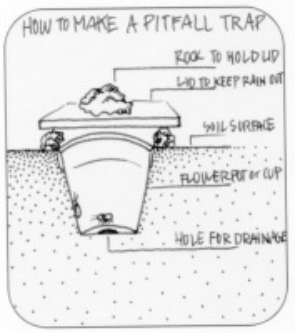
- **Construct a tripod made of wooden poles (e.g. bamboos). The construction must be strong and well anchored, so that it can't blown or thrown down by animals**
- **Mount an oil lamp or an electric bulb on the tripod. If electric light is used, make sure that neither the cable nor the bulb get contact to the water to avoid electrocution or catching fire**
- **Place a shallow bowl of water underneath, about five cm away from the lamp**
- **Add a few spoons of oil (or soap powder/liquid) to the water. Moths will be attracted by the light and will have oil sticking to their wings, hindering them to fly away.**

Use the light trap from evening until early morning.

Pitfall traps

Pitfall traps are used to catch insects and other organisms that crawl about on the ground (e.g. caterpillars of the African armyworm, ants, ground beetle adults and larvae, spiders, etc.). They walk into the trap (container) and then cannot find the way out.

The pitfall trap consists basically of a jar, a plastic cup, a glass or a metal container, placed in the soil having the top level with the soil surface. Occasionally, collectors place a funnel in the top of the container to reduce the likelihood of escape or evaporation of the fluid in the containers. In addition, some collectors place a tile or similar object on top of the trap to make it more attractive to crawling insects.



Pitfall traps are the best means of collecting crawling insects.

© University of Wisconsin

Benefits of insect trapping

- **Traps work 24 hours a day. Even if you scout for insects each day, you won't see nocturnal insects that may be damaging your plants**
- **Traps often target adult stages of pests. These appear long before the caterpillars or grubs that feed on plants. Therefore, traps facilitate early detection of pests before they cause damage to crops, and can help you correct certain problems before they cost you money**
- **Traps can indicate problem areas, or hot spots, requiring corrective action or spot treatments without having to treat all of your plants, and thus help reduce the use of pesticides**
- **Trapping programs give the information needed to base and document your management decisions**

To get the most from your traps

- **Check traps regularly (at least weekly)**
- **Identify (correctly) pests and other insects**
- **Keep accurate records**
- **Remove trapped insects to avoid confusion during subsequent counts**
- **Service (change sticky boards or water) or change traps regularly**

Information Source Links

- **ATTRA (2004). Thrips Management Alternatives in the Field. By George Kuepper. NCAT agriculture specialist . ATTRA publication #IP132. http://attra.ncat.org/attra-pub/PDF/thrips.pdf**
- **Elwell H.and Maas, A. (1995). Natural Pest and Disease Control. The Natural Farming network, Zimbabwe. ISBN; 0-7974-1429-0, Mambo Press, Gweru.**
- **For more information on fruit bagging see: Secretariat of the Pacific Community, (2001). Fruit fly control methods for Pacific Island Countries and Territories. Pest Advisory Leaflet No. 40. Plant Protection Service, Secretariat of the Pacific Community. www.spc.int**
- **Koppert Biological Systems (K) Ltd. P.O.Box 41852 - 00100 Nairobi, Kenya. www.koppert.com**

- **Lewis, T. (1997). Field and Laboratory Techniques. In Thrips as crop pests. (1997). Edited by T. Lewis. CAB International Institute of Arable Crops Research-Rothamsted, Harpenenden, Herts, UK. pages 435-475. ISBN: 0-85199-178-5.**
- **Stoll, G. (2000). Natural crop protection in the tropics. Margraf Verlag. Weikersheim.**
- **Weinzierl, R., Henn, T., Koehler, P. G. and Tucker, C. L. Insect Attractants and Traps. University of Florida. IFAS Extension. edis.ifas.ufl.edu/in080**

Information of www.infonet-biovision.org

Information of www.infonet-biovision.org

Natural enemies

Natural enemies

Natural Enemies (Farmers' Friends)

Introduction

Areas of land which have not been cultivated or disturbed contain hundreds or

thousands of species which tend to form a balance, with each of them depending on some of the others. Although large outbreaks of plant-eating pests do sometimes occur in natural systems, any one particular species is less likely to build up a large population if the organisms which feed on it are also present - in other words, its natural enemies or farmers' friends. Various beneficial organisms that can help the farmer to keep pests (and some diseases) under control and prevent them from causing economic damage.

Predators are one type of natural enemy which tend to keep the population of their prey in check. They catch and eat other insects and mites, including pest species. Parasitoids are another type of natural enemy. They lay eggs in or on other species of insect (called hosts) and the larval stage kills the host as it feeds on it and develops. The third major group of friends is pathogens. These are fatal or debilitating diseases and include fungi, nematodes, bacteria, viruses, and other microbes. Fungi, particularly *Deuteromycetes*, can infect pests externally under favourable conditions, but other pathogens must be ingested to be effective as control agents. Pathogens are very specific to their hosts. Pathogens are often referred to as biopesticides because they can be applied in similar ways to chemical interventions.

Beneficial living organisms which reduce pests and diseases are usually present in any crop unless broad spectrum pesticides (which kill a wide range of arthropods) have been used. These so-called natural enemies can be conserved by taking care

with farming practices so that they are not killed or are actually encouraged. If numbers of such biocontrol agents are still not sufficient to keep pests at acceptable levels, it is possible to release additional beneficial organisms of the same type - a process known as augmentation or inundation. Farmers who collect ladybird beetles in field margins and release them on their crop are practising augmentation. Alternatively if suitable types of beneficial organism are not present in the crop, they can be introduced. Where introduction involves a local beneficial organism which has simply not yet reached a particular crop, this is known as inoculation. If the introduced beneficial organism is from outside the area (typically from the country or area where the troublesome pest originated) and becomes established as the controlling factor for the pest in the new area, it is known as classical biological control. A new balance is created so that the pest becomes less important.

How farmers can help to keep the balance

Farmers can help to keep the balance in their favour in trying not to harm predatory insects such as ladybirds, spiders and hover fly larvae which feed on plant-eating pests such as aphids and caterpillars. Some of the ways to do this are:

- **Use control products only when necessary and then not broad spectrum ones (note that most botanical pesticides are broad spectrum)**
- **If control products are used - use them selectively**
- **Growing flowering plants which provide nectar and pollen to farmers? friends such as adult parasitoid wasps, hover flies and ladybird adults having living fences**

(hedges) around the crop to provide shelter and refuge for farmers' friends. These are sometimes called refugia, and examples include beetle banks (grassy areas near crops) and unsprayed field edges

- **Mulching to provide refuges for ground-living farmers friends such as predatory beetles**

Conservation of natural enemies

When crops are grown, it inevitably disturbs the natural balance, especially where the crop is a monoculture i.e. all one species of plant. However, the beneficial effect of predators and parasitoids continue to be critically important. If they are correctly managed, they will help prevent some of the pest problems which farmers encounter. An example of how farmers can help to keep the balance in their favour is to try not to harm predatory insects such as ladybirds, spiders and hoverfly larvae which feed on plant-eating pests such as aphids and caterpillars. These predators can be found on most crops together with parasitoid wasps (and occasionally parasitoid flies) which lay their eggs in/on pests. In IPM systems which aim to minimise dependence on pesticides, it is essential that the farmer can distinguish these natural enemies from pests and can use farming techniques which will conserve and encourage natural enemies.

Like humans, insects also suffer from diseases which can weaken or kill them. Types

of fungal, bacterial and viral pathogens which only affect insects and are safe for humans and animals have been identified. Some of these are commercially produced as biopesticides and some can be prepared on the farm.

Augmentation and inundation with natural enemies

Sometimes there are predators and other natural enemies present which are feeding on the pests, but they are not able to control them effectively, particularly those pests that are capable of breeding very quickly. Farmers can augment the number of natural enemies by bringing them in from outside the field, for example, ladybird beetles or parasitized aphids which contain young parasitoids. Some types of natural enemy can be specially bred in large numbers, and then released onto the crop in order to attack and control the pest. The natural enemies inundate the pest population. Many of the advances in this technique have been against pests of crops which have been economically important for a long time, such as cotton. for example, the egg parasitoid wasp called Trichogramma has been bred in laboratories to allow huge numbers to be released when eggs of the African bollworm are present on the crop. The same bollworm can be a serious pest of tomatoes, so it may be possible to use the same biocontrol tactics developed for cotton. Aphid parasitoids could theoretically be produced and released in a similar way, but these technologies are often not yet available to small-scale vegetable growers.

Using insect pathogens in pest control sprays

Naturally-occurring pathogens that kill insects (fungi, bacteria and viruses) can be

obtained from diseased insects and incorporated into sprays applied to control the pest. This is a type of inundation. Pathogen-based sprays are not yet widely available for vegetable pests except for Bt (Bacillus thuringiensis) a bacterium which kills larvae of moths and butterflies (caterpillars). One example under development is a virus which kills diamondback moth caterpillars - a serious pest of brassicas. The pathogen is called Plutella xylostella granulovirus (PlxyGV). The pathogen has the important advantage of being highly specific. In other words it does not harm other arthropods such as natural enemies so it works together with the natural processes which limit pest numbers. This contrasts with most pesticides which also kill natural enemies. Farmers sometimes use a type of home-made biopesticide - they gather diseased pests, crush and mix them with water, then spray the liquid onto the crop. The fungi, bacteria or viruses which were infecting the collected pests will infect other pests in the crop and kill them.

The types of natural enemies: Predators, parasitoids and pathogens.

Predators
These are organisms that prey and feed on other organisms. They often feed on various stages of the host (pest): eggs, larvae, pupae and adult. Each predator kills and feed on a number of prey individuals during their development (larvae to adult). Most adults are also predators.
For example: ladybird beetles, dragonflies, predatory mites, predatory bugs, predatory wasps and spiders.

Parasitoids
Organisms that during the larval stages feed on (external parasitoids) or in the pest (internal parasitoids). They complete their development on a single host, killing it. In their adult stages they are mostly free-living (with few exceptions) and feed on pollen and nectar or other sugary substances such as honeydew.
The most common parasitoids are parasitic wasps and flies.

Pathogens
Organisms that can cause diseases of pests. They include fungi, bacteria, viruses and nematodes. They can be important in controlling pest populations in agricultural systems. However, naturally occurring pathogens often are too rare to serve as important control agents or occur when the damage has already been done.
Some pathogens such as the bacterium *Bacillus thuringiensis* (Bt) and the fungus *Trichoderma viride* are commercially available in many countries, including Kenya.
Other fungi such as *Zoophthora* and *Entomophthora* can be readily found in the field at particular times of the year, infecting aphids, beetles, caterpillars, grasshoppers and whiteflies.

Feeding levels in agricultural systems

Natural systems support a wide range of plants and animals. The plants provide food for plant-eating animals such as antelopes and many insects. The plant-eating animals are themselves eaten by a wide range of predators. Plant-eating animals that feed on a crop that we value (for example aphids that feed on cabbage), are considered pests. Plant-eating organisms are also eaten by organisms called natural enemies, which can be considered "farmer's friends".

Type of organism	Example 1	Example 2
Plant	Tomato	Cabbage
Plant-eating animal	Caterpillar (pest)	Aphid (pest)
Predatory or parasitic animal	Parasitic wasp (natural enemy)	Hover fly larva (natural enemy)

These feeding levels (see table) exist in all stable natural and agricultural habitats. The number of animals from each feeding level is kept in check by complex interactions. In agricultural systems the balance between the four feeding levels is frequently upset and pest numbers increase rapidly, resulting in pest outbreaks. Reasons for this can be:

Monocultures: Planting of large tracts of land with one single crop type is referred to as monoculture. This makes it easy for pests to find the crop and once they have found it, to develop quickly because their food source is plentiful and closely spaced. Monocultures also contain few shelters and alternative food sources for natural enemies.

Poorly adapted crop cultivars: Many plant cultivars grown for food crops in tropical regions have originated from Europe and are not always adapted to local growing conditions and thus have low levels of natural resistance to pests and diseases.

Use of pesticide: Use of pesticides can cause several problems. In many instances, natural enemies are more susceptible to pesticides than the pest itself and are thus harmed or killed while the pest is not much affected. This causes pests to multiply much more quickly.
Pests may also develop resistance to pesticides. This occurs in situations where pesticides are used frequently and the same type of product is used for long periods. A farmer said: "I've been spraying once a week for the last month and the crop is being destroyed by pests. What is going on?" This is because some of the pests are naturally less susceptible to the pesticide and after a period of heavy pesticide use, only those remain (this is normally referred to as pests having developed resistance) and the increased frequency of spraying only affects natural enemies. Furthermore other beneficial insects, such as pollinators, are also harmed.

Importance of Identification

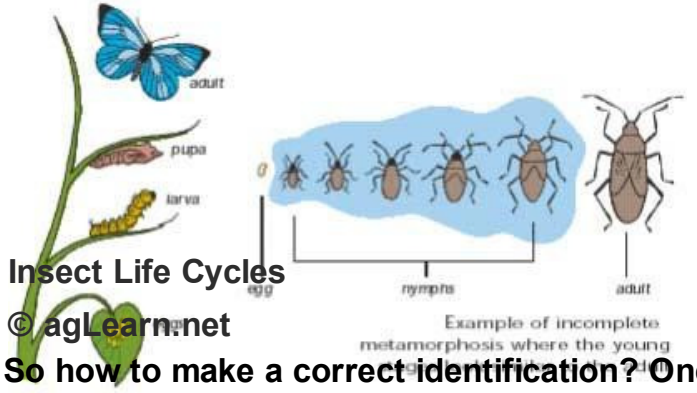
A key factor in protecting and conserving farmers' friends is being able to tell friends from enemies. Various studies have shown that many farmers (and also many agricultural professionals?) are not good at insect identification and know little about insect biology and behaviour. In vegetable pest management, if farmers cannot distinguish between pests and friends, they will be likely to control anything, whether helpful or a genuine pest. They do not want to risk having living things crawling over their crop and so resort to spraying.

Although proper identification of pests and beneficials is important it is not always easy. Take for instance ladybird beetles which are one of the most talked about and valuable farmers' friends because of their ability to eat large numbers of plant sucking aphids. But some ladybird species do eat plants and can cause crop damage! These species usually look dusty or slightly hairy - as compared with the very shiny species which are usually farmers friends. To make matters more difficult, most insects look very different at different stages in their development. For example, ladybird larvae look like tiny spotted crocodiles and are very different from the adults, but they also eat many aphids. This highlights the importance of being able to identify the living things on the crop no matter what life cycle stage is observed.

Insect Life Cycles

Most crop pests are arthropods, which means they have external skeletons and jointed legs. Within this group, there are insects which have 6 legs as adults and mites which have 8 legs as adults (but 6 legs when younger). Arthropods are usually considered to be pests if they eat any part of the crop plant (chewing pests), or if they suck the crop plant juices (sucking pests). The damage may be caused by adults or by the younger stages called larvae or in some cases nymphs. Other serious pests of vegetables include nematodes, tiny worms that live in and feed on plant roots (plant parasites), and larger animals such as rats, monkeys and even hippos.

Life stages of arthropods Arthropods can look very different at different stages in their life cycle. It is useful to understand these different forms so that pests can be identified regardless of the stage they have reached in their life cycle. Arthropods go through a process called metamorphosis which means change of form. Some have complete metamorphosis where the young stages look completely different from the adults - see the butterfly in the left hand picture below. Others go through incomplete metamorphosis where the young look a little like small versions of the adult, but without fully developed wings - see the bug in the right hand picture below.



Insect Life Cycles

© agLearn.net

So how to make a correct identification? One good source of information is the local extension office which should have field guides and pest and disease identification guides on local problems. Sometimes such guides are also available at universities or colleges and more and more such information is available through the Internet. If you know of any good ones be sure and share these with the rest of us. Here are some we have found.

It is also possible to find out yourself whether an organism is a friend or a pest by setting up an insect zoo to investigate what the organisms is doing on the crop. This involves putting the insect in a small jar together with leaves from that plant and any known pests which were also on that leaf. If it eats or sucks the leaves, it is a pest and if it eats the pests it is a natural enemy.

Biological Control Methods

Biological control is the process of pest management by the use of living organisms that prey on or attack pests. Four important steps are generally required to improve the biological control of pests: Three important steps are generally required to improve the biological control of pests:

- **Find out which natural enemies are present.**

In most cropping systems natural enemies are already present or close by and do not need to be introduced. It is crucial that natural enemies can be recognised and distinguished from pests.

- **Insect zoo**

To find out who is eating who or what, an "insect zoo" can be set up. A small group of suspected pests and natural enemies are kept together in ventilated jars or other small containers with a small portion of the crop, for example kale leaves. Always make sure that the insects have fresh food. Keep the zoo in a shaded place to avoid high temperature. Take care that the environment inside the zoo does not get too dry or too humid. Maintain the insect zoo until the animals have gone through their complete development, so that you can see who eats who or what. Insect zoos can be used to study the life cycle of insects and their behaviour. They are also very useful to study the effects of predators or Bt.

- **Select appropriate cultivars**

It is important to choose crop cultivars that are not highly susceptible to pests and diseases. Information on the susceptibility of different cultivars can often be obtained by asking other farmers, extension staff or relevant research institutes. If

the information is not available, it may even be useful to run on-farm trials of different cultivars.

- **Conserve natural enemies by cultural means**

There are many ways to encourage natural enemies on your farm:

- **Providing food sources for adult stages of natural enemies such as flowering plants (fennel, thistles, coriander, Indian mustard and other flowering brassicas) close to the crop**
- **Mixed cropping systems provide food and shelter and attract a wider range of natural enemies. Green manure plant such as legumes and sun hemp grown in rotation with other vegetables also improve soil fertility.**
- **Live fences (trees, hedges) act as windbreaks and provide shelter for natural enemies.**
- **Mulches around plants provide attractive environments for ground-living predators such as beetles and spiders.**

Important natural enemies or 'farmers' friends'

There are many other natural enemies, such as spiders, bugs, predatory wasps and mantids which play a vital role in regulating pest numbers.

Predators

Adult ladybirds mating

© Jim Occi, www.insectimages.org

Ladybird beetles / Ladybugs

The adults and larvae of ladybird beetles are important predators of aphids. A single ladybird can eat 200-300 aphids over its lifetime. Adults ladybirds are 7-10mm long, oval to nearly spherical in shape with short antennae.They are often brightly coloured with black margins, black with bright spots or shiny black. Eggs are elongated, usually yellow to orange in colour and are laid in clusters of 10-50 eggs near the prey (e.g. aphid colonies).

The larvae are soft bodied, wingless, and vary considerably in appearance , they look quite different and are usually longer and thinner (a little like tiny spotted crocodiles), coloured black or dark brown with various types of light markings. Their colour varies from black to dark brown with various types of markings or spots. Some larvae are covered with white wax resembling mealybugs. Larvae are usually very active moving around in search of prey. The pupae are oval-shaped and are glued to the leaf surface.

Main prey: Ladybird beetles are generalist predators. Both adults and larvae prey on aphids, leafhoppers, mealybugs, mites, scales and whiteflies. The larvae eat more pests (particularly aphids) than adults. A single ladybird can

Ladybird beetle larva

© Clemson University, insectimages.org

consume approximately 200 - 300 pests over its lifetime of 1-3 months.

Note that not all ladybird beetles are predators. There are several plant-feeding species such as *Epilachna* beetles also commonly known as melon bugs. Both the larvae and the adults feed on leaves and fruits. *Epilachna* beetles are pests of tomato, potato and cucurbits. The pest ladybird beetles can be distinguished from the beneficial ladybird beetles by their appearance. The wing cases of the adults of pest ladybird beetles are covered with short hairs giving them a non-glossy matted appearance. The larvae are pale yellowish in colour and covered with long spines.

Conservation: Ladybirds can be encouraged by growing non-crop plants which support aphid species which do not attack crops. Grow strips or groups of non-crop flowering plants such as fennel, thistles, coriander or carrots and milkweed. They can also be brought in by hand from outside the crop. Spraying with pesticide should be avoided wherever possible in order not to kill the ladybird adults and larvae but if it is necessary, selective methods should be used.

Lacewings

Lacewing adults have net-like semitransparent wings, large eyes and rather soft, fragile-looking bodies. They are greenish (green lacewings) or brownish (brown lacewings). Brown lacewings are smaller than green lacewings, measuring about 6-12 mm. The eggs of green lacewings are laid on characteristic fine silk stalks. Eggs of brown lacewings are laid singly on the side on plants without any attaching stalk. Lacewing larvae are greyish-brown, wingless and crocodile-like. They have long sickle-shaped mouthparts and some carry the skins of their prey on their backs. Larvae are very active. The pupae are whitish and spherical, resembling spider egg sacks.

Brown lacewing (*Micromus timidus*)

Main prey: Larvae and adults of brown lacewings are predacious. They feed on mites and soft-bodied insects, especially aphids, mealybugs, scales whiteflies, and small caterpillars, and insect eggs. Some green lacewing adults are predaceous, while others only feed on nectar from flower or honeydew from aphids. Lacewings are among the fiercest predators in the insect world. They can eat more

than 200 pests or pests' eggs a week. Older larvae can consume 50 aphids a day. However, if no other prey is available, they become cannibalistic.

Conservation: Make sure flowers (e.g. dill, sunflower, carrots) are present in the field or close to the crop to ensure food supply for adult lacewings. Populations can be maintained on a non-pest aphid species and other hosts outside crop area (in weedy areas on field margins).

Hover fly adult

Hover flies

Description: Hover fly adults are usually brightly coloured with yellow-brown or black stripes. They are sometimes confused with wasp and bees, but flies have only one pair of wings, while wasps have to pairs. They owe their name to their ability to float or "hover" in the air, like a helicopter. They can often be seen on or close to flowers, where they feed on nectar and pollen. Although adults help to pollinate plants, it is the larvae which are most useful since they are natural enemies of aphids and small caterpillars.

© Jonny N.Dell, retired, Courtesy of Bugwood.org

The eggs, despite their small size, are easily seen on leaves, especially where aphids are present. They are white, cylindrical and 1-2mm in size.

Hover fly larva. Close-up of larva preying on aphids.

© Clemson University, www.insectimages.org

The larvae are usually greenish or brown with one to three white stripes along the body. They are 1-13mm long, depending on the larval stage. They are often mistaken for caterpillars, although they do not have a distinctive head or legs as do caterpillars. They can also be distinguished by their slug-like appearance. The pupae are pear-shaped and maybe green or brown.

Main prey: Hover flies mainly prey on aphids and small caterpillars.

Conservation. Hover flies can be encouraged by allowing non-crop plants to grow around fields - these support non-pest species of aphids that hover fly larvae can feed on. They are attracted to all flowering plants but especially to fennel, milkweed, sun hemp, flowering brassicas or wild mustard, thistles, sunflower, coriander and dill. In rape and kale, some of the previous crop can be left to flower (provided the pest and disease levels are low) or a small number of plants from the current crop can be encouraged to bolt and flower by stopping watering. Avoid spraying with pesticide whenever possible but if it is necessary, use selective

methods

Different types of assasin bugs present on crops.

Predatory bugs

The most common predatory bugs include anthocorid (pirate) bugs, nabid bugs, and assassin bugs. The nymphs of bugs are similar to the adults in shape, but smaller and may vary in colour. Young nymphs are wingless, but wings develop gradually and wing pads can be seen as the nymphs develop.

Predatory bugs are variable in size. Anthocorid bugs or minute pirate bugs are tiny (2-3 mm long). The nymphs are brown, black or orange, while the adults are black with white patches on their wings. Assassin bugs are large insects (10-40 mm long). They are generally oval in shape, but some are elongated and thin, resembling stick insects. They can be distinguished from plant feeding bugs by their curved mouthparts.

© A. M. Varela, icipe. **Main prey: Both adults and nymphs of pirate bugs are important predators of thrips, mites, aphids, insects eggs and small caterpillars. Assassin bugs prey on other insects including plant pests, spiders and other small animals such as snails.**

Commercial availability: The minute pirate bug Orius jeanneli is commercially available in Kenya under the trade name (Oritech®) from Dudutech (K).

Praying mantis

Praying mantid adults are usually large with well-developed wings and characteristic forelegs that assume a posture similar to praying when resting, hence their common name. The forelegs are used for grasping the prey.

Females lay their eggs in hardened foam case attached to weeds or twigs. Nymphs are similar to adults, although smaller in size and initially have no wings. The wings develop gradually as the nymphs get older. Mantids wait in the foliage well camouflaged, until prey comes within their reach.

Praying mantis

© A. M. Varela

Main prey: Both nymphs and adults are indiscriminate eaters; they feed on pests such as moths, flies, crickets, bugs, etc. , but also on natural enemies such as beneficial bugs, flies and spiders. Their presence however indicates that there is no indiscriminate use of broad-spectrum pesticides.

Conservation: Avoid spraying pesticides. Maintain vegetation as natural habitats for mantis.

Rove beetles (Staphylinidae beetles)
Description: The adults resemble earwigs, although they do not have the well-developed pincers at the end of the abdomen. They are very variable in size, ranging from about 1 mm to 20 mm in length. The wing cases of most rove beetles are short and do not cover the segments of the abdomen. The abdomen may be raised in a threatening posture (like scorpions) when disturbed. Rove beetles are often reddish-brown, brown or black.

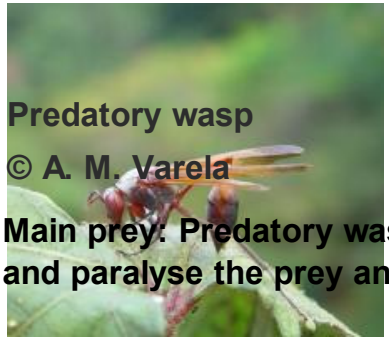
Rove beetle.
© A. M. Varela, icipe

The wing cases may have a different colour from the rest of the body.

Main prey: Some rove beetles are generalist predators and eat all stages of a wide range of insects in the soil or in the foliage. They may be important for control of beanflies, cutworms, scale insects and spider mites. The tiny rove beetles *Oligota* spp, (about 1 mm in length) are common predators of mites. Some rove beetles are parasitic; young larvae search the soil for cocoons of flies and after eating the pupa emerge sometime later as adults.

Conservation: Conserve or develop refuges for soil dwelling rove beetles. This could be done by promoting plant diversity, using mulches and keeping stones, logs or other items that provide protection.

Predatory wasps
Description: These are large wasps, often 12-30 mm long, usually black, which lay eggs inside or on other insects such as aphids and caterpillars, or even in the eggs of other insects. When the egg hatches the larva of the parasitoid feeds on its host and kills it. They may be solitary or may


Predatory wasp
© A. M. Varela

live in groups. Some form papery and honeycombed nests often found suspended by a stalk from leaves of plants or sides of buildings. Others have nests in the ground, in natural cavities or within tree stumps.

Main prey: Predatory wasps attack caterpillars, sawfly larvae or other prey; they sting and paralyse the prey and take it back to the nest as food for their brood.

Conservation: Avoid destroying nesting sites, unless they are a threat to humans. Avoid spraying pesticide unless absolutely necessary since adult parasitoid wasps walk around a lot on the leaves while searching for hosts so can quickly pick up a harmful quantity of pesticide. Parasitoid wasps can be attracted and sustained by ensuring that there are flowering plants nearby to provide nectar for them to feed on. They can also be encouraged by providing non-crop plants such as milkweed and thistles which encourage non-pest species of aphid.

Ants

Description: Ants are social insects and have a division of labour between different groups (workers, soldiers and reproductive forms) within each colony.

Ants attacking a cutworm caterpillar.

© A.M. Varela

Worker ants are responsible for food collection and are active foraging for food. Ants are generally not specific. They may feed on both pests and beneficial insects. They can be very effective at removing caterpillars and other pests from crops - they are thought to be one of the most important natural enemies of *Helicoverpa armigera* - the African bollworm. Some ants are important predators of eggs, larvae and adults of pests.

However, some species of ant also protect pests as they feed on honeydew excreted by some sucking insects such as soft scales, aphids, whiteflies, and mealybugs. In particular they stop natural enemies attacking aphids in order to maintain their supply of honeydew - the sugary liquid excreted by aphids as they suck the plant sap, and which the ants use as a food source.

Conservation: Excessive hoeing or ploughing will destroy ant nests so farming systems which use minimum tillage (very little hoeing or ploughing) are more likely to encourage beneficial ants.

Red fire ants or weaver ants (*Oecophylla longinoda*)
Description: Red fire ants nest on citrus and other fruit trees (guava, soursop, cashewnuts, coconut palms among others). These ants are present in many countries in Africa. They are common in the coastal regions in East Africa. They built nests on trees by joining leaves with silk produced by the larvae. These ants are very active moving on the trees and on the ground in search of food. They are highly voracious feeding on a large range of insects visiting the trees, and are important in controlling many insect pests in fruit trees and coconut palms. In spite of these benefits, weaver ants are considered by some as a pest due to their aggressiveness combined with painful bites, which makes fruit picking difficult, and to their association with honeydew-producing insects.

Weaver ant nest on a citrus tree

© A.A. Seif, icipe

They can foster the build-up of these insects, but it has been observed that they do kill some of them when the amount of honeydew produced by these insects is bigger than the amount required by the colony of weaver ants. The benefits provided by predatory ants feeding or deterring insect pests must be outweighed against the damage they may cost indirectly. As a whole weaver ants are considered beneficial. They have been used actively in China for the control of citrus pests for centuries (Way and Khoo, 1992). Experienced farmers in Asia and Africa have developed their own methods to deal with the inconvenience of weaver ants during harvesting.

How to harvest if weaver ants are present: A common pratice among farmers is to throw wood ash on the branches of the tree they want to climb. The ants fall down of the branches and have difficulties to return giving time to the farmer to harvest. Other farmers rub their hands and arms with wood ashes, to prevent the ants from attacking them. Other rub their arms and feet with certain repellant products before climbing the tree, use protective clothing or harvest af times of the day when weaver ants are least active (Van Mele and Cuc, 2007).

Predatory thrips

© A. M. Varela

Predatory thrips

Description: Thrips are tiny insects (0.5 to 3 mm in length), they have slender bodies, short antenna, and have piercing-sucking mouthparts, which enable them to cut and remove plant or insect juices. Adult thrips have four long narrow wings, fringed with long hairs, giving them a feathery appearance, when viewed under magnification. They vary in colour from pale-green yellow to brown or black; some are banded or have spots markings on the wings. Nymphs resemble adults in both size and colour but are wingless in the first stages. Wings develop gradually as the thrips develop. Most thrips are plant feeders, however some species

predatory on other insects or mites.

Main prey: Predatory thrips feed on mites and other soft-bodied insects such as pest thrips, aphids, maggots of leafminers, whiteflies, etc.

Conservation: Avoid use of wide spectrum pesticides.

Mite *Phytoseiulus longipes* a predator of the tobacco spider mite (real size-

Predatory mites (*Phytoseiulus persimilis*)
Description: Mature adult *Phytoseiulus persimilis* are shiny, light red to orange-red, and spotless. They eat plant-feeding mites. They are very small (less than 1mm) and difficult to see by eye but if populations of red spider mites are examined closely, any predatory mites present can be identified by their longer legs and much faster movement. The immature stages and young adults are glossy transparent to cream-coloured with a droplet-shaped body. Nymphs are smaller in size and move more slowly than adults. The eggs are glossy transparent to cream-coloured and oval about 0.2 mm long and are deposited on the underside of the

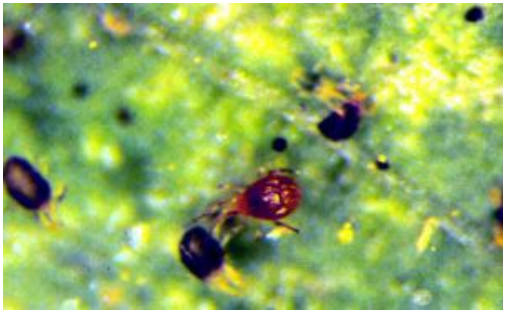
1mm). leaves.

© icipe

They can provide effective control of spider mite populations on tomatoes but it can take some time for numbers to build up, especially if the plant variety has very sticky stems and leaves. Most predatory mites cannot survive without live prey to feed on, so hedges and living fences and other non-crop plants can help to provide a refuge and food source for them between crops. Dust tends to kill predatory mites so regular irrigation, which reduces dust, will tend to encourage these natural enemies. Also, colonies of plant-feeding mites can be kept on potted plants and when predatory mite numbers build up they can be transferred to the crop. In some countries the mites are commercially available for releasing onto the crop (a type of inoculation).

Main prey: *Phytoseiulus persimilis* predates exclusively on spider mites and does not feed on plant material. *Phytoseiulus persimilis* is very efficient in searching out its prey. An adult can eat up to 5 spider mite adults or 30 eggs and young spider mites per day, whereas an immature can eat 6 eggs and young spider mites in two days. Under favourable conditions, 21-27°C and relative humidity beyond 60%, it completes its life cycle within 7 days, which is almost twice as fast as its prey, and is thereby capable of eradicating spider mite populations quickly.

Phytoseiulus persimilis* is sensitive to the host crop of its prey. Whereas *Phytoseiulus persimilis



A predatory mite (*Phytoseuilus persimiles*) (red) feeding on spider mites

© icipe

multiplies very well when feeding on spider mites feeding on beans, it multiplies very poorly when feeding on spider mites feeding on roses. *Phytoseiulus persimilis* does not feed on the tobacco spider mite (*Tetranychus evansi*), a very important mite pest in the region. A different species of predatory mite *Phytoseiulus longipes*, has been introduced from South America for control of this spider mite, and experimental releases have started (icipe).

Conservation: *Phytoseiulus persimilis'* survival is entirely dependent on the maintenance of a low-level spider mite population. *Phytoseiulus persimilis* is very sensitive to relative humidity (RH). Its optimum condition is 75% RH and eggs require a minimum of 60% RH to hatch. *Phytoseiulus persimilis* is sensitive to most insecticides and many fungicides.

Commercial availability: *Phytoseiulus persimilis* is available from Dudutech (K) Ltd, Koppert Biological Systems (K) Ltd and Real IPM Ltd.

Amblyseius swirskii

***Amblyseius* spp. (also called *Neoseiulus* spp.)**
Description: Mature adult *Amblyseius* spp. are shiny, transparent to cream-coloured, and some have a bit of orange markings. They have a more elongated body shape, as compared to *Phytoseiulus persimilis*, and are about 0.45 mm long. They are less active and slower than *Phytoseiulus persimilis*. The immature stages look like the adults; they are smaller in size and move more slowly. The eggs are glossy transparent to cream-coloured and oval about 0.15 mm long. Differentiation of the various Amblyseius species is very difficult in the field and requires assistance from a skilled laboratory technician.

Main prey: *Amblyseiulus californicus* has a preference for spider mites, whereas *Amblyseius cucumeris* has a preference for thrips and Amblyseius swirskii has a preference for immature whiteflies. Nevertheless, Amblyseius species can feed on preys other than their preferred prey and on mould and nectar. Amblyseius species are not as efficient in searching out their preys as *Phytoseiulus persimilis* and thus, disperse less widely through the crop. They do not reproduce as much and develop as fast as *Phytoseiulus persimilis*.

Conservation: *Amblyseius* spp. can sustain their population at very low prey density, survive on alternative food sources, even without food supply for some time.

Amblyseius **spp. can survive higher temperature and the adverse effect of low humidity is weaker than for** ***Phytoseiulus persimilis*****. Population growth under warm dry conditions is therefore better for** ***Amblyseius*** **spp. than** ***Phytoseiulus persimilis*****.** ***Amblyseius*** **spp. can sustain more insecticides and fungicides, in general, as compared to** ***Phytoseiulus persimilis*****. Commercial availability:** ***Amblyseius californicus*** **and** ***Amblyseius swirskii*** **are available from Koppert Biological Systems (K) Ltd, and** ***Amblyseius cucumeris*** **is available from Dudutech (K) Ltd.**

Crab spider

© Edward L. Manigault,

Spiders

Description: Spiders are not insects; they have 8 legs instead of 6. Egg sacs of spiders are usually covered in whitish-silk. The eggs within the sac hatch to release several spider nymphs at once, they are sometimes called 'spiderlings'. Nymphs are similar to adults, but smaller in size.

Main prey: Spiders found on crops can be divided roughly in two groups: webbing spiders and hunting spiders. Webbing spiders catch their prey in nets or webbing, while hunting spiders forage actively or lay in wait for their prey.

Bugwood.org **Conservation: Spiders can be very important predators in agricultural systems. They prey on moths, flies and other pests they can catch. As generalist feeders, spiders sometimes also prey on beneficial insects as well as pest species.**

Parasitoids

Parasitic wasp emerged from caterpillar. Note emergence hole in

Parasitic wasps
Description: There is a wide range of parasitic wasps with a wide variation also in size (1-6 mm long). Parasitic wasps attack eggs, larvae, pupae and sometimes adults of many other groups of insects. They usually lay their eggs within or on the body of the host. Eggs hatch into tiny yellow-creamy larvae that feed on the body fluids or the body tissues of their host. The mature larvae of the parasitic wasp pupate in or outside the host body. The number of wasps that can develop within a single host varies with the parasitoid and the host. In aphids, leafminers, mealybugs, usually one single parasitic wasp develops on a single host. In the case of caterpillars, a single wasp, a small number, or a large number of wasps (sometimes more that 100) may develop within

mummified caterpillar
© A. M. Varela

each caterpillar, depending mainly on the species of parasitoid. Larvae of some wasps pupate in the host, while others emerge from the host when feeding is completed and pupate nearby. Adult parasitic wasps feed on pollen, nectar, honeydew and other sugary substances, but some are predacious feeding on the host contributing to mortality caused by their larvae.

There may be few or no symptoms of parasitoid presence within its insect host. In other cases such as aphids, mealybugs and some caterpillars the host insect may become swollen and/or permanently paralysed. When the larvae of the parasitic wasp pupate, the parasitised aphid or mealybug turns brown and hard and remains stuck to the leaf. In this stage they are known as mummies and can be easily recognised.

Parasitic wasp Oomyzus laying eggs in diamondback moth caterpillar
© icipe

The parasitic wasps emerge through a round hole in the aphids or mealybug abdomen a few days later. Parasitised whiteflies nymphs can be distinguished from healthy ones but their colour; parasitised nymphs are dark while healthy nymphs are usually yellowish greenish.

Field collection and rearing of immature stages (eggs and larvae) of pests to check if any parasitoid emerges is often a useful method to determine whether parasitism has occurred.

Main prey: Parasitic wasps are important natural enemies of moth and butterfly eggs, bug eggs, caterpillars, leafminers, aphids, mealybugs, and whiteflies. They play an important role in natural control. In cases where the naturally occurring natural enemies do not provide satisfactory control, or in cases where an exotic pest has been introduced without its natural enemies, parasitic wasps have been introduced and released. Some examples of parasitic wasps introduced in the region for control of important pests are: *Diadegma semiclausum* and *Cotesia plutellae* for control of the Diamond back moth on crucifers, *Cotesia flavipes* for control of cereal stemborers, *Apoanygyrus diversicornis* for control of the cassava mealybug, *Gyranusoidea tebygi* and *Anagyrus mangicola* for control of the mango mealybug; *Diglyphus isaea* for control of leafminers, *Cales noacki* for control of the woolly whitefly on citrus and *Encarsia formosa* for control of whiteflies.

Commercial availability: Parasitic wasps commercially available in Kenya: *Aphidius transcapicus* (Aphitec®) for control of aphids, Trichogrammatoidea sp. (Grammatech®) for control of moth and butterfly eggs, *Diglyphus isaea* (Diglytech®) for control of leafminers and *Encarsia formosa* (Encartec®) for whitefly control. These parasitic wasps are available from Dudutech (K) Ltd. *Eretmocerus eremicus* (Ercal®) for whitefly control is available from Koppert Biological Systems (K) Ltd.

Conservation: Adult wasps feed on nectar, honeydew, or pollen before laying eggs. Keeping flowering plants close to, around or/and

within the crop may attract parasitic wasps and provide good habitats for them. Some flowering plants that have been recommended are dill, fennel, coriander, nasturtiums, flowering crucifers, sun hemp, clover, alfalfa, parsley, sunflower, and marigold.

Braconid wasp

© Scott Bauer, USDA Agricultural Research Service, Bugwood.org

Parasitic flies
Description: The most important are tachinid flies. The adults look like rather the common house flies, but are

Tachinid fly , a parasitoid of caterpillars. Note brown fly puparium and dead caterpillar.

© A. M. Varela

larger (8-12 mm in length) and have more stout, bristly hairs on the abdomen. They are usually grey in colour with some markings. Female flies lay tiny whitish oval eggs on their host, and sometimes on leaves. Upon hatching the fly larvae (maggots) burrow through the body and feed on the prey. With species that lay eggs on leaves, eggs are ingested by caterpillars or larvae of beetles while feeding on foliage. Pupation occurs either within or outside the body of the host. Some species pupate in the soil. Adults feed on nectar and pollen.

Main prey: Tachinid flies are important parasitoids of caterpillars, beetle larvae and adults, and earwigs, bugs and grasshoppers.

Conservation: Provide sugar containing food sources for the adult such as flowers or honeydew. Encourage habitat diversity. Avoid spraying pesticides. When necessary select a product and application method that is less harmful to natural enemies.

Pathogens

Bacteria:
A large number of naturally occurring, insect-specific bacteria have been isolated from insects, plants, and the soil, but only a few have been studied in detail. *Bacillus thuringiensis* is the best-known insect pathogen.

Description: *Bacillus thuringiensis* (Bt) is a naturally occurring bacterium that produces substances toxic to some insects. Bt works by interfering with digestion; therefore, to be effective it must be eaten by the insects. Insects are more sensitive to Bt in the larval stage. After larvae ingest Bt spores, the bacterium produces toxins that paralyse the digestive tract of the larvae causing it to cease eating. Death will follow from hunger or infection; the time of death can range from 12 hours to 5 days after ingestion, but since the insects stop feeding shortly after exposure, damage to the crop is reduced.

Main prey: There are different strains or varieties of Bt that differ in toxicity to insects: The *Bt kurstaki* and *aizawai* affect moths (caterpillars), *Bt tenebrionis* and San Diego affect leaf beetles, and *Bt israelensis* (BTI) affects mosquitoes, black flies and fungus gnats. The different strains of Bt are specific, this means they do not harm beneficial or non-target insects. Commercial availability: Several microbial pesticides based on different strains of Bt are available in Kenya: Xentari WDG and Florbac (*Bt* var. *aizawai*), Thuricide HP wettable powder and Dipel 2X WP (*Bt* var. *kurstaki*). As the larvae must eat Bt treated foliage for these insecticides to work,

throughout coverage of the foliage is very important, and use of a sticker is advisable. Bt should be applied when the larvae are small.
For further information on Bt click here

Grasshoper killed by a fungal infection

Fungi:
Description: Fungal strands (hyphae) enter the insect body through openings. The fungal hyphae (mycelia) develop and consume the insect from inside. Insects and mites killed by fungi become stiff and, under sustained wet or humid conditions, become covered with whitish, cream, green, red or grey coloured fuzz, the fruiting bodies or spores of the fungus. Spores are transferred on insect bodies, wind, rainwater or wind. Fungi commonly found attacking insects include *Beauveria bassiana*, *Metarhizium anisopliae*, *Zoophthora* spp. and *Entomophtora* spp.

Some fungi are natural enemies of plant pathogens. They are antagonistic, this is they compete with and /or suppress the development of pathogens which cause

 diseases to plants, and some are used in the biological control of plant diseases.

Commercial availability: Some fungal-based commercial products for control of pests and diseases are available in Kenya: e.g. *Beauveria bassiana* (Bb Plus®) for control of aphids, thrips, and whiteflies available from Juanco SPS Ltd.; *Trichoderma asperelum* (Trichotech®) available from Dudutech (K) Ltd. and Trichoderma spp (Rootgard®) available from Juanco SPS Ltd. for control of fusarium wilt; *Pochonia chlamydosporia* (Klamitech®) available from Dudutech (K) Ltd. and *Paecilomyces lilacinus* (Pc Plus®) available from Juanco SPS Ltd. for control of plant pests nematodes.

Viruses:
Description: A wide range of viruses has been identified attacking insects, and some of them have been used as biological pesticides. Viruses are commonly found among caterpillars and sawflies. The most common types are granulosis viruses and nuclear polyhedrosis viruses. They are species specific. Viruses need to be ingested (unlike fungi) in order to enter and replicate within the insect body. Caterpillars or sawflies infected by nuclear polyhedrosis viruses become flaccid, die rapidly, and hang limply by the abdominal legs from leaves. At the slightest touch the insect body ruptures spilling the virus particles onto leaves infecting other insects. Other viruses act more

slowly; infected caterpillars appear pale or have a chalky colour, become swollen and the development is retarded. Insects infected with viruses usually die prior to reaching adulthood and may turn black or brown after death due to secondary infection with bacteria.

Nematodes:

Nematodes are long, thin roundworms, so tiny that they usually can only be seen under the microscope. Insect-infecting nematodes are found in the soil, and infect many different type of insects living or foraging in the soil or on the ground such as the larvae of some moths, butterflies, beetles, and flies, as well as adult crickets and grasshoppers.

The most commonly studied nematodes belong to the groups Steinernematidae and Heterorhabditidae, and have been used in the biological control of insect pests. These nematodes are associated with bacteria, which are released from the nematode into the body cavity of the insect, where they multiply, killing the insect within 48 hours. The nematodes then feed on the insect liquefying tissues, develop and reproduce for several generations inside the cadaver. When the food supplies run out, juvenile nematodes move into the soil to find new hosts. The bodies of insects killed by nematodes are yellow, orange or bright red in colour.

In some cases, farmers can produce homemade microbial pesticides by collecting diseased larvae and crushing and mixing them with water in a blender. They then filter out the large tissue masses to leave the liquid for spraying the crop. The pathogen will infect and kill other pests in the crop.

Information Source Links

- **Aglearn.net, the Network for Sustainable Agriculture, Thailand. Vegetable IPM Course, Natural Enemies. www.aglearn.net**
- **Entomophatogenic nematodes. en.wikipedia.org/wiki/Entomopathogenic_nematode**
- **Hajek, A. (2004). Natural enemies. An Introduction to Biological Control. Cambridge University Press.**
- **Natural enemy gallery. www.ipm.ucdavis.edu/PMG/NE/brown_lacewing.html**
- **OISAT: Online Information Service for Non-Chemical Pest Management in the Tropics. www.oisat.org**
- **Van Mele, P. and Cuc, N. T.T. (2007). Ants as friends. Improving your tree crops with weaver ants. (2nd edition). Africa Rice Center (WARDA), Cotonou, Benin and CABI, Egham, U.K. 72 pp. ISBN: 92-913-3116.**
- **Verkerk, R. (2001). Farmers' Friends - recognition and conservation of natural enemies of vegetable pests: a field guide for extension staff and trainers in**

Zimbabwe. Biology Department, Imperial College of Science, Technology and Medicine, UK. ISBN: 0-9540132-0-4 Online version (2.5 MB)

- **Wabule, M. N., Ngaruiya,P. N., Kimmins, F. K. and Silverside, P. J. (Eds) (2003). Registration for Biocontrol Agents in Kenya. Proceedings of the PCPB/KARI/DFIDF CPP Workshop. Nakuru, Kenya, 14-16 May 2003.**
- **Way, M. J. and Khoo, K. C. (1992). Role of ants in pest management. Annual review of Entomology. Vol 37: 479-503.**

Information of www.infonet-biovision.org
