Integrated Pest Management – IPM

An attentive reader of pest management literature may notice that the term "Integrated Pest Management", or IPM, is often used interchangeably with the term "Integrated Pest Control", or IPC. They are indeed very similar to one another. However, while IPC refers to various methods of controlling pests, including the integration of natural methods with chemical pesticides, IPM also considers ecological and economic factors, including prioritising the careful monitoring of insect populations and the surrounding environment. With IPM it may be that no pest control is necessary, or that a certain kind of pest control is better than another, or that the best option is several used together, in order to achieve the best result for your economy, society, and environment. Many methods of IPM are therefore promoted by FAO to achieve different objectives in different countries, each offering concrete ways farmers can combat pests in ways to promote healthy crop production, fiscal returns, and overall safety.

IPM Principles (by FAO)

1. Growing Healthy Crops

Choosing varieties that naturally resist diseases and pests, as well as fertilizer, irrigation, and soil management that will best aid plant development, are vital principles of IPM. Growing strong plants—those that will best resist disease and insect damage—is the foundation of IPM.

2. Understanding and Sustaining Natural Predators

There are many natural predators of pests that are friends of sustainable agriculture. It is necessary for the farmer to observe insect life to both understand pest populations and recognise the role of natural predators in a farm's lifecycle and food chain. Effective biopest control will incorporate these natural enemies of pests: predators, parasites (or parasitoids), and pathogens.

2.1 Predators are animals or insects that prey on other animals or insects, typically those that are smaller than them, in large numbers, and at every stage of the prey's lifecycle (egg, immaturity, chrysalis, maturity). Typical predators of pests include birds, frogs, toads, lizards, snakes, spiders, dragon flies, ladybugs, orange ladybugs, ground beetles, green lacewings, stink bugs, and praying mantises. Predators can be categorized into two groups:

1. Biting predators (eg ladybugs, orange ladybugs, ground beetles).
2. Sucking predators (eg stink bugs).

2.2. Parasites, or parasitoids, are small organisms that survive on other organisms, known as the host, in the process weakening or killing that organsism. A parasite can enter and develop inside a host in all stages of its development (egg, immaturity, chrysalis, maturity), and can live its entire life in a single host. Female parasites harm their hosts by laying eggs inside them, for example Trichogramma and Anastatus.

2.3 Pathogens are microorganisms that live and prosper on animals or insects, causing disease, or, ultimately, death. Disease-causing pathogens include: viruses, bacteria, fungi, nematodes, and protozoa. Various pathogens will naturally attack pest insects, making them vital elements of integrated pest control.

2.3.1. Viral Biopesticide: Utilising viruses in pest control is beginning to attract widespread attention. One efficient example of such a virus is the Nuclear Polyhedrosis Virus, or NPV, a viral biopesticide that can specifically target certain pests—for example, the beet armyworm NPV will only harm beet armyworms; the cotton bollworm NPV will only target cotton bollworms. Other beneficial insects will not be harmed. A good point about NPV is that it can multiply rapidly in its host, killing them quickly, but can also spread easily, including transmission by butterfly.

Symptoms: When caterpillars contract NPV they will start moving more slowly, eat less, their bodies will begin to change colour, and they will attempt to climb to the highest tips of plants. There they will sit calmly, stop eating altogether, and die, hanging suspended by their heads. The wall of their stomach will then break open and NPV's crystallized protein particles, which contain the virus, will be released, dispersed by wind and water. Pests therefore propagate their own virus.

2.3.2. Bacterial Biopesticide (Bactericide): Bacteria are microorganisms that live in plants and soil and can be both harmful and beneficial. The most commonly used bacteria for biopesticide are of the Bacillus species, for example Bacillus Thuringiensis (Bt). Bt is capable of targeting specific pests, such as beet armyworms, cabbage loopers, diamondback moth, white caterpillars, and cotton bollworms, while leaving natural and beneficial predators unaffected. Bacillus subtilis (Bs), meanwhile, can control diseases caused by fungus and bacteria, and is proven to be safe for humans, animals, plants, and the environment. Such bacteria must be consumed first by the insect, whereupon it can enter their stomach and cell-walls, releasing poison that will slow its digestive system, cause the insect to become swollen and, finally, burst open and die.

2.3.3. Fungal Pesticide: Many varieties of fungi are utilised around the world to combat pests and plant diseases. In Thailand the most commonly used are Trichoderma and Beuveria. Trichoderma is used to control root rot and wilt caused by other fungi. Beuveria is used against rice thrips, moina, white flies, aphids, and brown planthoppers, among others.

2.3.4. Nematodes: Nematodes are small organisms that live in the soil and water. Some can cause certain diseases, for example the nematode *Meloidogyne spp*. causes root-knot diseases in tomatoes, betel, and other vegetables. Other nematodes, however, known as "free-living" nematodes, do not cause disease. These can be separated into two groups, both of which can be used in biopest control: Steinernema and Heterorhabditis. The most commonly used variety is *Steinernema carpocapsae*, which can harm many kinds of insects by excreting a poisonous bacteria inside them, causing them to die in 24-48 hours.

2.4. Natural Herbicides: Many plants in Thailand can be utilised in biopest control, and have already been used in certain areas for a long time. Neem, galangal, turmeric, Siam weed, lemon grass, non taai yaak, derris, and others can be used as repellents and to disrupt the eating habits and development of pest insects. Among these plants the most beneficial is Neem. Extracts from neem are currently widely used in Thailand and around the world for pest control.

Methods of Conserving and Protecting Natural Predators

1. Protect and conserve the plants that serve as food for these natural predators in farms, rice fields, and gardens. These include plants of the genus Jussiaea, species of balsam plants, pickerel weed,

globe amaranth, goat weed, morning glory, and various grasses. These are plants that do not have real economic value, but their pollen and nectar provide food for beneficial natural predators throughout the year, helping sustain healthy populations.

2. Create environmental conditions that will support natural predators. One way to do this is employing crop rotation, which will both help natural predators survive each season while controlling the new influx of pests in the next growing season.
3. Increase moisture with watering, or provide sufficient water to beds during dry seasons. This will also help natural predators survive and propagate.
4. Don't burn rice residue after harvest, as this will upset the equilibrium of a farm's ecosystem. It is one reason pests spread quickly at the beginning of certain seasons: natural predators have been killed.
5. Observe both your natural predators and pests closely and consistently. Don't use chemicals in areas with high natural predator populations and low pest populations, for example.

The Benefits of Taking Care of Natural Pests

1. By taking measures to support natural predators, agriculturalists are utilising a natural resource that already exists in their farms, rice fields, and gardens, to practice long-term, efficient pest control.
2. Helping to maintain a balanced ecosystem will decrease both established pest numbers and the arrival of new pests.
3. Biopest control makes plants safer to eat, so it benefits consumers.
4. Biopest control rewards farmers in many ways—economically, socially, and environmentally—by decreasing the amount of chemical pesticides that need to be imported and reducing the obstacles facing exporting to foreign markets.

3. Survey Your Plots Regularly

It is important to monitor and evaluate the development of your plants, including the presence of diseases, weeds, and pests. Plots should be surveyed weekly for pest damage and other factors affecting the ecosystem, including natural predators, soil, water, and air quality, and anything else that will affect your plants.

4. Farmers as Experts

An essential element of modern agriculture is the farmer taking responsibility for the management of her own production and income. This means gaining an understanding of how various elements are related and bringing that understanding to the management of a farm. This will help a farmer make independently, increasing both the efficiency and potential scope of management. Becoming the expert on a farm therefore means learning new skills and gaining a correct understanding of agricultural ecosystems.

Biopest Control Methods

Biopest control methods range from the extremely simple, which farmers can practice daily by themselves, given the right training, to the more difficult, requiring specialised training. Agricultural

scientists and professional farmers already understand that some of these methods have mild effects, while the effects of others are strong. This is why they must be used together, or integrated. The ultimate aim is to find the combination that works most efficiently, saves most resources, is most safe for the farmer and consumer, and kindest to the environment.

Methods of Biopest Control

1. Appropriate Plant Management

This means maintaining appropriate environmental conditions to help plants develop, grow strong, and resist pests.

1.1 **Improving soil**. This means preparing beds with the appropriate pH level for plant development, mineral content, and surface consistency, without aiding the development of pests.

1.2 **Use good plant varieties**. Quality plant varieties are better at resisting pest. Help them by using the appropriate planting ratios, spacings, and seasons.

1.3 **Water and fertilizer**. Apply regularly, using the right quantities and formulas.

1.4 **Tillage**. Certain pests are killed when the soil is turned and they are exposed to sunlight.

1.5 **Weeding**. Many weeds are home to pests and secondary hosts to plant diseases. Weeds also consume the food of plants, making them weak.

1.6 **Pruning**. When branches are too long foliage grows too dense, preventing plants from synthesising enough sunlight and increasing moisture. This creates a more desirable home for pests.

1.7 **Crop rotation**. Crops planted should alternate season by season, or planting should alternate between plants from different families. This will interrupt the food source of various pests.

1.8 **Crop integration**. If a single crop is planted across a wide area and pests arise, they will spread rapidly across the entire population. Integrate crops to limit pest food sources and opportunities for them to spread.

1.9 **Postpone planting**. It is sometimes useful to postpone the planting of certain annual plants, or those with short lifespans, to avoid times when diseases are rampant. For example, in Thailand cassava is normally planted at the end of the rainy season, from October to January. The cassava plant then hits drought in March-April, coinciding with the hot weather perfect for the spread of the cassava mealybug. It's therefore recommended cassava is planted at the beginning of the rainy season instead, about mid-April, so that it doesn't go without water and maintains strength. The rainy season then provides inhospitable conditions for the cassava mealybug. Another example is the current spread of the brown planthopper in Thailand on rice farms where rice is planted year-round. This provides a source of food for the brown planthopper that never goes away. It's therefore recommended that rice isn't planted more than twice a year in order to disrupt the brown planthopper's lifecycle.

2. Mechanical Control

This is the use of machines or other tools to lower pest populations. If numbers are low enough, human labor can be sufficient.

2.1 **By Hand**. The simplest form of pest control: pick pests off plants, or hold the plant and shake them out, and exterminate.

2.2 **Human Labor**. Pruning diseased plant matter, or those parts covered with established pests, and burning it to exterminate pests.

2.3 **Netting**. Netting can be used to isolate plants from outside pests entirely.

2.4 **Traps**. Insects and other animal pests, such as mice, birds and bats, can be exterminated in traps.

2.5 **Motor-run Machines**. Some motor-run machines can be used for pest control, for example a grass hopper-catching machine and an insect-sucking machine.

3. Using Physics for Pest Control

This is the use of methods and scientific instruments to lure, repel, and exterminate pest populations through the use of heat, sound, and light.

3.1 **Radiation**. Radiation can be used to exterminate a pest population from a crop before exporting, for example irradiating fruit before exporting it to America to kill durian seed borers, mango seed weevils, and the oriental fruit flies Bactrocera dorsalis and B. correcta. Or radiating herbs to kill fungi, etc.

3.2 **Sound**. A hand-held machine that produces sound waves at a low frequency can be used to drive certain pests from an area.

3.3 **Heat**. Baking soil is one way heat can be used to exterminate pests. Hot steam can also be used to exterminate pests clinging to crops.

3.4 **Traps**. This method must target specific insects. For example, light can be used to target those insects that like to fly around at night (place a container of water beneath a light bulb). Vacuums can also be used to suck insects, a method popularly used with moths and brown planthoppers. Methyl eugenol-baited traps, meanwhile, are effectives ways trap male fruit flies, while protein-baited traps can lure oriental fruit flies of both sexes.

4. Using Natural Predators to Control Pests

4.1 **Kinds of Natural Predators**: As noted above, predators (such as dragonflies, spiders, (), etc), parasites (such as various parasitic wasps, nematodes, etc), and pathogens (such as bacteria, fungi, viruses, etc) can all be used to control pest populations.

4.2 **Advantages**

i. Low-cost, as the natural predators already live in agricultural ecosystems, will work without pay, and will lower other pest-control inputs on the farm.

ii. Sustainable in the long term, as natural predators will sustain their own populations if they have enough food and are not harmed by chemical pesticides.

iii. Natural predators do not cause pests to develop disease resistance, or give rise to new varieties of pests.

iv. Natural predators do not harm forms of life other than pests, and do not poison the environment. They will also not harm crops, as they do not eat crops for food.

v. Natural predators do not harm farmers, consumers, or the environment.

5. The Sterile Insect Technique (SIT)

The FAO has identified SIT as an effective method of biopest control that doesn't harm the environment. Once released the sterile insects will procreate with ordinary insects, creating eggs that do not hatch. This will decrease the overall insect population. If enough sterile insects are released, three generations will see significant decreases in the pest population. Several pests have been successfully controlled in Thailand with this method: various kinds of fruit fly, Diamondback moths, and cotton bollworms.

6. Natural Extracts as Pesticides

Various extracts taken from natural sources have potential to control pests, such as neem seed extract, lemongrass, betel, derris, Non Taai Yaak, etc.

7. Chemical Control

Careful use of chemicals is acceptable in an integrated pest management system. However, they must be seen as a final measure only necessary when other methods have been tried without success. (Much more.)

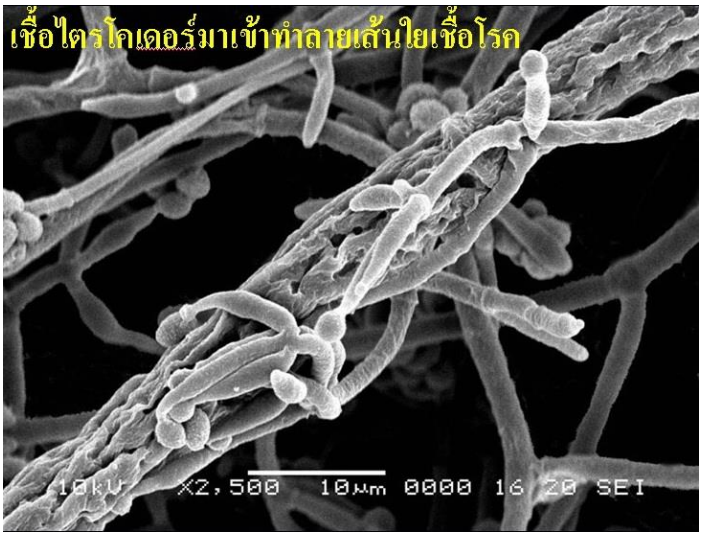
A Comparison of Chemical Pest and Biopest Control Methods

Using Chemicals	**Using Biopest Control**
• Solve problems quickly, but for a short time only. • Expensive (chemicals and renting sprayers) • All chemicals are dangerous • Creates resistance in pests, and causes new kinds of pests to arise	• Solves problems in the long term. • Inexpensive (not necessary to buy or rent anything). • Safe, as everything comes from nature. • Helps maintain an ecological balance.

Substances Used for Biopest Management

Trichoderma

Trichoderma (*Trichoderma harzianum*) is a high-grade fungus that grows well in soil, plant matter, animal remains, or other organic material. It consists of white fibres and propagates via spores. When raised in a petri dish the white fibres and green spores are visible; in other varieties the spores may be white or yellow. Trichoderma is known as an "antagonistic" fungicide: it can control many plant diseases that live in soil through exploitation, or parasitic behaviour, competing and consuming the food eaten by pathogens. Aside from this, Trichoderma can help dissolve minerals into forms that are easily consumed by plants, thereby aiding their development, as well as building resistance in plants against all disease-causing fungi and bacteria.



These are ways in which Trichoderma combats diseases:

- **Highly Competitive:** Trichoderma's ability to quickly develop its white fibres and spores enable it to succeed in competition against other pathogens or microorganisms in a particular area. Trichoderma is also capable of upsetting other activities of disease pathogens, and lowering their intensity.
- **Parasite of Disease Pathogens:** Trichoderm's white fibres are able to bind and pierce other organisms, including those fungi that cause disease. Trichoderma will also eliminate those structures harmful fungi build to facilitate propagation, or to last until the growing season.
- **Inhibits or Harms Disease Pathogens:** Trichoderma can produce bio-antibiotics, toxins, and enzymes to combat pathogens that cause disease.
- **Stimulates Disease Resistance:** Trichoderma will help protect plant roots, making the root system healthy, strong, and more resistant to pathogens that cause disease. It will promote seed gemination and seedling growth, while also inducing plants to produce enzymes and proteins such as pentyl pyrone and arsenic acid to stimulate disease resistance.

The Benefits of Trichoderma

Trichoderma can exterminate:

1. *Pythium spp.*, which causes rot in seedlings, root and stem rot, and leaf rot in tomato and other vegetables.
2. *Phytopthora spp.*, which causes fruit and flower drop in longan, lychee, and durian, and root and stem rot in chili, durian, tangerine, lime, pepper, watermelon, cucumber, tomato, and banana.
3. *Sclerotium spp.*, which causes root and stem rot, seedling burn, sclerotium stem rot, and wilt diseases in various crops, including tomato, strawberry, and potato.
4. *Rhizoctonia spp.*, which causes root and stem rot, seedling rot, and, in durian, leaf blight.
5. *Colletotrichum spp.*, which causes anthracnose in mango, grape, guava, jujube, rose apple, papaya, chili, onion, multiplier onion, shallot, garlic, and potato.
6. *Alternaria spp.*, which causes leaf spot in cabbage, kale, chinese cabbage, cauliflower, broccoli, strawberry, and chilli.
7. *Fusarium spp.*, which causes leaf burn in orchard trees and various vegetable crops.

How to Grow the Fungus Trichoderma from Live Cultures

According to the Chiang Mai Centre for Pest Control

Materials and tools:

1. Raw rice
2. Clean water
3. Heat-tolerant plastic bags, 8 x 12 inches
4. Rubber bands, pins
5. Electric rice cooker
6. Live Trichoderma cultures

Step 1: Preparing food to raise the fungus

1. Cook rice in the electric rice cooker, using a ratio of 3 parts rice to 2 parts water.

2. When it's cooked, stir together and then put into plastic bags while still hot. You should have about 250 grams in each bag (or two big ladle-fulls). Your rice should still be a little hard.

3. Flatten your bags of rice evenly, pressing the air out of each one, and then set aside until they are just warm, almost cool.

Step 2: Adding the Trichoderma cultures

1. Pour two teaspoons of Trichoderma into each bag. Try to do it in a non-windy place to prevent contamination by airborne microorganisms.

2. Secure the mouths of the bags firmly with rubber bands, shaking each to make sure the Trichoderma is thoroughly dispersed.


3. To allow sufficient ventilation, use a pin to pierce about twenty holes in the bag beneath the rubber band.

4. Lie your bags of rice down so that there is as thin a layer at the bottom as possible, making sure to pull the sides of the bag up off the rice to maintain good ventilation.

Step 3: The Trichoderma matures

1. Arrange the bags of rice on shelves or a table, taking care they don't touch or overlap, in a room safe from ants, insects, and other animals.

2. The room used for maturing your Trichoderma should have good light and be well-ventilated, but direct sunlight shouldn't touch any of the bags.

3. After 3 days the white fibres of the Trichoderma will be proliferating on your rice. Without opening your bag, use your fingers to arrange the fibres in chunks, allowing the fungus to continue spreading throughout the entire bag. Return the bags to their original positions, pulling the sides of the bag out to keep good ventilation. Allow the fungus to grow for another 4 days.

4. After 7 days the fungus will produce green spores. These can be taken and used immediately. If you don't want to use them straight away, store in the fridge. They can be kept for about two weeks.

Methods of Using Trichoderma

Plants/Flowers/Houseplants

1. Mix with seeds before planting.



2. Mix 1 kg of Trichoderma, 5 kg of soft rice bran, and 40 kg of compost, and scatter evenly over the soil before planting, and again every 14 days during their sprouting, flowering, or fruiting stages, for normal plants. When disease is spreading, apply every 5-7 days.

3. Mix 1 kg of Trichoderma liquid with 100-200 liters of water and spray onto the soil or directly onto plant beds at any stage of their development.



Fruit/Perennials

1. Mix 1 kg of Trichoderma, 5 kg of soft rice bran, and 40 kg of compost until well combined and uniform, then scatter into holes before planting, and then scatter around the base, beneath its foliage, 3-4 times a year.



2. Spray Trichoderma liquid onto soil or directly onto plants every 1-2 months, or every 7-10 days if disease is actively spreading. Apply to soil 3-4 times a year, when the soil is damp.




Rice

1. Soak seeds before broadcasting.

- Soak rice seeds in Trichoderma liquid (1 kg of Trichoderma to 200 litres of water) for 18-24 hours.

- Soak for 30-60 minutes and let sit for 1 day.



2. Release a Tricoderma liquid in the rice field. For this method, use 2 kg of Trichoderma per rai.


3. Mix Trichoderma with chemical fertilizer and apply to the field. For this method, use 2 kg of Trichoderma per rai.



4. Make a Trichoderma liquid and spray onto the field. For this method, mix 1 kg of Trichoderma with 100-200 liters of water and a sticking agent. During periods of flowering and seed production rice can be sprayed at 5-10%.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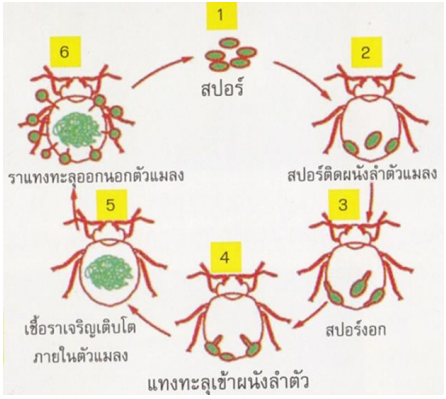
Beuvaria

The principles of sustainable agriculture encourage a reduction in the use of chemicals to control pests, something which will also lower capital inputs on farms. It's therefore necessary, however, to find other means of pest control. In nature there are many natural means of maintaining ecological equilibrium. For example, the spread of disease is one way life on this planet is controlled. Diseases spread by fungi, bacteria, and viruses are often efficient ways of reducing or eliminating certain insect populations. Bacteria and viruses both have limitations, however: insects must consume them for them to work. In agriculture there are many kinds of pests to contend with, at all stages of a plant's development. Fungi have some advantages over other pathogens: they can enter the body of the plant, and therefore kill many more kinds of insects—all those that suck the juice of the plant: aphids, rice thrips, (ไรขาว), mealybugs, (มวน); all those that eat plants: beetles and caterpillars; and even many insects that live in the soil.

The role of Beuveria in controlling pests

Beuveria (scientific name: *Beauveria bassiana*). is made of white fibres, which can be observed clearly when grown on a fungus-raising material, or other suitable food, like agar-agar. Beuveria's insect-attacking ability is realized when its spores make contact with an insect. Within 12 hours of contact, if there is moisture and appropriate food on the body of the insect, the spore will sprout white fibres, pierce the insect's torso, enter it's body, and develop inside. At this time the insect will weaken, like a person that has become sick. It will lose its appetite, and, finally, die. When it dies the spores will pierce the torso

again and reemerge. Whether it works fast or slow, the success of Beuveria lies in its ability to pierce the body of the insect.



Within 3-7 days of entering an insect Beuveria can produce obvious signs of success. Spraying the fungus over an entire pest-filled area, therefore, enables the spores to make contact with many insects and is an efficient way to lower overall population numbers. It will also not hurt insects that are beneficial predators or parasites, for example *Encarsia spp.*, a parasitic wasp of the family Aphelinidae, or the predatory group of insects known as lacewings, or *Chrysopa*, which eat pests of the very small variety, such as aphids, mealybugs, butterfly eggs. Note how useful Beuveria can be to businesses and other agricultural producers, considering how easily it can be produced via a process of fermentation, or propagated on a fungus-raising food, to develop spores that can tolerate ultraviolent light, temperature, and high humidity.

How to Produce Beuveria

Materials and tools:

1. Live Beuveria cultures
2. Raw rice
3. Clean water
4. Heat-tolerant plastic bags, 8 x 12 inches
5. Rubber bands
6. Pins
7. Pot used for steaming

Method of production

1. Spoon the raw rice into the plastic bags and add water (two parts rice to one part clean water). Tie the mouth of the bag tightly with a rubber band and arrange neatly inside the pot, adding bags until the pot is full.

2. Steam the bags inside the pot for 30 minutes. Some of the rice will still be hard. Remove the rice and let the bags cool. Mix the bags thoroughly with your fingers, making sure the rice that's still hard is well-mixed with the softer rice. Put aside and let cool further until just warm.

3. Open the bags and add the fungus. First shake the Beuveria cultures in their bottle until they break up. Then pour about 1-2 teaspoons into each bag. Tie the bags firmly at the mouth and shake until the fungus is well-mixed in the rice.

4. Use pins to pierce about 15-20 holes in the bag for ventilation.

5. Store in a well-lit place. Within 3 days the fungus will appear on the rice; mix it again with your fingers to spread the fungus throughout the entire bag. After about 7 days the white fungus will completely fill the bag. It can now be used.

Methods of use

Adding to soil

Use 100 grams of Beuveria (1-2 handfuls) per square metre.

1. Fruit: Control pests when fruiting by scattering the fungus around the base of the tree, beneath its foliage. Break up the soil and cover the fungus, or cover it with something else (rice straw, dried grass, or other plant matter) to protect it from the sunlight. Apply again every two weeks.

2. Vegetables: After preparing your beds, scatter the fungus and then mix with the soil before sowing seeds or transplanting.

Spraying leaves

Mix 10 grams of Beuveria (1 soup spoon) with one liter of water. Once mixed you will see the fungus floating on the surface of the water, so you must add a sticking agent such as dishwashing liquid. Mix spores from the Beuveria-raising bag into the water. Strain the fungus-raising material from the liquid and use the rest for spraying. Spray on the underside of leaves, trying to cover every insect. You should spray when cool, and avoid sunshine. Spray regularly every 2 weeks.

If you need to spray Beuveria in a large area you can increase the volume of the mixture. First mix the fungus with a smaller amount of water, in a small container, however, so that you can strain out the fungus that floats on top first, then add water to reach the right ratio.

Correct use

Although using Beuveria is a great method for farmers, consumers, and the environment, it should still be applied correctly. Take note of the following points:

1. After spraying you will not see dead insects immediately, like you will with chemical insecticides.

2. You should try to spray the entire body of the insect, or cover the whole leaf, and don't forget to spray when the weather is cool.

3. At first you should use Beuveria as prescribed here continuously, until the fungus is able to establish itself in the area you want. After that, you can let more time pass between applications.

Method of producing dry Beuveria

You have already developed your Beuveria. Now put it in a deep, clean tray and leave it in the shade for 10-12 days, covering with a thin cloth to protect it from sunlight. After that pack into bags and store in the refrigerator for later use.

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Bacillus thunringiensis (Bt)

Materials and Tools:

1. Bacillus thunringiensis, or Bt	1,000 cc (1 liter)
2. Sweet condensed milk	8 cans
3. Molasses	4 liters
4. Water	80 liters
5. Plastic bucket with a sealable lid	1
6. Air pump, with accessories (the same kind used for fish)	1 set

Method of production

1. Pour the 80 liters of water into the plastic bucket.

2. Add 1,000 cc of Bt.

3. Add four cans of sweet condensed milk.

4. Stir until well-mixed.

5. Put the lid on the bucket and seal tightly. (You should have already pierced a hole in it to allow the air pump to enter.)

6. Turn on the air pump to increase the oxygen in the water. Or, if you don't have an air pump, use a stick to stir 2-3 times per day, for 3 days.

7. After 3 days add another 4 cans of sweet condensed milk and 4 litres of molasses. Stir until well-mixed.

8. Turn on the air pump, or stir 2-3 times per day for another 3 days.

Important

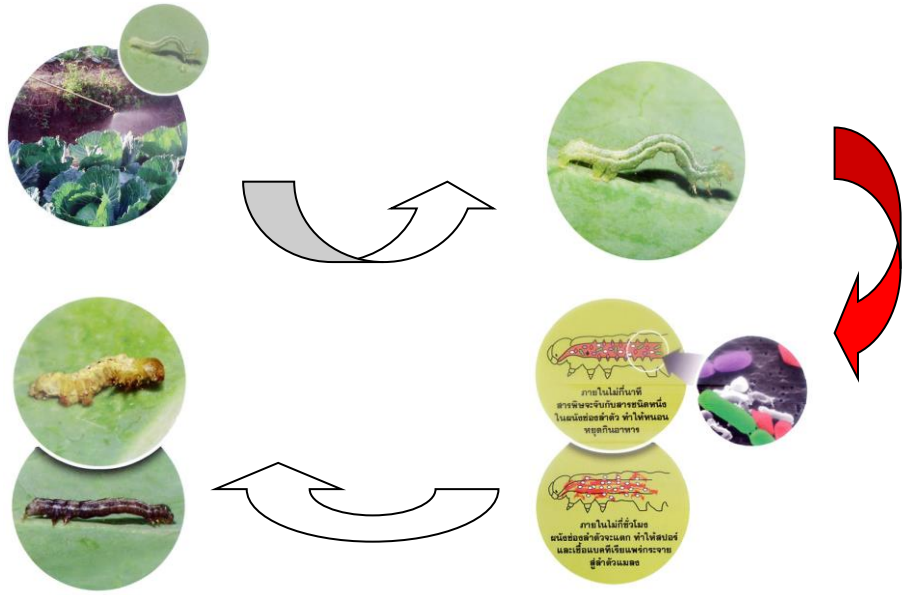
Bacillus thunringiensis (Bt) is a microorganism that can effectively control many kinds of caterpillars. It consists of living particles (spores) and the poisonous crystals of bacteria. When a caterpillar eats Bt, the poison created by Bt will slow down the caterpillar's digestive system, causing convulsions, paralysis, and ultimately death within 1-2 days. For humans, animals, and the environment, however, Bt is non-toxic.

Examples of caterpillars Bt is effective against

Diamondback moth-Green longan looper-Common brimstone butterfly-Cotton Bollworm-Cluster Caterpillar / Cutworm

How does Bt work?

Bt doesn't work in the same way as general chemical insecticides. It doesn't kill insects with the same severity; insects won't die immediately after spraying. Bt poisons the alimentary canal, the parts of an insect's body that processes food. Once consumed, Bt will enter the system.



Techniques for the use of Bt

1. Bt should be used on caterpillars that are still small.

2. Bt should be sprayed in the evening when there is less sunshine and more moisture.

3. Bt should always be mixed with a sticking agent. This will help Bt stick to surfaces of plants longer.

4. Adjust the nozzle of your spraying device to allow the maximum output possible, so that as great an area is sprayed as possible.

5. During times when caterpillars are hatching and spreading, Bt should be sprayed once every 3-5 days, and 2-3 rounds, continuously, each time.

6. Bt shouldn't be mixed with chemicals used to protect plants from disease, especially those which will actively harm bacteria, for example antibiotics, copper oxide, etc. Bt also shouldn't be mixed with alkaline water.

*The container used to mix the Bt should be stored away from sunlight and heat.

The Merits of Using Bt

1. Bt will target the insects you don't want, without affecting other kinds that you don't need to control, for example beneficial predators and parasites.

2. Bt is safe for plants, animals, and humans, both users and consumers.

3. Bt leaves no harmful residue. After spraying your plants with Bt, you can consume them. You don't have to waste time waiting before you harvest.

4. Bt is highly efficient compared to other microorganisms.

Points to Remember

Bt shouldn't be used on mulberry plots used as feed for silkworms, and shouldn't be sprayed anywhere near places silkworms are raised, as its harmful to them.

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Bacillus Subtilis (Bs)

Materials and Tools:

1. Bacillus subtilis, or Bt	1,000 cc (1 liter/kg)
2. Sweet condensed milk	8 cans
3. Molasses	4 liters
4. Water	80 liters
5. Plastic bucket with a sealable lid	1
6. Air pump, with accessories (the same kind used for fish)	1 set
7. Chicken eggs	5-10

Method of preparation

1. Pour the 80 liters of water into the plastic bucket.

2. Add 1,000 cc of Bs.

3. Add four cans of sweet condensed milk and 5-10 chicken eggs.

4. Stir until well-mixed.

5. Put the lid on the bucket and seal tightly. (You should have already pierced a hole in it to allow the air pump to enter.)

6. Turn on the air pump to increase the oxygen. Or, if you don't have an air pump, use a stick to stir 2-3 times per day, for 3 days.

7. After 3 days add another 4 cans of sweet condensed milk and 4 litres of molasses. Stir until well-mixed.

8. Turn on the air pump, or stir 2-3 times per day for another 3 days.

About Bs

The bacteria Bacillis Subtilis (Bs) is another useful microorganism capable of protecting plants from diseases that arise from many kinds of fungus and bacteria. Bs also doesn't harm humans, animals, or the environment, and doesn't leave a harmful residue. It's a bacteria that naturally lives within plants, so it will not produce harmful effects when it comes into contact with them. It's a highly beneficial microorganism for its potential to lower the rate of disease. Bs can:

1. directly fight bacteria that cause disease.

2. produce many kinds of antibiotics.

A prominent characteristic of Bs is its superior ability (compared to other microorganisms) to compete for nutrients in nutrient-deficient environments.

Pathogenic fungi and bacteria, and their disease symptoms, that can be controlled by Bacillis Subtilis

Disease Symptoms	**Pathogenic Fungi and Bacteria**
Root rot	*Fusarium* spp. *Sclerotium* sp. *Phytophthora* spp. *Rhizoctonia* sp. *Pythium* sp.
Soft rot	*Erwinia* spp.
Wilt	*Pseudomonas solanacearum*
Bacterial blight	*Xanthomonas* spp.
Canker	*Xanthomonas* spp.
Leaf spot	*Cercospora* spp. *Septoria* sp.
Anthracnose	*Colletotrichum* sp.

Using Bacillis Subtilis

Plants	Targeted Disease	Rate of Use
Plants of the Brassicaceae family, including kale, cabbage, cauliflower, Chinese cabbage, mustard greens, etc.	(โรคใบเหลืองกรอบ) Blight, which is caused by the fungi *Fusarium*; (โรคใบทอง), caused by the bacteria *Xanthomonas*; and Leaf spot, caused by the fungi *Alternaria*.	Use 50 grams of Bs for every 20 liters of water. Water holes before planting and apply again every 7-10 days.
Root vegetables, including onion, garlic, ginger, galangal, potato, taro, etc.	Root rot, which is caused by bacteria such as *Erwinia*; purple blotch, caused by the fungi *Alternaria.*	Use 50 grams of Bs for every 20 liters of water. Water holes before planting and apply again every 7-10 days.
Plants of the Cucurbitaceae family, including watermelon, cucumber, luffa, bitter melon, etc.	(โรคเถาแตก-โคนเน่า), which is caused by many kinds of fungi, including *Phythophthora, Pythium, Fusarium*, etc.	Use 50 grams of Bs for every 20 liters of water. Water holes before planting and apply again every 7-10 days.
Other plants, such as tobacco, tomato, chili, asparagus, etc.	(โรคเหี่ยวเขียว)Wilt, which is caused by the bacteria *Rhizoctonia*; Anthracnose; and leaf spot.	Use 50 grams of Bs for every 20 liters of water. Water holes before planting and apply again every 7-10 days.
Fruit, including durian, citrus, longan, guava, etc.	Blossom drop, which is caused by the fungus *Botryodiplodia*.	Use 50 grams of Bs for every 20 liters of water. Spray every 7-10 days.

Natural Methods of Insect Control

Neem *Azadirachta indica* Juss. Var. Sinensis Valeton

Family Meliaceae

General characteristics: Neem is a perennial that will grow 5-10 metres tall. The trunk has grey or light-brown bark. Every part of the tree has a bitter flavor because of the presence of the chemical Nimbidin, which isn't poisonous. Flowers grow in bunches at the end of branches, and will appear once old leaves have fallen from the tree. The petals of the flowers are white and perfumed. The tree will flower from December to March.

Means of Propagation: Seed or cutting.

Parts used: Leaves, fruit, bark, and seeds can all be used in pest control.

Important substances: - Neem bark has the chemical compounds nimbin and desacetylnimbin.

- Neem leaves contain the flavonol quercetin.

- Neem fruit contains the most bitter of substances, bakayanin.

- Neem flowers contain the glycoside nimbosterin (0.005%), very spicy essential oils (0.5%), as well as the chemicals nimbecetin and nimbosterol, fatty acids, and other bitter-tasting elements.

- Neem seeds consist of 45% margosic acid, or "nim oil," as well as nimbin, numbidin, and the chemical compound azadirachtin, which can kill insects. The seeds contains about 0.4-1% azadirachtin: Indian Neem contains 7.6 mg/gram on average; Thai Neem contains 6.7 mg/g on average; and Philippine Neem (*Azadirachta excelsa*) contains 4.0 mg/g on average.

Beneficial uses: Neem's effectiveness against insects can take many forms. It can be used as an insecticide, a repellant, make insects lose their appetite, and stunt their development. For example, neem can make caterpillars to lose their ability to shed their skin (unable to escape or develop into their next phase, the caterpillars die trapped inside), due to an active compound of neem which creates new hormones. These hormones can also affect the egg production and lower the amount of eggs produced. The chemical compound azadirachtin will work well against caterpillars, such as the diamondback moth, (หนอนใยกะหล่ำปลี), cabbage webworm, leaf miner, cutworm, spiny cotton bollworm, (หนอนหลอดหอม), stem borer, and (หนอนบุ้งปอแก้ว). However it is not effective against the red cotton stainer bug, flea, various beetles, green stink bug, pea-pod borer, mealybugs, and scale insects. It can be used for protection against fungus and bacteria.

Tobacco *Nicotiana tabacum L.*

Family Solanaceae

Means of propagation: Seed

Parts used: Leaves.

Important substances: Tobacco leaves contain organic acids (malic acid, citric acid, and oxalic acid), the polyphenols rutin acid, chlorogenic acid, and quercitrin, and the essential oils alcohol and nicotine.

Beneficial uses: Increase protection from and control stem borers, cabbageworms, leaf miner, cotton bollworms, butterfly caterpillars, aphids, rice thrips, various mites, and flea beetles. Tobacco can also control and protect plants from diseases.

Method of use: Mix 1 kg of tobacco with 2 liters of water and soak for one night. Strain and remove tobacco leaves, add 54 litres of water (3 ปี๊บ), and spray, not

letting it touch your body. 3-4 days after spraying your plants can be consumed as normal.

Citronella *Cymbopogon nardus Rendle.*

Family	Gramnineae
Means of Propagation:	Root
Parts used:	Leaves and stems
Important substances:	Citronella contains methyl eugenol, verbena oil, lemon oil, and indian molissa oil.
Beneficial uses:	Citronella can be used to control cutworms, diamond back moths, mosquitoes, and cockroaches, lure male fruit flies, and repel lesser grain borers.
Method of use:	1. The oil of citronella can be mixed with other oils and sprayed to drive away pests. 2. Pound 4kgs of fresh, full-flavoured citronella leaves, 4kg of galangal, and 4kg of neem leaves into a paste, then soak together in 36 liters of water (2 ป๊บ) and leave overnight. Strain free of solids and use this liquid as a concentrate. Mix 10 soup spoons with 20 liters of water to create a good spray for vegetable plots, rice fields, and fruit orchards. 3. Take the root and leaves of citronella and chop into the small pieces, then pound until you have about 500 grams of fine paste. Mix this with 10 liters of water and leave for 1 day. Strain free of solids, mix with a leaf-sticking agent, like dishwashing liquid or shampoo, and spray.

Goat weed *Ageratum conyzoides L.*

Family	Compositae
Means of Propagation:	Seed
Parts used:	Leaves and stems
Important substances:	-
Beneficial uses:	Goat weed can be used to control pests.
Method of use:	Pound about 1 kg of leaves and stems, then soak overnight in 18 liters of water (1 ป๊บ). This water can be used as a spray.

Non Taai Yaak *Stemona collinsae Craib.*

Family	Stemonaceae
Means of Propagation	Root, seed
Parts used:	Root
Important substances:	Stemonine
Beneficial uses:	Non Taai Yaak can be used control and give protection from harmful fungi and bacteria, as well as repelling various kinds of pests.
Method of use:	Pound about 1 kg of Non Taai Yaak root and soak overnight in 18 liters of water (1 ปี๊บ), or coconut oil. Spray this liquid to kill various kinds of insects and caterpillars.

Garlic *Allium sativum* L.

Family	Liliaceae (Alliaceae)
Means of Propagation:	Bulb
Parts used:	Bulb
Important substances:	When garlic has been crushed, or in garlic oil, there is about 0.6-1% allicin, or diallyl sulfide, a strong-smelling compound that is also present in sulphur.
Beneficial uses:	Increase protection from and control cutworms, aphids, thrips, various beetles, as well as downy mildew and soybean rust.
Method of use:	1. Soak 1 kg of finely-chopped garlic in kerosene or benzene for 24 hours. Then add a small amount of liquid soap and mix thoroughly. Strain this mixture until only a clear liquid remains. Before using dilute this mixture 20 times, or add about 100 liters. 2. Finely crush three large bulbs of garlic and soak in kerosene for two days. Strain and mix the solution with 1 tablespoon of liquid soap. Mix thoroughly. Before using dilute with 10 liters of water. 3. Pound 1 handful of garlic until fine and soak in half a liter of hot water for 24 hours. Strain free of solids and mix with 4 litres of water and ½ a tablespoon of liquid soap. Spray twice a day, every other day, in the morning. 4. Crush 2 large bulbs of garlic and 2 teaspoons of dried chilli until fine. Add to 4 litres of hot water, adding a little liquid soap. Stir and then strain before using. This formula works well against caterpillars that attack fruit.

5. Dry one handful of peeled garlic cloves in the sun and then pound into a powder. Sprinkle on affected plants when they are not moist.

Turmeric *Curcuma domestica (Curcuma longa)*

Family Zingerberaceae

Means of Propagation: Root or rhizome.

Parts used: Root or rhizome.

Important substances: Cucurmin, and some essential oils.

Beneficial uses: To control and drive away various insects, including beet armyworms, cutworms, diamondback moth caterpillars, cabbage webworms, and various other caterpillars, bean fly larvae, cowpea weevils, rice weevils, darkling beetles, lesser grain borers, common fruit flies, and water fleas.

Methods of use: 1. Mix 500 grams of crushed fresh turmeric root with 20 liters of water and soak overnight. Strain free of solids and spray your vegetable beds.

2. Mix 1 part finely-pounded turmeric root with 2 parts cow urine. Strain free of solids and spray as a natural insecticide. If you're using on caterpillars, dilute the solution six times.

3. Mix 500 grams of finely-pounded turmeric root with 2 liters of water and soak overnight. Strain free of solids for a powerful concentrate. Mix this concentrate with 8 liters of water and spray your beds. This solution will effectively repel diamondback moth caterpillars and beet armyworms.

Marigolds *Tagetes erecta* Linn.

Family Compositae

Means of propagation: Seed and cutting.

Parts used: Flowers.

Important substances: Marigold flowers contain flavonoid glycosides, tagetiin (0.1%), and some fluorescent compounds. The leaves contain the chemical compound kaempferitrin, and the seeds contain oil.

Beneficial uses: Increase protection from and control diamondback moth caterpillars, cabbage worms, brown planthoppers, leafhoppers, scale insects, mealy bugs, aphids, beetles, white flies, flies, grasshoppers, and nematodes.

Method of use: Marigold flowers can be mashed and pressed to produce a concentrated liquid. After straining, mix 10 liters of this liquid with 10 liters of clean

water. Before using, add 1 tablespoon of liquid soap to help the solution stick to your plants.

Indian Long Pepper	*Piper longum* Linn.
Family	Piperaceae
Means of propagation:	Cuttings
Parts used:	Peppers
Important substances:	Old peppers contain the alkaloids piperine (6%) and chavicine, and essential oils (1%).
Beneficial uses:	Oil extracted from old peppers will efficiently protect plants from and control pests, including diamondback moth caterpillars, cutworms, pest insects that affect rice storage, beetles, and weevils.
Method of use:	Bake 0.5 kg of dried Indian long peppers at a temperature of 50°C and then soak them in 1.5 liters of alcohol. Next, blend the solution until fine and leave overnight before straining out the unwanted solids. Use the remaining liquid to spray.

Lemongrass	*Cymbopogon Citratus*
Family	Gramineae
Means of propagation:	Root
Parts used:	Leaves and stems
Important substances:	Lemongrass contains the essential oil called lemon grass oil, also known as verbena oil, or Indian molissa oil.
Beneficial uses:	This oil contains elements that are poisonous to mosquitoes, flies, and other insects, and acts as an effective repellent. It can also be effective against various fungi and bacteria.
Method of use:	Pound about 1-2 kg of fresh leaves and stems until fine. Soak overnight in 18 liters of water. Strain free of solids and spray to repel mosquitoes and other insects.

Boraphet	*Tinospora crispa* Miers. Ex Hook. F&Thoms.
Family	Menispermaceae
Means of propagation:	Seeds and old vines.
Parts used:	Vines.

Important substances:	Boraphet contains the bitter principle picroretine. It also contains the diterpenoid Tinosporan, similar to columbin, which can be extracted from the vine and root. Amines are also found in Boraphet: N-trans-feruloyltyramine, N-cis-feruloyltyramine, and the phenolic glucoside tinotuberide.
Beneficial uses:	Boraphet can protect plants from stem borers and cutworms. It can also control the following diseases: (โรคข้าวตายพราย), (โรคยอดเหี่ยว), and (โรคข้าวลีบ).
Methods of use:	1. Pound 1 kg of Boraphet vines and soak overnight in about 18 liters (1 ปี๊บ) of water. This liquid can be used as an insecticide. 2. For beds to raise seedlings: cut 5 kg of Boraphet vines into small pieces, pound fine, and soak in about 18 litres (1 ปี๊บ) of water for two hours. This liquid can then be sprayed on your beds. Alternatively, chop up your Boraphet vines and scatter them directly onto the bed, 1 kg per 4 metres. 3. Cut about 10 kg of Boraphet vines into 5-inch pieces. Scatter these pieces across 1 rai of rice field 7 days after transplanting or sowing your rice. Apply again when your rice is two months old. This is an effective method of controlling stem borers and cutworms.

Bird Chilli	*Capsicum frutescens* Linn.
Family	Solanaceae
Means of propagation:	Seed
Parts used:	Chillies, seeds, flowers, leaves.
Important substances:	Capsaicin
Beneficial uses:	Bird chilli can protect plants from the following pests: cabbage worms, aphids, ladybugs, weevils, insects that live in storage rooms, and ants. Fresh chillies can be used to kill insects, seeds can kill fungus, and leaves and flowers can suppress viruses, including Cucumber Green Mottle Mosaic Virus (CGMMV) and Tobacco Lead Curl Virus (TLCV).
Method of use:	Boil 100 grams of dried Bird chillies in 1 liter of water and then pound into a fine paste. Mix the paste with the water and then strain out the solids. Add another 18 liters (1 ปี๊บ) of clean water before adding a sticking agent like liquid soap or shampoo. This solution can be sprayed every 7 days. Your solution should be tested a little first, as too concentrated a solution will burn plant leaves. If plants display these symptoms dilute further with water. Care should also be taken to protect the skin of the sprayer from irritation.

Rosebay/Oleander *Nerium indicum* Mill.

Family: Apocynaceae

Means of propagation: Cutting, seed.

Parts used: Flowers, leaves, and stems.

Important substances: The bark and seeds of oleanders contain the glycoside neriodorin, neriin, oleandrin, and folinerin, which have effects similar to digitalis. The bark contains the glycoside cortenerin, which has an effect similar to folinerin.

Beneficial uses: Oleander is effective against many pests that eat the stems and leaves of plants: various beetles, various ants, and leaf-eating insects. The flowers also attract fruit flies.

Method of use: 1. Pound 1 kg of oleander flowers and leaves and soak in 9 liters (½ a ปี๊บ) of water for two days. Strain free of solids and spray as an insecticide.

2. Soak oleander leaves and bark for at least 30 minutes and then use this solution to spray ants and insects on the trunks of fruit.

3. Mix 40 grams of finely sliced oleander leaves with 1 kg of soybean seeds. This will allow you to store soybean seeds for six months without attracting pests.

Siam Weed *Eupatorium odoratum* Linn.

Family: Compositae

Means of propagation: Seed

Parts used: Leaves and stems

Important substances: Stems contain eupatol, coumarin, 1-eupatene, beta-amyrin, flavone, and salvigenin. Leaves contain ceryl alcohol, beta-sitosterol, anisic acid, trihydric alcohol, tannin, isosa kuranetin, and odoratin.

Beneficial uses: Siam weed can be used to exterminate various caterpillars and aphids.

Method of use: Dry the stems and leaves of Siam Weed in the sun and then pound into a powder. Soak 400 grams of this powder in 8 liters of water and leave for 24 hours. This solution can be sprayed every 7 days.

Ginger *Zingiber offcinale* Vern. Adrak

Family: Zingiberaceae

Means of propagation: Root

Parts used: Root

Important substances:	Ginger contains the important essential oils camphene, cineol, pellandrene, linalool, zingiberene, borneol, and those substances which give ginger its spicy zing, zingerone and shogaol.
Beneficial uses:	Ginger can be used to control fruit flies, cowpea weevils, and a wide variety of beetles.
Method of use:	Pound fresh ginger root until fine and soak overnight in 1 liter of water. Strain free of solids and add 10 litres of clean water. This can be sprayed on your vegetable beds and fruit trees.

Galangal	*Alpinia galanda* Sw.
Family	Zingiberaceae
Means of propagation:	Root
Parts used:	Root
Important substances:	Galangal contains the essential oils garangol, cineole, pinene, gingerol, shogaol, cineol, camphor, cinnamicaldehyde, 1-acetoxychavicol acetate.
Beneficial uses:	Increases protection from and controls rice weevils, red flour beetles, and fruit flies.
Method of use:	Pound together 200 grams each of galangal, neem seeds, and lemon grass. Soak overnight in 20 liters of water and then strain free of solids. Dilute this solution with 18 liters of water (1 ปี๊บ) for enough insecticide to spray over 1 rai.

Kaffir lime	*Citrus hystrix* DC.
Family	Rutaceae
Means of propagation:	Seed, cutting.
Parts used:	Leaves and fruit.
Important substances:	Kaffir lime contains the essential oils pinene, limonene, citronellal, and citronellyl acetate.
Beneficial uses:	Kaffir lime leaves contain substances that will repel fruit flies and prevents them from laying eggs. It can also control golden apple snail populations.
Method of use:	Kaffir lime leaves contain useful essential oils: chop them up, soak them in water for seven days, and scatter over your rice fields.