SOLOMON ISLANDS

86 Extension Fact Sheets

The IPPSI Team
Honiara

January 2011

Produced with support of IPPSI (Improved Plant Protection in Solomon Islands), funded by Australian Centre for International Agricultural Research (ACIAR), Canberra.

The fact sheets were formatted using a design developed by Eric Boa and Jeffery Bentley of the Global Plant Clinic. The GPC is managed by CABI and is part of the Plantwise program, funded by the UK Department for International Development, Swiss Development Corporation and ACIAR.

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Alomae & Bobone

Extension Fact sheet 1

Common names: Alomae and Bobone
Scientific name: *Colocasia bobone rhabdovirus*; *Taro vein chlorosis virus*; *Taro badnavirus.*

Hosts: *Colocasia bobone rhabdovirus* and *Taro vein chlorosis virus* have only been recorded from taro; *Taro badnavirus* has been recorded from *kongkong* taro and *edu* (*vili, nepa*), but not in Solomon Islands.



Damage

Alomae (photo, left) is a deadly disease that has had a huge impact on taro production in Solomon Islands. Most taros are susceptible. On Malaita, those taro are called 'male'. The impact has been worse on Malaita than on other islands. Previously, the disease was kept in check by strict cultural practices. Nowadays, it is very difficult to grow 'male' taro in the lowlands. In recent years, the disease has spread to other islands where it has been devastating, such as the Weather Coasts of Guadalcanal and Makira. It is not unusual in these places for entire gardens to be destroyed by Alomae.

Bobone (photos, centre & right) does not kill taro; it reduces the yield by about 25 per cent. Plants usually start to produce healthy leaves after 4-6 weeks, and then appear normal. The disease only occurs in a few varieties of taro. These are called 'female' taro on Malaita. They are resistant to Alomae.

Biology and Life Cycle

Insects (photo, right) spread the viruses that cause Alomae and Bobone:

- The rhabdovirus is spread by *Tarophagus*, a planthopper;
- The badnavirus is spread by *Planococcus* and *Pseudococcus*; these are mealybugs.

The planthoppers and mealy bugs suck up the viruses as they feed; the viruses multiply in the insects, which then spread them as they move and feed on healthy plants.

When 'male' plants are infected by the rhabdovirus, the plants develop Alomae, and die. When 'female' plants are infected by the rhabdovirus, they develop Bobone, but they recover.

Apart from being spread by insects, the viruses are also spread in planting material. It is likely that all taro are infected with *Taro badnavirus*, without showing symptoms, or only rarely do they show symptoms. The viruses spread from mother plants to suckers. Also, it is likely that

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HT works for MAL; GJ is with TerraCircle Inc.

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all 'female' taro are infected with the rhabdovirus. Bobone often occurs after planting, when plant hoppers are absent. Possibility, stress at planting causes the virus to multiply. Alomae is spread from one garden to another in diseased 'tops' and suckers used for planting.

Detection and Inspection

It is important to inspect taro gardens regularly. Look at the youngest leaves. If the plant has Alomae, the leaf will be:

- Stunted, slightly curled, bent backwards, crinkled, and often paler than older leaves.

If the plant has Bobone, the leaf will be:

- Stunted, thickened, curled or partly curled, darker green than usual, and the leaf stalks will have galls – small outgrowths.

Plants with Alomae stop growing and the youngest leaf remains rolled and yellow. Plants with Bobone produce leaves that are stunted and distorted, and then healthy leaves develop.

Management

CULTURAL CONTROL

Alomae is best controlled by cultural methods. These methods rely on farmers' understanding how the disease spreads. It is very important that farmers:

- Understand that insects spread Alomae, as they fly between plants and gardens;
- Work together, each one applying the methods in his or her garden;
- A village group is formed, which meets regularly, exchanges ideas, and the members help each other;
- Plant resistant varieties: 'Female' taros are resistant to Alomae, and they can be used where the disease is severe, especially in the lowlands.

Farmers should do the following:

- Make new gardens as far away from old ones as possible;
- Avoid taking planting material from diseased to new gardens;
- Pull out Alomae plants carefully, making sure that any planthoppers are trapped in the leaves or between the stalks – or put a rice bag over the plants before pulling them out - then burn them;
- DO NOT pull out plants and leave them in the garden or throw them into the bush – the insects will come back again.

BIOLOGICAL CONTROL

Cyrtorhinus, a bug that feeds on the eggs of *Tarophagus*, reduces the population of the plant hopper, but experience shows that it is not enough to stop the spread of Alomae.

CHEMICAL CONTROL

Regular spraying with pyrethroid insecticides (permethrin or lambda cyhalothrin) will kill *Tarophagus* and reduce Alomae. It will not prevent Bobone.

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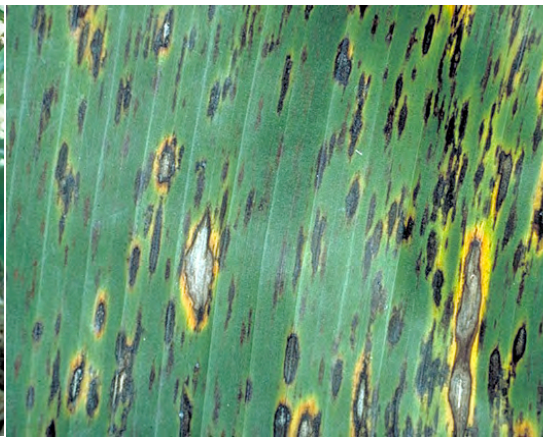
Black Sigatoka

Extension Fact Sheet **2**

Common names: Black Sigatoka, Black leaf streak
Scientific name: *Mycosphaerella fijiensis.*

Hosts: The fungus infects bananas and plantains, *Musa* species.



Damage

Red-brown streaks appear on the underneath of the third or forth youngest leaf. These form long spots with grey or light brown centres and dark brown or black margins (photo, right). The spots join together, often with yellow areas between. The infected areas invariably form bands several centimetres wide on either side of the midrib. In severe infections, spots do not occur, but large areas of the leaf turn black and die. Generally, the streaks are more common at the tips and edges of the leaves (photo, left).

The effect of the disease is a loss of leaves: leaves die early. Instead of lasting 200 days they last only 50. This reduces yield by 35-50%, depending on severity of the infection and on the variety. Cavendish varieties are particularly susceptible and these are grown for sale worldwide. About 30% of the production costs in commercial plantations are spent on fungicides to control the disease.

The weight of the bunch and the ripening of the fruit are affected by the number of leaves on the plant: if too few at flowering then bunch weight is low; if less than five leaves at harvest, the fruits ripen early.

Biology and Life Cycle

Spores are produced in the dead, grey areas on the upper leaf surface. The fungus has two type: ascospores and conidia (see diagram[1]). The ascospores are the more important. They are released from the upper leaf surface during rain or high humidity. They travel by air currents or rain splash, and land on the underside of the emerging leaves. The spores germinate and

[1] The diagram of the life cycle is from APSnet Education Center. Back Sigatoka of bananas and plantains. The permission of The American Phytopathological Society to use this diagram is gratefully acknowledged.
http://www.apsnet.org/edcenter/intropp/lessons/fungi/ascomycetes/Pages/BlackSigatoka.aspx

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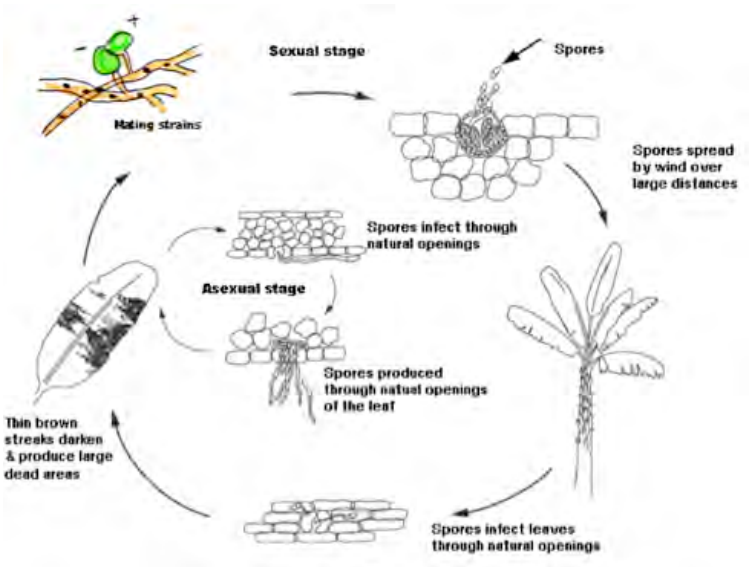
the germ tubes enter through natural openings in the leaf. The fungus grows within the leaf, killing plant cells, before returning to the surface to produce more spores. Different strains of the fungus (plus and minus) come together to form the sexual stage (see diagram).

Detection and Inspection

On leaves, a rapid development of red-brown and yellow streaks, drying from the margins back to the mid-rib, and early death of leaves, are typical of this disease.

Management



CULTURAL CONTROL

Carry out the following recommended to allow more air into the plantation to dry the leaf surface, to prevent infection, or to reduce the number of spores:

- Cut off leaves (if more than 50% infected), or cut out parts of leaves;
- Plant at wide spacings;
- Weed regularly;
- Cut out suckers, leaving 3-4 plants of different sizes per plant;
- Remove and burn old infected leaves;
- Use a mulch to improve plant health.

RESISTANT VARIETIES

Many plantains in Solomon Islands are either resistant or partly resistant to Black Sigatoka. However, if farmers want to grow varieties with Cavendish qualities for household use or the market, then they should ask MAL. The Honduran Foundation of Agricultural Research has bred varieties, e.g., FHIA-1; FHIA-2, FHIA-3. These are dessert or dessert/cooking bananas with resistance to Black Sigatoka.

CHEMICAL CONTROL

Fungicides are only recommended for commercial plantations, these are:

Protectant fungicides:

- dithiocarbamates (e.g., mancozeb);
- Banana misting oil.

Systemic fungicides

- triazoles (e.g, propiconazole and flusilazole);
- strobilurins (e.g., azoxystrobin).

It is important to rotate the fungicides in the different groups to prevent the build up of resistant strains of the fungus. In drier times, mancozeb can be used alone.

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Brown Root Rot

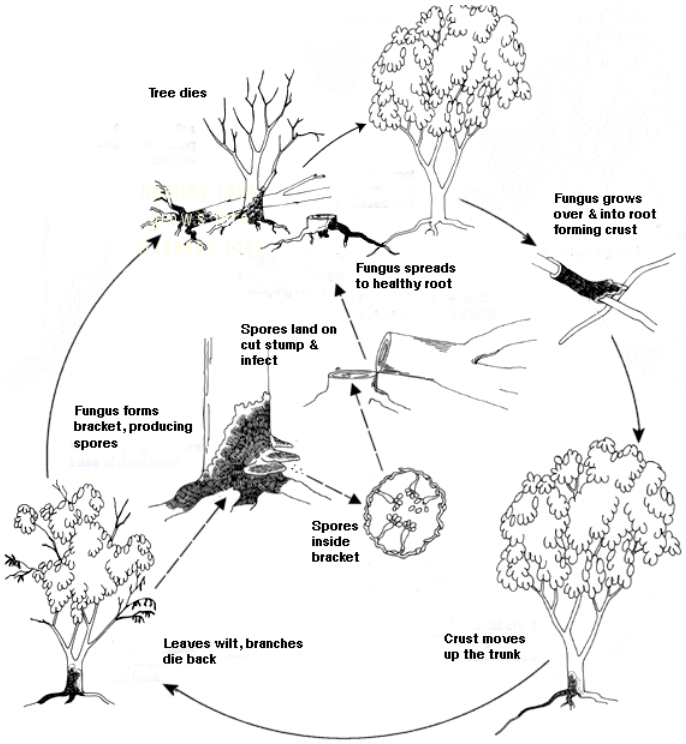
Extension Fact Sheet 3

Common name: Brown root rot
Scientific name: *Phellinus noxius.*

Hosts: The fungus has a wide host range, attacking native forest trees and plantation crops, including cocoa, oil palm, rubber, coffee and *Cordia* (especially in Vanuatu).

Damage

The fungus attacks the roots, and this causes the leaves to yellow and wilt, beginning at the branch tips. Very quickly, all the leaves fall. The fungus forms a dark brown to black crust on the trunk with a white margin, often with clear drops of liquid; the crust grows up to one metre (photo, left). It grows on the roots, too, and often soil and small stones can be seen within it.



Once a tree is infected, there is no way to cure it: it will die. If left unattended, the fungus will spread outwards along the roots to healthy trees around; infection of these will lead to their death and further spread, so that in a short time a large number of trees are killed.

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Biology and Life Cycle

Phellinus lives in the forest where, under natural conditions, it does little harm. However, when the trees are cleared for cocoa or a plantation of timber trees, condition becomes ideal for its spread. In the new plantation, all the trees are alike and if susceptible to *Phellinus*, spread is rapid.

The fungus spreads from the old stumps, left when the forest was cleared. These become infected by spores or more likely by the fungus in the soil. The fungus spreads from these to the cocoa by root-to-root contact. Eventually, it reaches the base of the tree and climbs the outside. The fungus has enzymes to extract nutrients from dead and dying roots and stems. The life cycle is illustrated above (diagram[1]).

The crust is sterile, that means it does not produce spores. However, spores are produced in the brackets. These are dark brown above with red-brown margins and grey underneath. They have not been seen on cocoa in Solomon Islands, but they occur on rotten stumps of many forest trees (photo, centre) and on *Leucaena* (photo, right), and probably on other shade trees.

Detection and Inspection

Routine inspection of the base of the trees is necessary to look for the crust that grows up the trunk. Also, look for brackets of the fungus on old stumps of forest trees. Also, look for them on shade trees, e.g., *Leucaena*.

Management

CULTURAL CONTROL

After clearing the forest, it is important to survey for stumps that have brackets of *Phellinus* growing from them. These should be removed together, if possible, with all roots larger than 2.5 cm diameter. The surveys need to be done on a regular basis, every 3 months at least.

If diseased cocoa trees are seen, remove them immediately, taking out as much of the larger roots as possible. Also, carefully remove the soil from around the trees nearby and inspect for the crust at the base of the trunk and on the larger roots. If seen, remove the trees.

CHEMICAL CONTROL

There is no chemical control option for this disease.

[1] The diagram of the life cycle is from APSnet Education Center. Brown root rot. The permission of The American Phytopathological Society to use this diagram is gratefully acknowledged.
http://www.apsnet.org/edcenter/intropp/lessons/fungi/Basidiomycetes/Pages/BrownRootRot.aspx

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Butt & Root Rots

Extension Fact Sheet 4

Common name: Butt and root rots
Scientific name: *Ganoderma* (photo, left & right) and *Trametes* (photo, centre).

Hosts: Oranges and other types of citrus are attacked. These fungi have a wide host range and infect many forest and plantation trees. *Ganoderma* is a major problem in oil palm.

Damage

Damage to the roots and trunks of oranges and other citrus by butt/root rot fungi prevents the movement of food and water. Leaves turn yellow and fall, fruit production ceases, and there is a slow dieback of the branches. Inside the trunk a white rot occurs. Later, either when the tree is still alive or when it is dead, the brackets appear at the base of the trunk (the butt).

It is not known how many months or years pass between infection of an orange and development of the bracket. The first sign of damage is usually dieback of a branch. Slowly other branches die, until the whole tree is dead; this can take several years.

Biology and Life Cycle

Ganoderma and *Trametes* are often called bracket or shelf fungi, because of the shape of the structure that grows out from the tree. This is the only part of the fungus that can easily be seen: the rest is in the soil or inside the tree causing white rots. The bracket or shelf is the part of the fungus where the spores or seeds are produced; the spores are very small, too small to be seen by the eye.

The fungi are spread by spores produced by the brackets. Many millions of spores are produced and these travel long distances in the wind. There are two ways that infection occurs: either the spores fall to the soil, germinate and grow or they enter through wounds in the tree. Wounds are the more likely. Fungal threads develop and these grow through the trunk.

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Spread of the fungi in the soil is probably through root-to-root contact.

Once inside the tree, the fungi follow the central areas where water and food flow between the roots and the leaves. Brackets develop only when rots are extensive. They may last only a few months (*Trametes*) or a long time (*Ganoderma*).

Detection and Inspection

If branches start to die back, then it is possible that the roots have been infected with *Ganoderma* or *Trametes*. There is no way to be sure until the brackets form. However, it is worthwhile checking the base of any old dead or dying trees nearby incase these have brackets growing from them.

Management

CULTURAL CONTROL

Dig out infected trees: There is no effective treatment for *Ganoderma* or *Trametes* once the bracket appears. It's a sign that the fungi have been feeding on the tree for some time, and large rots are already present. The tree should be removed. Dig it out along with all the main roots.

Do not damage healthy trees: Spores of the fungus can enter the butt through wounds. Do not damage the bark. Stop people cutting the bark with bush knives!

CHEMICAL CONTROL

Chemical control is not an option for these diseases.

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Chilli Viruses

Extension Fact Sheet 5

Common name: Chilli viruses
Scientific name: *Cucumber mosaic virus*; *Tomato mosaic virus*; possibly other viruses.

Hosts: *Cucumber mosaic virus* has a very wide host range, including cucurbits, tomato, banana, tobacco and many species of legumes – there are many strains. *Tomato mosaic virus* also has a wide host range: other than tomato it infects tobacco and numerous weeds. The host range of these viruses in Solomon Islands is not well known.

Damage

Leaves show yellow spots and blotches, curls and crinkles when infected with *Cucumber mosaic virus.* Infections with *Tomato mosaic virus* produce a general yellowing of the leaves. However, it is difficult to identify these viruses by symptoms alone.

Usually, symptoms are not severe, and it is likely that yields are not reduced greatly. Plants continue to produce acceptable crops of fruits. However, some plants near Auki, Malaita, have shown severe symptoms of yellow, distorted, bunched leaves, and fruit production on these plants is low (photo). It is not known what viruses are present in these plants[1].

Biology and Life Cycle

Cucumber mosaic virus infects a wide range of crops and weeds. Aphids (green fly) spread the virus from plant to plant. The aphid, *Aphis gossypii*, is common in Solomon Islands and is possibly the most important means of spread. Aphids spread *Cucumber mosaic virus* in a non-persistent way; this means that they pick up the virus when feeding, and transfer it immediately to healthy plants on their mouthparts.

[1] Dr Denis Persley, Queensland Department of Primary Industries & Fisheries suggests that the symptoms might be due to a whitefly-transmitted geminivirus.

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Tomato mosaic virus is easily spread as it is not easily destroyed and is highly infectious. The main sources of infection are:

- The seed; the virus contaminates the outside of the seed;
- Old crops of tomato and chilli; these serve as a source of virus for new crops;
- Undecomposed plants in the soil;
- People handling the plants, seedlings in particular;
- Other crops (e.g., tobacco), and weeds (e.g., Cape gooseberry, *Physalis* spp.).

Detection and Inspection

Look for yellow and green patterns on the leaves, mild distortions and curling. It is not possible to be sure which virus is present in plants with these symptoms; sap from leaves needs to be sent for analysis using antisera or molecular methods.

Management

CULTURAL CONTROL

- For *Cucumber mosaic virus,* do not plant new plots of chilli next to old ones; they will act as a source of the virus. Pull out and burn the old plants before planting a new crop.
- For *Tomato mosaic virus*, destroy old crops as soon as possible; and avoid handling seedlings, especially after handling older plants.

RESISTANT VARIETIES

Nothing is known about the resistance of chilli varieties to these two viruses.

CHEMICAL CONTROL

This is not an option. Insecticides take time to kill insects; by the time the aphids are dead, they have already fed and passed on the virus.

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Black Pod & Canker

Extension Fact Sheet 6

Common name: Black pod
Scientific name: *Phytophthora palmivora*. It is NOT a fungus but a Water mould, related to algae.

Host: The Water mould attacks cocoa; it causes Black pod and canker. Elsewhere, it causes diseases on breadfruit, coconut, papaya, and many other crops.

Damage

Phytophthora infects pods of any age, from the time they are small, and called cherelles, to the time they are yellow and mature. The pods are at first brown (photo, 3rd from left), then black (photo, left); they dry but stay on the tree. Pods are destroyed in 10 days or less, depending on size. In Solomon Islands, the fungus destroys up to 40% of the pods. The number destroyed depends on rainfall, variety and management of the trees.

The Water mould invades the trunk and branches causing cankers (photo, 2nd left). This happens when the fungus in the pods or in the flowers grows back into the tree. From the outside, the branch initially looks healthy, but later cracks appear, and the infected area may be slightly sunken. When the bark is removed the red colour of the canker is seen. Trees can be killed by canker if the trunk is infected, but more often the fungus causes branch dieback.

The fungus also infects young leaves (photo, right), especially the leaves of water shoots or chupons. In this case, the damage is usually minor.

Biology and Life Cycle

The fungus needs rain to complete its life cycle. Spores are produced on the pods and spread in wind and rain to other pods nearby or to new plantations. If they land on a pod or young leaf, and it is wet, they germinate. There are two ways: a) the spores germinate like a seed and infect the pod or leaf; or b) the spores produce smaller spores which burst out and swim short distances over the pod or leaf surface, then they germinate and infect. In both cases, the Water mould kills the cells. On pods, a brown circular spot is produced, which expands very quickly. On young leaves, infections often start at the leaf tip and follow the veins, which turn brown. Infection on the stems of water shoots causes leaves to wilt.

White areas containing the spores form on the pods. Spores are also produced on the leaves, but they are less obvious. Spores on pods and leaves are splashed by rain to those all around;

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they also fall to the ground and remain in the soil or on leaf litter. Heavy rains splash the spores from the soil up to 1 m above ground, infecting pods on the trunk (photo, 3rd left). Apart from wind and rain, spread can occur in other ways:

- The Water mould in the canker grows back into the pod, via the stalk;
- Ants build 'tents' of soil containing spores over mealybug colonies on the pods;
- Flying beetles that breed in the pods move spores to healthy pods;
- Rats moving through the plantation transfer the Water mould by chewing first on infected and then healthy pods. Possibly, bats do the same;
- On pruning tools used to cut off pods and chupons.

Detection and Inspection

The Water mould is obvious on pods as brown rapidly growing spots. Cankers are less obvious; sometimes, they dry out, become sunken and there are splits between dead and healthy tissue. There may be a red liquid, but this is rare on Amelonado.

If it is not certain that *Phytophthora* is the cause of a black pod, take a piece of the pod, cut a hole in a healthy pod and place it in the hole. Put the pod in a plastic bag. Look for a rapidly growing brown rot, and a white area at the margin.

Management

CULTURAL CONTROL

Good circulation of air in the plantation is important to dry pods and leaves quickly after rain, reducing the time when infection can occur. Therefore:

- Use a light shade (about 600 trees per hectare if they are planted);
- Plant cocoa not less than 3 m apart;
- Prune to create an open canopy: cut out branches close to the fork (jorquette), especially those forming a second storey; cut out branches near or touching the ground; remove water shoots.

Remove diseased pods as often as possible, at least every month, preferably more often during the main crop season. Take the pods from the plantation and bury them.

RESISTANT VARIETIES

Amelonado is more resistant than other varieties tested in Solomon Islands, such as Na32 and Trinitario. Resistant, high yielding varieties have been bred for resistance to Black pod disease in Papua New Guinea.

CHEMICAL CONTROL

Copper sprays are useful, if applied regularly (every 2 weeks) to the pods, especially during the main crop season. Trunk injections using phosphorous acid are also effective. They are applied with a purpose-made syringe, once or twice a year, depending if there is low or high disease. See MAL extension staff for advice.

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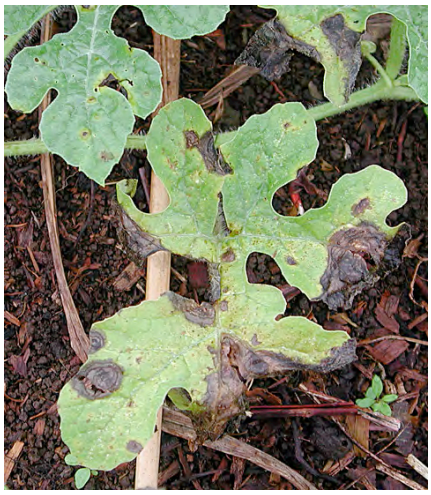
Gummy Stem Blight

Extension Fact Sheet 7

Common name: Gummy stem blight
Scientific name: *Didymella bryoniae.*

Host: watermelon (*Citrullus lanatus*), cantaloupe melon (*Cucumis melo*) and cucumber (*Cucumis sativus*).



Damage

The spots enlarge rapidly and the leaves blacken, shrivel and die (photo, left). It happens so quickly that it is called 'blight'. The loss of leaves, and the damage to the vines, means that the fruits are starved of food, and do not develop properly.

If the disease is not controlled when first seen, it spreads very quickly, especially during days of heavy and continuous rain. It is common for whole crops to be ruined by Gummy stem blight.

Biology and Life Cycle

The fungus produces small, black, round structures, like baskets, inside leaf spots; the baskets can just be seen with the naked eye; they are clearer with a hand lens. There are millions of tiny spores inside these baskets.
When they are ready, and when it rains, the baskets burst open and the spores come out. Wind and rain carry the spores to other leaves. When the spores land on watermelon leaves, they germinate like a seed. The fungus enters the leaf and grows inside. As it grows, it kills the leaf, forming the round, brown spots. The spots grow and join together. Then more baskets of spores develop, and the cycle starts again.

Detection and Inspection

In the nursery, look for large brown spots on the leaves (photo, right). In the field, look for the rapid development of black spots and blotches, that are typical of this disease, especially during wet weather.

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Noe, farmers sometimes mistake the disease for damage caused by the caterpillar of a moth, *Diaphania indica*. These roll the leaves with silk threads and eat the parts between the veins. (See *Diaphania* Watermelon worm Fact Sheet No. 33).

Management

CULTURAL CONTROL

Carefully choose the soil and site for the nursery:

- Take soil only from areas where watermelon has not been grown before;
- Make the nursery far away from watermelon gardens;
- DO NOT make the nursery downwind from watermelon gardens (otherwise the wind and rain will blow spores onto the nursery).

In the nursery do the following:

- Check for leaf spots, at least every 2 days. If spots are present, remove the plants and burn them;
- If there are many spots, do not use any of the seedlings; throw them away and start again. Sterilise the soil and/or spray the next lot of seedlings with a fungicide;
- Sterilise the soil by heating it for one hour, either (a) in a half 44-gallon drum over a fire, or (b) in an earth oven over hot stones.

Do not plant watermelons in the same land as the last crop. Leave a break of 3 years. The fungus can survive in the soil, living on plant remains. After harvest, collect and burn the vines.

Rotate with sweet potato, cassava, taro, but NOT with crops in the watermelon family, such as cucumber, pumpkin and melon. Do not plant watermelon next to older crops that already have Gummy stem blight.

CHEMICAL CONTROL

Use one of the following fungicides: Bravo (chlorothalonil), Dithane M-45 (mancozeb) or copper oxychloride. Spray every 7-10 days. See the leaflet: Gummy stem blight published by MAL.

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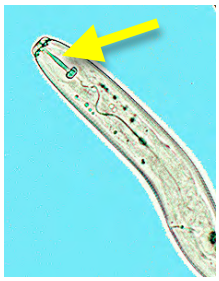
Lesion Nematode

Extension Fact Sheet **8**

Common names: Rough skin, Storage rot, Brown dry rot
Scientific name: *Pratylenchus coffeae.*

Hosts: In Solomon Islands, lesion nematodes cause a disease on yam (*Dioscorea alata*) and, possibly, banana (*Musa* species). Note; the burrowing nematode, *Radopholus similis*, also causes a disease on banana that looks very similar.



Damage

On yam: damage to roots prevents the plant from taking up water and nutrients. When roots are damaged, plants become stunted and/or die early. Often, symptoms of the disease are not seen until the yams are harvested because: (a) in many yam gardens the foliage of different plants is mixed together, making it difficult to see individual plants; and (b) damage done by nematodes often comes late, so symptoms of poor growth can be mistaken for early maturity.

Damage to the tubers does not stop at harvest. The nematodes continue to multiply during storage, and the dry rot areas spread (photo, top left). Often, other organisms help with the decay. Decay of the outer areas of the tubers means a loss of planting material.

On banana: Spots appear due to the nematodes feeding and breeding inside the roots; later the spots join together forming characteristic red and/or black patches – best seen when roots are split (photo, top right). The roots die and the outer parts rot. The result is a weak, stunted root system; plant growth is slow, fruiting is poor and plants readily fall over in the wind.

Biology and Life Cycle

Like all nematodes, *Pratylenchus* has six life stages: egg, juvenile (4) and adult (See diagram below). The nematodes lay eggs in the root, or in soil close by. Eggs hatch in a few days and the young nematodes, called juveniles or larvae, moult several times before they become

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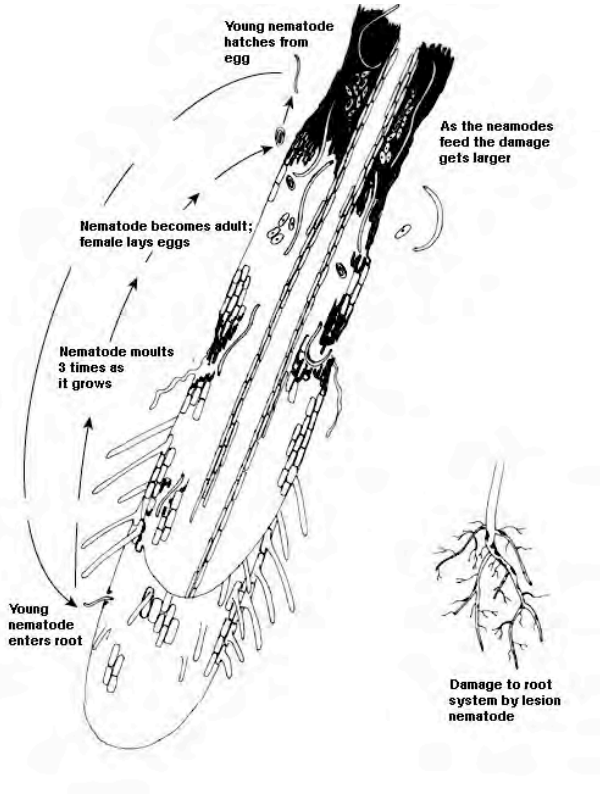
adult. The larvae as well as the adults enter the roots; they force their way between or through the cells. *Pratylenchus* has a stylet or spear (photo, left below arrowed) in its mouth, and it uses this to penetrate the roots and to feed on the cells.

The life cycle is 2-3 weeks, depending on moisture and temperature. When the cells die, the nematodes migrate through the root (photo, lower right) or tuber in search of healthier parts, or they return to the soil and search for another root. The nematodes spread short distances in soil water. They are spread long distances on yam setts and banana suckers.

Young and adult nematodes feed on roots of weeds during fallow periods, and on the roots of other crops between crops of yam and banana. They also remain alive in stored yam tubers or in the banana corms. When infected yam tuber pieces or banana suckers are planted, the nematodes emerge and move through the soil until they find young roots to infect.

Detection and Inspection

Look for signs of dry rot on yam tubers at harvest, and in storage. Look for bananas that have blown over, and roots with red and/or black patches.



Management

CULTURAL CONTROL

- Leave at least 3 years between crops of yam grown on the same land. If possible, allow the land to fallow naturally or plant marigolds or cover crops, e.g., green panic *(Panicum maximum*), siratro (*Macroptilium atropurpureum*) and velvet bean, *Mucuna* sp.;
- Use local knowledge, and plant where crops have grown well before;
- DO NOT store tubers with signs of dry rot. Regularly inspect tubers in storage; remove those with Brown dry rot;
- Inspect yam cuttings and banana suckers before planting. On yams, select and cut healthy yams first. Cut diseased yams and remove any dry rot. Wipe knife with bleach between cutting each tuber. On banana, cut off roots and cut out any rots on the corms.
- There is no information on resistant varieties.

HOT WATER TREATMENT

Hot water treatment of yam tubers and banana suckers is an effective method of killing nematodes. It has to be done carefully. The temperature of the water and the time of dipping must be controlled. It is 51°C for 10 minutes for yam and 53°C for 20 minutes for banana. Seek assistance from MAL before carrying out hot water treatment.

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Mango Flower Blight

Extension Fact Sheet 9

Common name: Mango flower blight
Scientific name: *Glomerella cingulata* (it also has the name of *Colletotrichum gloeosporioides*). *Glomerella* is the sexual stage of the fungus. The disease is often referred to as Anthracnose of mango. Another fungus also causes leaf spots: *Stigmina mangiferae* (see below).

Host: mango. Many other crops are hosts of this fungus, including avocado, coffee, eggplant, papaya, sweet pepper, tomato and yam. There are different strains, infecting different hosts.

Damage

The fungus causes severe damage during wet weather. It causes flower blight, leaf spots (photo, left), young shoot blight and fruit rot. In wet weather, flower blight results in low yield and shoot dieback. Young infected fruits develop black spots, shrivel and fall off. Infection of mature fruit leads to losses in storage (photo, right).

Biology and Life Cycle

Masses of spores occur in tiny dish-like structures in the spots; they are splashed by rain onto other leaves, flowers and shoots. They germinate, like a seed, infect and produce more spots and blights. Young leaves are most susceptible to infection.

At first, the spots are small, black and irregular, often expanding to form large dead areas that dry and fall out. On mature fruits, the fungus remains as pinpoint infections until the fruit ripens; then the infections form dark brown to black spots with pink spore masses.

Detection and Inspection

Look for flower blights, and spots on young leaves and fruits in wet weather. However, it is not always easy to distinguish between diseases caused by *Glomerella* and *Stigmina*. Spots of *Glomerella* are usually larger on the leaves, whereas those of *Stigmina* are about 6 mm diameter, surrounded by a wide greenish zone.

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Stigmina causes black spots on the leaves, which may merge to form large black areas. During wet weather the fungus can cause early leaf fall (photos, below).

Management

Under local conditions, there is little that can be done to prevent infection from these pathogens. Control requires trees to be pruned and sprayed with fungicide.

CULTURAL CONTROL

It is important to prune trees to allow air to flow freely through the tree canopy to reduce humidity. Trees should be less than 4 m tall for easy management and harvesting. Diseased twigs should be removed and burnt along with fallen leaves.

RESISTANT VARIETIES

Indo-Chinese/Philippine varieties are said to have some resistance to the fungus and need to be tested in Solomon Islands. They have good flavour, and flesh with low-fibre. See MAL for information.

CHEMICAL CONTROL

Frequent and timely application of chemicals (e.g., copper oxychloride or mancozeb) is necessary to control *Glomerella* leaf and flower blight. Applications need to begin when the flowers first appear and continue at recommended intervals until the pre-harvest waiting period.

Post-harvest dips in fungicide (carbendazim)/hot water (5 minutes at 52°C) control fruit infections, preventing storage rots.

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Mitimiti Corm Rot

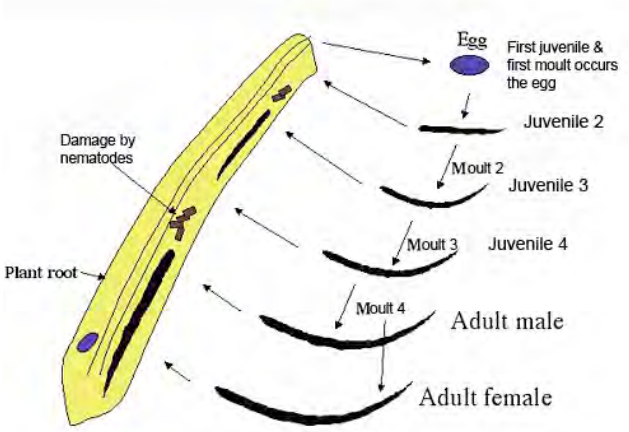
Extension Fact Sheet **10**

Common name: Mitimiti disease, Mitimiti corm rot
Scientific name: *Hirschmanniella miticausa*. It is only known from Solomon Islands.

Host: *Colocasia* taro. It is not known from any other crop.

Damage

The nematode causes a corm rot. Corms show irregular zones of dry, brown rot, 1-10 mm wide, developing from the base. At first, the lines of rot follow the water and food transport systems inside the corm. Healthy tissue alongside the rots is red and corms look similar to uncooked fatty meat (hence the name 'mitimiti' in Solomon Islands). Often, the bottom part of the corms is completely decayed by secondary, brown soft rots (photo, right).



The nematode reduces plant growth and corm size. However, dryland taro often fail to show signs of the disease until harvest. In Rennell and Ontong Java, where taro are grown in swamps, cultivation has been abandoned, as damage is severe (photo, left).

Biology and Life Cycle

There is little known about the biology of this nematode: it has not been studied. However, the life cycle is probably typical of other migratory nematodes, with eggs, juveniles (4) and adults (photo, right) of both sexes (see diagram). The eggs are laid in the soil or in the roots, and juveniles or adults move in and out of the roots. In this way, it is similar to the lesion nematode, *Pratylenchus*.

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It is likely that in dryland situations, nematodes move short distance by swimming in films of water around soil particles or are moved greater distances in ground water. In swamps, the nematode spreads by swimming and in water currents.

Spread to new areas is on infected planting material, either in roots and corm pieces or in contaminated soil. How long the nematode can survive in the soil after plants have been harvested is not known.

Detection and Inspection

Look for the reddening of corms and brown, dry rots at the base of the plant. Nematodes need to be extracted from corms and roots for confirmation. Note, that this disease has only been found in Choiseul, Kolombangara, Ontong Java and Rennell.

Management

QUARANTINE

The spread of mitimiti disease from one island to another should be prevented by local quarantines.

CULTURAL CONTROL

The most effective and practical control measure is to 'clean' the planting material free from nematodes. Remove the outer leaves and trim the corm back to white healthy tissue, leaving a few centimeters without roots; this will ensure freedom from nematodes. It is best to avoid planting suckers with corms attached as it increases the risk of spreading the nematode, as is it not possible to see if rots are present.

On hillsides, avoid planting down the slope from gardens where *Hirschmanniella* was present before, as nematodes may be carried in soil or run-off water.

RESISTANT VARIETIES

There is no information on resistance of varieties, except that a semi-wild variety known as Tiko on Malaita had resistance when planted on Ontong Java. This variety was crossed with variety Luhu from Guadalcanal. Other Solomon Islands varieties were crossed with a wild variety from Bangkok. The result of planting these seedlings on Ontong Java is unknown.

HOT WATER TREATMENT

- Hot water treatment of planting material has been suggested for the control of *Hirschmanniella*. Hot water treatment of 'tops' at 50°C for less than 30 minutes did not damage them, but at 55°C for 15 and 30 min some were killed;
- If it is done, there is a need to carefully measure the temperature and time. Also, the 'tops' must have more and 1 cm of corm tissue;
- DO NOT use the method except on small numbers of taro to establish a source of nematode-free planting material.

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Athelia Wilt

Extension Fact Sheet 11

Common names: Wilt, Southern blight, Athelia wilt
Scientific name: *Athelia rolfsii*, the sexual state of the fungus. It is also known by the asexual state, *Sclerotium rolfsii*. The sexual stage (see secondary cycle, below) is not often seen.

Hosts: The fungus has a wide host range. In Solomon Islands, it is common on carrot, beans, cucurbits, sweet pepper, peanut (photo, right), sweet potato (photo, left), taro and tomato.

Damage

The fungus is soil borne. It usually infects the lower stem near the soil surface. On peanut, the first sign of the disease is a wilt of a single leaf and soon after the wilt of the entire plant. During warm wet weather, the fungus spreads from plant to plant.

Biology and Life Cycle

When the cotton wool-like growth of the fungus comes into contact with susceptible roots, leaves or stems, direct penetration occurs, but it can also penetrate through wounds. The fungus produces chemicals that produce soft rots in 2-4 days after infection. When the soft rots girdle the stem, the foliage wilts and plant death follows soon after. The fungal growth can easily be seen with the naked eye.

About 7 days after infection, the cotton wool-like growth begins to form sclerotia. These are 0.5-2 mm diameter and made up of tightly packed bundles of the fungus. They are white and then light brown as they mature. Sclerotia are the resting stage of the fungus, keeping it alive when there are no plants to infect. Sclerotia may remain alive for several years in soil, potting media, or in plant debris. Other than sclerotia, the fungus can survive between crops in the remains of plants. The life cycle of *A rolfsii* is given below (see diagram[1]).

[1] The diagram of the life cycle is from APSnet Education Center. Southern blight. The permission of The American Phytopathological Society to use this diagram is gratefully acknowledged.
http://www.apsnet.org/edcenter/intropp/lessons/fungi/Basidiomycetes/Pages/SouthernBlight.aspx

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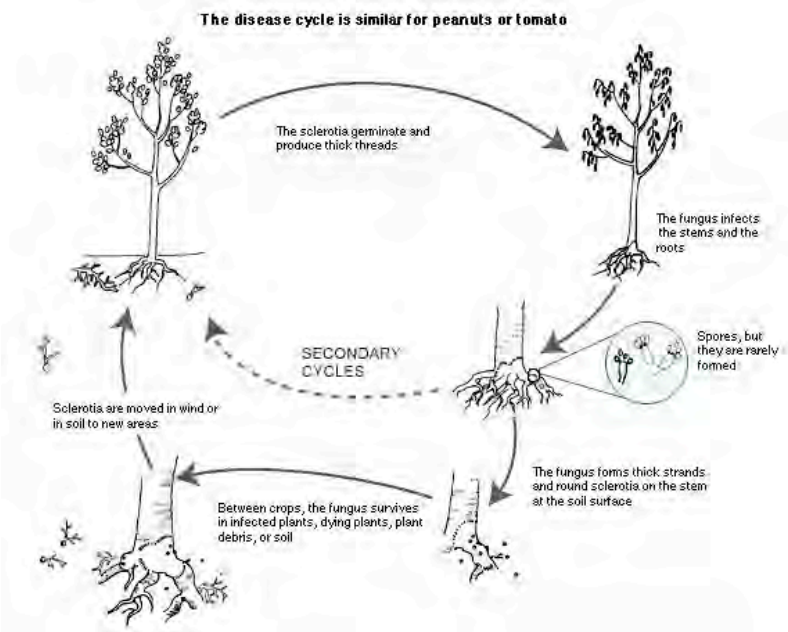
Spread over short distances is by the cotton wool-like growth; spread over long distances is by movement of infected plant material or infested soil. The wind can carry soil containing the sclerotia.

Detection and Inspection

The presence of the thick white cotton wool-like growth at soil level and the presence of sclerotia are very typical of this fungus. Look for plants that have wilted suddenly.



Management

CULTURAL CONTROL

The fungus has such a large number of hosts that crop rotation is not a practical solution. However, bananas appear resistant to infection and maize and cabbages are little affected. The following measures are important:

- Avoid land where there is a previous history of this disease;
- After harvest, remove plant remains and burn them;
- Where possible, plough the land deeply: sclerotia do not survive for more than 45 days if buried 20-30 cm;
- Check that plants taken from a nursery are free of the fungus;
- Remove infected plants with soil around the roots as soon as they start to wilt, taking care not to spread the fungus by dropping soil/sclerotia onto other plants;
- Remove wilted sweet potato plants and replace with cassava.

RESISTANT VARIETIES

Little success has been reported in finding varieties - of the crops that are susceptible - with resistance to this fungus.

CHEMICAL CONTROL

Many fungicides have been recommended for the control of *A. rolfsii*, but they are either not available and/or too expensive for use in Solomon Islands.

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Pink Disease

Extension Fact Sheet 12

Common name: Pink disease
Scientific name: *Phanerochaete salmonicolor* (also known as *Corticium salmonicolor*).

Host: Cocoa is a major host, but it occurs on *Agathis* (kauri), *Citrus*, *Cordia* and *Hibiscus*.

Damage

Branch dieback occurs, and occasionally death of the tree when infections occur at the fork or jorquette. Often, patches of infected trees are seen as the disease spreads. If management is poor, and weather conditions encourage the disease, losses can be high, but usually the disease is of minor importance. Trees between 2 and 6 years are said to be more severely affected.

Biology and Life Cycle

Spores of the fungus are spread by wind and rain. They need water to germinate; they can infect through healthy bark. The first sign of the disease is white threads of the fungus over the bark; they look like cobwebs. White pustules appear through cracks and through the natural openings in the bark. Later, a pink crust develops which produces spores. Later still, but only occasionally, the colour fades and orange-red pustules, which contain another type of spore, are seen. At this stage, the bark is often sunken, split and gum is present; these areas are called cankers. The leaves on the infected branches die, but remain attached.

When it is too dry and unfavourable for growth, the fungus remains alive in the branch and trunk cankers.

Detection and Inspection

Look for the pink crust on the stems and trunk. The fungus is often seen on the main fork or jorquette. Regular surveys to detect infections are very important. Often the first sign of the disease is the sudden death of a branch, with the brown leaves remaining attached.

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Management

CULTURAL CONTROL

- Prune out the infected branches as soon as the fungus is seen. If the fungus has infected the fork or jorquette, then consider a chemical treatment, otherwise the tree will have to be cut down and allowed to regrow from the stump. It is important to prune during dry weather. The pruned branches should not be left in the plantation, but taken out and burnt. Always prune at least 30 cm below any sign of the fungus;
- The health of the trees may be important in preventing outbreaks of this disease. If trees are stressed, because they are too close or growing in soils with poor nutrition, then they may be more susceptible;
- Shade is another important factor: heavy shade creates conditions of high humidity, which is ideal for infection and spore production. Therefore, make sure shade is properly controlled.

CHEMICAL CONTROL

Copper fungicides are useful if applied as a paste. Prune the branches and apply the paste to the cut ends and along the remaining parts. Apply to infections at the fork or jorquette.

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Sweet Potato Scab

Extension Fact Sheet 13

Common name: Sweet potato scab
Scientific name: *Elsinoe batatas*, but sometimes known as *Sphaceloma batatas* (the asexual stage).

Hosts: It is only known from sweet potato.

Damage

Young leaves are infected along the veins, and infections also occur on the leaf stalks and stems. As the leaves grow, the damage to the veins presents proper expansion, and they twist, curl and tear. On older leaves, infections produce pinpoint spots between the veins. In severe cases (rarely seen in Solomon Islands), shoot-tips are killed.

Varieties differ in the amount of damage that occurs. The disease has been severe in Fiji and Tonga. In Tonga, there were epidemics of the disease in the 1980s when farmers stopped growing most varieties. Damage to the young shoots can slow early growth and result in reduced yields. In Papua New Guinea highlands, comparisons between healthy and diseased plants, showed a 60% difference in yield of storage roots. Most varieties in Solomon Islands are resistant to the fungus, and yields are not likely to be affected.

Biology and Life Cycle

The fungus is taken to new gardens on planting material. As the cuttings grow, the fungus produces very small spores in the scabby areas. These spores are spread by rain-splash from plant to plant. They germinate, like seeds, in water on the surface of the leaf and stem, penetrate and cause the spots and scabby lesions. Soon after infection, more spores are produced.

It is possible that the fungus survives in crop debris, but this is not important unless crops are planted one after the other. Most spread is from planting infected vines.

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Detection and Inspection

Look for the brown scabby marks on the leaf veins, stalks and stems. Look for torn, cup-shaped leaves and twisted stems.

Management

CULTURAL CONTROL

There is probably little that farmers can do to control this disease using cultural methods. If the disease is severe in the crop, it might be better not to replant on the same land, but it is doubtful that it will make any difference. This is because the disease is spread from crop to crop in already infected planting material, and also from spores in wind-driven rain.

If growers really want to grow susceptible varieties, because of their taste and high market demand, for instance, then they should do the following. It is very important that they start the crop with disease-free planting material.

- Make a nursery – raised beds, shaded by coconut leaves – and plant washed sweet potato roots, leaving a small gap of 1-2 cm between each;
- Cut vines 30 cm vines long when the roots sprout, checking each one to ensure that scab is not present;
- Plant vines in new gardens, where sweet potato has not been grown for 1-2 years.

Vigorous early growth will reduce the impact of the disease when the plants become infected later.

RESISTANT VARIETIES

This is the most important method of control. Varieties differ in their susceptibility to the disease. Some are very resistant. These should be selected and grown in preference. It is for this reason that scab is not usually a problem in Solomon Islands. Farmers avoid those varieties that show severe symptoms.

CHEMICAL CONTROL

Fungicides have been used to control the disease in Tonga and Papua New Guinea, but mostly by scientists. They could be used by commercial farmers, for instance, by those who want to grow a susceptible variety for the market. The recommendation is to:

- Dip the cuttings for 15 min in mancozeb before planting;
- Spay with mancozeb at the first appearance of symptoms;
- Repeat spraying at 14- day intervals, until 1-2 months before harvest, depending on the weather.

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Taro Leaf Blight

Extension Fact Sheet 14

Common name: Taro leaf blight
Scientific name: *Phytophthora colocasiae.* It is NOT a fungus but a Water mould, related to algae.

Hosts: The fungus attacks taro and *edu* (*vili*, *nepa*; *Alocasia*); these are the only two hosts known from the Pacific islands.

Damage

Taro leaf blight reduces the life of the leaves: instead of lasting 40 days they last 20. The result is that plants have few leaves and small corms. Yield is reduced by about 40%.

Taro leaf blight also causes a firm, brown corm rot after harvest. It takes 7-10 days, before the corm is completely decayed; often other fungi are present in the rots.

Biology and Life Cycle

The Water mould is active in wet weather. Spores are produced on the leaves and spread in wind and rain to leaves of other plants nearby or to those in distant gardens. If they land on a leaf, and it is wet, the infect it. This happens in two ways:

- The spores germinate, like a seed, and infect the leaf; or
- The spores produce smaller spores, which burst out and swim short distances over the leaf before they germinate and infect.

In both cases, the Water mould kills the cells of the leaf and brown spots appear. The spots grow very fast. They have yellow margins, and red-brown droplets develop on the under surface. The droplets dry as dark pellets (photo, above right). Infection occurs anywhere on the leaf surface, but often at the edges where rain and dew collect.

After a few days, a white ring can be seen at the margin of the spot (photo, next page); this is the area where spores are produced. There are millions of them. However, the spores dry out quickly in the sun and by mid-morning they have shrivelled and died. They only stay alive if it is cloudy or raining.

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Apart from wind and rain, spread can occur in other ways: (a) on suckers planted with infected leaves attached; (b) on stalks of planting material – probably on the cut ends in wet weather when stalks are trimmed for planting.

Corms become infected only after harvest, when the suckers are removed.

Detection and Inspection

Look for spots that grow rapidly (photo, above left), and leaves that die early - plants have 3-4 leaves instead of 6 -7. Look for secondary spots produced below the first ones. White rings of spores border the spots, seen most clearly in the early morning. Look for dark, irregular- shaped pellets on the underside of the spots.

Management

Where rainfall is high, taro leaf blight is difficult to control. Cultural methods can be tried, but they are often not effective.

CULTURAL CONTROL

- Make new gardens as far away as possible from old ones;
- Inspect young taro twice a week; cut off infected leaves as soon as they are seen. Do this often, but it can only delay the disease in places where rainfall is high;
- Plant suckers without leaves attached;
- Trim taro leaves when the 'tops' are dry to prevent spores infecting the cut ends of the stalks.

Apart from the above, the best cultural practice is to make gardens in the highlands. The disease is much less at cooler temperatures.

RESISTANT VARIETIES

Breeding programs in Papua New Guinea and Samoa have produced plants resistant to taro leaf blight. Some of these are available from MAL. In Solomon Islands, a hybrid, LA16, has been found to be resistant to taro leaf blight.

CHEMICAL CONTROL

- Use copper fungicides (especially copper oxychloride), but they have to be used often and are only recommended where taro are grown for sale;
- Use metalaxyl (a systemic product) in combination with copper; it gives even better control, but costs are high;
- Use phosphoric acid alternating with mancozeb (used successfully in Samoa).

To prevent storage rots, wash the soil off the corms, trim the leaves and put them in plastic bags. Washing the corms in 1 per cent household bleach beforehand improves storage.

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White Thread on Cocoa

Extension Fact Sheet **15**

Common name: White thread
Scientific name: *Marasmiellus (Marasmius) scandens.*

Host: Cocoa is the major host, but it also occurs on mango.

Damage

M scandens is a fungus. The disease that it causes, white thread, is associated with poor tree maintenance. If management is poor, large number of leaves can be destroyed, but the impact on yield has not been recorded. Normally, the disease is of little economic importance.

Biology and Life Cycle

The life cycle of this fungus has not been fully described. The white threads are a collection of strands of the fungus, and these grow over branches and leaves (photo, left). The fungus produces toadstools, and these produces spores. However, the toadstools are not often seen.

Spread of the fungus is thought to occur as follows:

- It grows along the branches as white threads, extending onto the leaf stalks and then over the surface of the leaf blades, which turn brown and die;
- From tree to tree when infected branches fall from shade trees;
- As airborne spores released from toadstools that form in wet weather.

As the leaves are infected, they turn dark brown and die (photo, right), but even though they are no longer attached to the branches, they remain suspended in place by the threads of the fungus.

Detection and Inspection

Look for patches of dead leaves, held in place by white threads. The fungus can be more clearly seen over the leaf blades when they are wet (photo, left).

Management

CULTURAL CONTROL

Prune out the infected leaves and branches; this is the best way of managing outbreaks of white thread. The prunings should be taken out of the plantation and burnt.

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CHEMICAL CONTROL

Chemical control is not recommended for this disease.

Horsehair blight

Common name: Horse hair blight
Scientific name: *Marasmius crinis-equi.*

The fungus is often thought to cause a disease, but it does not. The threads are brown to black resembling horsehair. The fungus grows over the healthy leaves, but does not infect them. However, when the leaves break naturally from the stems, they are held in place by strands of the fungus; this gives the appearance that the fungus has killed them.

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Yam Dieback

Extension Fact Sheet 16

Common names: Yam dieback, Lightning disease
Scientific name: *Glomerella cingulata* (it also has the name of *Colletotrichum gloeosporioides*). *Glomerella* is the sexual stage of the fungus. The disease is often referred to as Anthracnose of yam.

Hosts: The fungus exists as many strains, which attack crops and weeds. Some of the strains infect several hosts. Yam (*Dioscorea alata*) is a major host; other yams, for instance, *pana* (*D esculenta*) and African yam (*D rotundata-cayanensis*) are not hosts or show only occasional leaf spots.

Damage

The fungus is damaging during wet weather. Leaf spots occur (photo, left) and these produce masses of spores. On susceptible varieties, leaves quickly turn black (photo, lower right) during long periods of rain, for instance, during cyclones. Shoots are destroyed and the stems die back. New shoots grow from the planting piece, but these also become black and die back. Plants can be killed without producing tubers or each shoot produces several small tubers before it dies.

The blackening is so sudden on some varieties of yam that farmers say the yams have been struck by lightning.

Biology and Life Cycle

It is not known for certain where the fungus comes from. There are three possibilities:

- It is in the soil;
- It is in the planting material; and
- It comes from other plants, weeds or crop plants.

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It is most likely that it comes from other weeds and crops. In the Caribbean, tubers are infected and these are a source of the fungus. Infection of the tubers has not been found in Solomon Islands. Here, the fungus has been found on other crops and weeds.

Symptoms depend on rainfall and the susceptibility of varieties. On young leaves, the spots may enlarge rapidly and sometimes merge. On some varieties, only the young veins are infected; in this case the leaves become cup-shaped as they expand (photo, top right). On older leaves, pinpoint spots develop that do not expand. Usually, the young, infected leaves fall early.

Spores are produced in tiny, dish-like structures in the spots and are splashed by rain onto other leaves and stems. They germinate like a seed, infect and produce more spots and spores. On older leaves, they germinate, but do not infect or only produce pinpoint spots. On some varieties, large numbers of spores on the old leaves cause the leaves to turn black, especially when they are exposed to sunlight.

Detection and Inspection

Look for brown leaf spots, sometimes with a yellow halo, that are typical of infection. Look for plants where older leaves go black during long periods of rain, and shoots die back. Tuber infection has not been detected in the Pacific, but it is important to inspect planting material very carefully, and only use pieces that are healthy.

Management

CULTURAL CONTROL

The most important cultural control measure is to plant early, in August and September, so that plants are at the tops of their supporting poles before the storm season. Other measures have been suggested, but their usefulness is in doubt:

- Interplant with maize;
- Do not weed when the plants are wet;
- Crop rotation – i.e., do not plant yams on the same land, one year after another;
- Bury plant remains after harvest; and
- Avoid damage to the tubers at harvest.

RESISTANT VARIETIES

Varieties differ in resistance to the disease; some are resistant at all stages of growth, others only when mature, when they have a full canopy. Farmers should be advised to select those that show resistance. If susceptible varieties are also planted, not only is there a chance that the disease will destroy them, but also they will increase disease pressure on the more resistance types. Variety Kinabeyo from the Philippines is an example of a resistant variety. See Kastom Gaden Association for supplies.

CHEMICAL CONTROL

Although fungicides, for instance, benomyl (no longer manufactured), chlorothalonil, copper, dithiocarbamates (e.g., mancozeb) have been recommended in the Pacific and Caribbean, they can only delay the start of an epidemic. They are not effective during long rainy periods.

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Banana Scab Moth

Extension Fact Sheet 17

Common name: Banana scab moth
Scientific name: *Nacoleia octasema.*

Hosts: Banana, plantain, Heliconia and Pandanus.

Damage

The caterpillars do the damage (photos, above, left & right). After hatching they feed on the skin of the young fruit, while hiding in protected areas between the fingers and the fruit stalk. Sometimes they eat through the skin and feed on the pulp of the banana. Damaged areas form a black scab (photo, top right).

Biology and Life Cycle

Eggs are laid in the early evening on or near to an emerging banana bunch. The eggs are flat, oval-shaped and about 1.3 mm across. They are laid in clusters of up to 30 and look like overlapping fish scales.

The caterpillars hatch after about 4 days and move to the young fruit under the tightly closed bracts (the leaves around the young bunches) to feed. As the bracts and hands lift from the bunch stalk, the caterpillar moves to the next closed hand. When newly hatched, the caterpillars are about 1.5 mm long and clear yellow; when fully-grown, they are up to 50 mm long, and vary from pinkish-grey to very dark brown.

After feeding for about 2 weeks, the caterpillars are ready to pupate. They spin a thin silken cocoon, adding some rubbish, which helps to hide it. Inside the cocoon, the caterpillar turn into brown pupa. The cocoons are either on the banana plant or nearby in the leaf litter.

After 8-10 days, the adult moths emerge; they are a pale straw colour, with a wingspan of about 30 mm. They have a row of small black dots around the edges of the wings (photo, below). Moths hide during the day; they mate and lay eggs in the early evening.

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Detection and Inspection

Look at the young developing fruit. Look for feeding damage - black scabs on the skin, or caterpillar droppings. Banana bunches should be inspected when bracts have begun to lift, but before they start to fall.

Management

NATURAL ENEMIES

The caterpillars are attacked by many kinds of tiny wasps that are hard to see. Spiders and other general predators also attack them.

CULTURAL CONTROL

- Inspect the banana crop daily for emerging flower stalks - by the time flower stalks have bent horizontally, shortly after emergence, some fruit damage may already have occurred;
- Partly or completely remove the flower bracts, then spray the fruit with water, or dust them with ashes. This will reduce the damage.

CHEMICAL CONTROL

- In Australia, chlorpyrifos, bifenthrin, acephate, and bendiocarb are the recommended chemicals for bunch injection;
- Inject when the bunch is still upright in the throat of the plant. Inject 20 to 40 ml of dilute insecticide about a third of the way down from the top of the spear. Injections above or below this will either damage the fruit or not be effective.
- Use biopesticides. These are biological insecticides that cause insect diseases. Use the following, instead of sprays of water and dusts:
    - Spinosad (Success), *Beauvaria bassiana*, *Metarhizium anisoplea*, and Bt - *Bacillus thuringiensis* (Dipel). Spinosad and Bt are sometimes sold in Honiara;
    - But note, biopesticides are expensive, but they do not kill the natural enemies, as do synthetic insecticides.

Note, spraying with chemicals (rather than injecting them) often does not work against this pest, because the insect is so well hidden.

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Pod-Sucking Bug

Extension Fact Sheet 18

Common name: Bean pod-sucking bug
Scientific name: *Riptortus serripes* and *Riptortus linearis*.

Hosts: These bugs attack legumes, such as long bean, soybean, and mung bean. They may also attack rice and clover.

Damage

Damage is done by adults (body length 25 mm) and nymphs (they look like ants) feeding on the pods and seeds (photo, top left & right & lower left). The feeding causes the pods to rot, or to develop without seeds inside. This insect can cause a lot of damage to bean crops.

Biology and Life Cycle

Riptortus lays its eggs on the bean leaves and other plants; usually the eggs are laid singly. Both adult and nymphs sting the beans in the pods and suck their juices, so that the beans cannot mature. The pods turn brown, shrivel and die.

Detection and Inspection

Look at the pods and under the leaves; look for ant-like bugs (photo, top right). Look closely for small holes and damaged, shrivelled pods.

Management

CULTURAL CONTROL

Plant long beans near *Bixa* (photo, lower right), a method recommended by a farmer on Malaita (see leaflet: *What is the pest spoiling your long beans?*). *Bixa* is known as the Lipstick tree, because of its seeds. They are deep red, soft, and children use them to paint their faces,

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lips included. When the fruits open, they attract large numbers of *Riptortus.* The insects feed on the seeds, preferring them to the seeds of beans. In this way, the insects are 'trapped' on the *Bixa*, and long beans escape damage.

CHEMICAL CONTROL

- Insecticides have not been tested against *Riptortus* in Solomon Islands. It is likely that synthetic pyrethroids would be effective, such as lambda cyhalothrin or permethrin. See your MAL extension officer for details.
- A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

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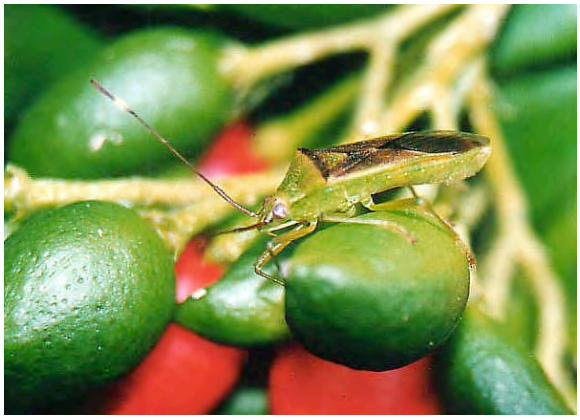
Amblypelta Bug

Extension Fact Sheet 19

Common names: Cassava shoot dieback, Coconut premature nut fall
Scientific name: *Amblypelta cocophaga* and other species.

Hosts: Coconut, causing premature nut fall; shoot-tip dieback of *Eucalyptus deglupta* and cassava, and cocoa pod distortion.



Damage

As *Amblypelta* feeds it injects a poison. In coconuts, the young fruit (buttons or nuts) fall; in *Eucalyptus* and cassava, the shoots wilt and die, and cankers form on the stems (photo, left); in cocoa, sunken black spots occur and young pods become distorted as they grow.

Early or premature nut fall of coconuts in Solomon Islands has been a major problem in some parts of the country since the 1930s, and has been investigated by a number of entomologists. The islands of Guadalcanal, Malaita and Nggela are those most affected. Loss of coconuts was estimated to be between 10 and 20%, but on individual farms on Malaita and Nggela losses were devastating. It is difficult to be accurate as nut fall is patchy, depending on the distribution of various ant species and their interaction with *Amblypelta*. Also, coconut has a natural fruit drop of over 60%.

Another problem occurred in the 1980s. *Amblypelta* dieback was seen on *Eucalyptus*, threatening the success of forest replanting schemes on Kolombangara, in particular. *Amblypelta* caused death of the leading shoot. After a while, other shoots developed, but these, too, were attacked and the trees became hedge-like.

Biology and Life Cycle

The adult Amplypelta is about 20 mm long, the legs are pale green, while the wings are pale-brown (photo, above right). Females lay eggs on or near the host plant. Nymphs hatch a few days later. They are dark brown with long legs and antennae; they look like adults without wings. Nymphs feed in the same way as adults, and on the same plants, using needle-like mouthparts. It is not known if nymphs inject poison, but it is likely. Wings develop when nymphs become adult, 3-4 weeks after emerging from the egg.

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Detection and Inspection

Look for a bug with pale green body, long legs, and pale brown wings. Look for the very long needle-like mouth, almost as long as its body. The young bugs look like the adults, except they are smaller. Look for wilting shoots of cassava and Eucalyptus, and look for stem cankers. On coconuts, look for palms that shed large numbers of young nuts.

Management

NATURAL ENEMIES

In 1937, four egg parasites were collected in Indonesia and released in Solomon Islands against *A. cocophaga*. However, these did not control the pest. Later, a Tachnid fly was introduced from Queensland, but this, too, was unsuccessful. A Braconid wasp was found on Kolombangara infecting late stage nymphs; this too does not control the populations successfully.

Amblypelta is found at low numbers on coconuts and probably other hosts. The damage caused by one adult is significant, so it is unlikely that parasites could reduce numbers enough to prevent economic losses.

MANIPULATION OF ANT SPECIES

Attempts over many years to control premature nut fall have tried to encourage some ant species whilst removing others. Mostly, this means removing *Pheidole megacephala* and *Iridomyrmex cordatus* and encouraging *Oecophylla smaragdina*. The idea is to have ant species that discourage *Amblypelta* from feeding on the young coconuts. *Oecophylla* invades the palm in search of food and at the same time disturbs *Amblypelta* from feeding.

Removal of *P. megacephala* using herbicide and insecticide applied to the base of the trunk is possible. Once removed, soursop trees are planted among the coconuts, the fruits of which readily become colonised by mealybugs, which are 'farmed' by *Oecophylla* for their honeydew. The success of this strategy was patchy, however, as the ant populations keep changing. Also, removal of *I. cordatus* is difficult as it makes its home in the crown of the palm, not in the ground.

In more recent years, a fire ant, *Wasmannia auropuntata*, has become established throughout Solomon Islands. This ant is capable of protecting palms against *Amblypelta* as well as displacing *I. cordatus* and probably *P. megacephala*. It is, however, a fire ant and it is unpleasant working in plantations of coconut or cocoa where it is present.

CHEMICAL CONTROL

A number of insecticides applied as sprays or as trunk injections from different chemical groups have been tested against premature nut fall. Some are effective; however, the height of coconut palms prohibits easy application, and it is unlikely that such treatments are economic. To be effective, they need to be applied frequently, perhaps 8-10 times a year.

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Diamond Back Moth

Extension Fact Sheet **20**

Common name: Diamond back moth
Scientific name: *Plutella xylostella.*

Hosts: Cruciferous vegetables - head cabbage; Chinese cabbage; radish; cauliflower and broccoli; non-crucifer plants: *Amaranthus* and watercress.

Damage

The caterpillars do the damage. The first two stages are small and feed by mining the leaf; later, when they are too large to mine, they burrow through the leaf. The result is 1-2 cm wide cavities on the lower leaf surface leaving the waxy layer intact, which gives the appearance of windows in heavily damaged plants. Economic damage is most severe when heading begins. The caterpillars tunnel into the heads of cabbages.

Note: other pests often occur on ball cabbages along with this moth, and the combined damage is considerable. The other pests are cabbage webworm, *Hellula undalis;* cutworm, *Spodoptera litura;* and cabbage cluster caterpillar, *Crocidolomia pavonana*. (**See Fact Sheet no. 78 for *Crocidolomia***.)

Biology and Life Cycle

The eggs are small (0.4 mm long), cylindrical or oblong, white when laid, changing to yellowish brown as they mature and ready to hatch. The eggs are mostly laid singly or in groups of two or three, on the lower leaf surface along major veins. One adult female lays 100-150 eggs in a life span of 3-7 days. The incubation period ranges from 3-8 days depending on the temperature.

There are four larval or caterpillar stages. At hatching, the caterpillars are light brown; later, when fully grown, they are dark green (photo, right). When disturbed, the larvae wriggle backwards, and may drop from the leaf on a silk thread. The larval period ranges from 14-28 days, after which they make a silken cocoon and pupate.

The pupa is dark green or light brown, about 10 mm long, and usually stuck to the underside of the leaf. Pupation lasts 5-10 days.

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After pupation, the adult moth emerges from the cocoon. It is about 10 mm long with a 13 mm wingspan, dark brown with three white diamond-shaped patterns on its back; these give the moth its common name (photo, left). The adult lives for up to 35 days.

The life cycle is complete in less than 1 month, depending on the temperature. The moth is most active at night.

Detection and inspection

The onset of Diamond back moth infestation can be monitored by:

- Visiting the field everyday, looking for any adults or larvae on the plants;
- Putting yellow sticky traps in the field to catch flying adults;
- Putting sticky traps baited with Diamond back moth sex pheromone to trap male adults.

Management

NATURAL ENEMIES

There are several parasitioids of the different stages: eggs - *Trichogrammatoidea bactrae*; caterpillars - *Cotesia plutellae*, *Diadegma semiclausum*, *Microplitis plutellae*, *Oomyzus sokolowskii*; pupae - *Diadromus collars*.

CULTURAL CONTROL

- Always start with healthy, insect-free seedlings;
- Hand pick larvae when numbers are low;
- Destroy crop residues after harvest, and crucifer weeds before planting and during the cropping period;
- Grow head cabbages during the cooler times of the year (June-November) to avoid infestations - done by some farmers on the Guadalcanal Plains;
- Grow collards, *Brassica oleracea acephala* cv. Vates, as a trap crop. Trap crops for the other species are: radish and green mustard (*B. juncea*) for *Hellula undalis*); Chinese cabbage (*B. pekinensis* cv. Tempest) or flowering green mustard for *Crocidolomia pavonana*. (Note that the latter was also useful as a trap crop for *Halticus tibialis*);
- Where farmers have the resources, grow plants under nets or in green houses;
- For watercress, grown on rafts in the river, sinking one half for 30 min and then the other end, to drown the caterpillars is a measure worth trying. Drown one half of the plants, then the other half, is done so that spiders are able to survive. Spiders are natural enemies of the Diamond back moth caterpillars.

CHEMICAL CONTROL

- If pesticides are used, there is need for careful choice. If one chemical is used all the time, it is likely that the Diamond back moth will develop resistance to it;
- Those products that are recommended are plant-derived products, such as chilli (with the addition of soap), and synthetic products that contain disease-causing organisms, such as spinosad (Success) and Bt - *Bacillus thuringiensis*. Spinosad and Bt are sometimes sold in Honiara.
- Indoxacarb (Steward), a new product with a novel action is not yet available in Honiara.

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Fruit Flies

Extension Fact Sheet **21**

Common name: Fruit flies
Scientific names: Mango fly (*Bactrocera frauenfeldi*) (below, left); Melon fly (*Bactrocera cucurbitae*) (below, 2nd left); Breadfruit fly (*Bactrocera umbrosa*) (below, 3rd left); Solomon fly (*Dacus solomonensis*) (below, right). There are many more fruit fly species in Solomon Islands, but these are major pests.

Hosts: Mango fly has a wide host range; those hosts that are of importance to subsistence and commercial agriculture are: avocado, black sapote, breadfruit, capsicum, carambola, cut nut, golden apple, grapefruit, guava, jackfruit, kumquat, mangoes, Malay apple, papaya, paper mulberry, passion fruit, plantain, pomelo, sapodilla, snake gourd, sour orange, soursop, Tahitian chestnut and tropical almond. Wild hosts are Indian laurel, figs, and many forest fruits. **Breadfruit fly** infests breadfruit, jackfruit and bitter gourd. **Solomon fly** attacks cucumber, pumpkin and particularly snake gourd. **Melon fly** hosts are cucurbits, including watermelon, cucumber, pumpkin, snake gourd, bitter gourd and ivy gourd.

Damage

Eggs are laid in fruit, and maggots cause the fruits to rot. Melon fly may also lay eggs in flower buds and stems. It is an important fruit fly, destroying crops of pumpkin and snake gourd.

Biology and Life Cycle

Female flies lay eggs in fruit, leaving small holes in the skin. Eggs are white or pale yellow, about 0.8 mm long and 0.2 mm wide. As the female lays eggs, it also adds bacteria from the fruit surface; these help rot the fruit and provide food for the larvae or maggots.

The eggs hatch after 1 or 2 days, with the maggots feeding on rotting fruit flesh. Maggots are white, and their body tapers to a pointed head containing a pair of black mouth-hooks. The maggots grow to different sizes: mango fly up to 8 mm, melon and breadfruit fly up to 11 mm, and Solomon fly even larger. There are three moults. Maggots usually live from between 1 and 2 weeks. When fully grown they drop to the ground and burrow into the soil. Their skins harden to form brown, barrel-shaped pupae. These hatch into adult flies after 1 or 2 weeks.

Mango fly adults are mostly black, about 6 mm long, with a dark stripe across the wings. **Melon fly** adults are orange-brown, about 8 mm long, with three yellow stripes along their backs, and two brown spots near the wing tips. **Breadfruit fly** adults are about 8 mm long, with bold black, yellow and orange body markings, and three wide brown bands on the wings.

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Solomon fly adults look like wasps with a slim waist, have brown bodies about 12 mm long, and their wings have a brown band along the front edge.

Flies mate and lay eggs about 2 weeks after pupation. Melon and Breadfruit flies mate at dusk, while Mango fly mates at any time. Female flies need protein to develop eggs. Melon fly females lay more than 1000 eggs, and live for about 5 months, longer than the other species.

Detection and inspection

Look for rotten fruit, and small holes in the skin. Open up fruits and look for maggots inside. Rear maggots to determine species. Distinctive features are: **Melon fly:** yellow stripe in the middle of the upper body between the wings; black T on the rear body; dark patches on edge of wings. **Mango fly:** reddish brown with yellowish abdominal cross bands, transparent wings with small brown spots on the tips. B**readfruit fly:** mix of black with yellow stripes., and wings with broad black bands. **Solomon fly:** large, reddish-brown. Lures are used: either Cue-lure, to attracts mango, melon and Solomon fly, or methyl eugenol, to attract breadfruit fly.

Management

QUARANTINE: Melon fly, which entered Solomon Islands from Papua New Guinea in 1984, is not present yet in Makira, Rennell/Bellona and Temotu Provinces.

NATURAL ENEMIES**:** Fruit fly maggots are parasitised by small wasps. Spiders, ants, assassin bugs and beetles feed on maggots, pupae and adults. Weaver ants (*Oecophylla*) stop flies from laying eggs. Chickens, pigs and flying foxes eat the fruit and maggots.

CULTURAL CONTROL

- Collect fallen, damaged and overripe fruits, and bury them (at least 50 cm), feed them to pigs or seal them inside plastic bags and put in direct sunlight for several hours;
- Choose varieties of fruits and vegetables that are less susceptible to attack; and, if possible, harvest early to avoid infestation;
- Form a bag with a double layer of newspaper over the fruit and staple or sew in place. Effective for guava, mango and carambola. Use leaves of pandanus, betel nut, sago palm or swamp taro, after softening over a fire. In PNG, whole banana bunches are bagged inside banana leaves to stop banana fly and to improve market look;
- Encourage weaver ants (*Oecophylla*), by placing bamboo poles as 'roads' from nests to new areas. Useful in citrus, native almond and mango.

CHEMICAL CONTROL: Use insecticides as cover sprays, but they will also kill beneficial insects. Better if they are used together with baits as follows:

- **Protein-bait technique**. A protein and an insecticide are spot-sprayed around crops. The protein is made from yeast, and can be bought in PNG (mango fly on guava and carambola), Tonga and Vanuatu. Useful, but needs farmers to synchronise efforts.
- **Male-annihilation-technique**. Male fruit flies are killed, so females cannot mate and lay eggs. A high density of bait stations are arranged on a grid - 400 per km^2 or 1 every 20 m - and treated with a male lure (Cue-lure or methyl eugenol) and an insecticide (fipronil). The baits are made of fibreboard, cardboard or coconut husk. An entire orchard or village is covered, plus a 50 m buffer zone around the outside.

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Sliperi Kabis Flea Beetle

Extension Fact Sheet **22**

Common names: *Sliperi kabis* or *Neka* flea beetle, *Bubulu* (on Malaita)[1]
Scientific name: *Nisotra basselae.*

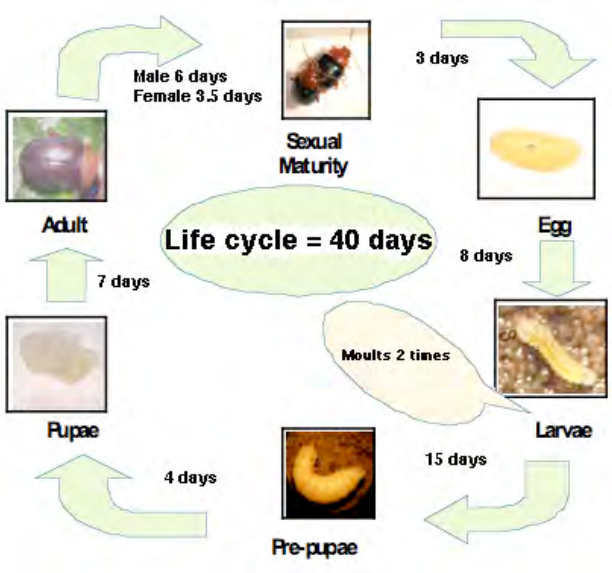
Hosts: *Sliperi kabis* (*Abelmoschus manihot*), possibly *Hibiscus tilaceous* (under lab conditions, but not seen in the field); not on *Sida*, nor the garden hibiscus, *Hibiscus rosa-sinensis.*

Damage

Adult beetles feed on leaves creating many small (1-5 mm diameter) holes (photo, right). The damage is so severe that in many places in Solomon Islands people have stopped growing *sliperi kabis*. The larvae feed on small roots, especially the tiny root hairs. Whether this affects the growth of the plant is unknown.

Biology and Life Cycle

Eggs are laid singly or in small batches just below the surface of the soil. They hatch after 8-9 days. The larvae remain in the soil for 12-18 days, feeding on small roots. They moult twice before they pupate. After pupating for 4-6 days, adults emerge from the soil. Males emerge first, taking 6-8 days to become sexually mature; females take 3-5 days. The adults disperse by walking, jumping and flying. They may drop to the ground if disturbed.



The number of generations per year is unknown. Research into the biology of the beetle is being done in Solomon Islands.

[1] Information supplied by Maclean Vagalo, MAL Director of Research, Honiara, and Chris Reid, Entomologist, Australian Museum, Sydney.

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Detection and inspection

Look for small holes in the leaves and the presence of beetles. The adult beetles are about 4 mm long and can be found on both sides of the leaves. The head and part of the section below are orange/brown (photo, left). The wing cases are black. The beetles are less obvious during the hotter times of the day, when they move under the leaves.

Management

QUARANTINE

Temotu, and Rennell and Bellona Provinces are free from of the beetle. Therefore, no leaves of *sliperi kabis* or other parts of the plants should be taken there. Extension services should constantly remind people of this, with messages on the radio and in newspapers.

NATURAL ENEMIES

Parasites of the adults include nematode worms and mites. The adults do not seem to be affected by the presence of the fire ant, *Wasmannia auropunctata*. *Nisotra* may be toxic to visual predators, like birds and lizards.

CULTURAL CONTROL

There are a number of possibilities:

- Plants grown under shade may have fewer beetles; however, too much shade gives poor plant growth;
- Thick mulches of straw, grass or other organic materials (several centimetres thick) may prevent female beetles from laying eggs at the base of the stems;
- There is some evidence that planting in clover reduces infestations;
- Plant *sliperi kabis* far from plants infested with the beetle; the beetles do not fly long distances;
- Plant more *sliperi kabis* in the wet season when beetle numbers are lower;
- Hand pick the beetles when infestations have just started; this will delay beetle populations reaching damaging numbers later;
- Cultivate the soil at the base of the plants to expose eggs, larvae and pupae to the sun and predators.

CHEMICAL CONTROL

- Orthene (acephate) is often used in Solomon Islands; other insecticides, such as synthetic pyrethroids are likely to be effective and safer to use;
- Lambda cyhalothrin and permethrin are available in Honiara. Before these chemicals are used, farmers should read the instructions on their safe use;
- A variety of *Derris*, brought many years ago from Papua New Guinea, is effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

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Sliperi Kabis Shoot Borer

Extension Fact Sheet **23**

Common name: *Sliperi kabis* shoot borer
Scientific name: *Earias vittella.*

Hosts: The moth attacks sliperi kabis *(Abelmoschus manihot)*, okra, hibiscus, and tomato.

Damage

Caterpillars do the damage by feeding inside the stems (photo, top right). The tips and leaves wilt and die (photo, left). Caterpillars also feed inside fruits and pods of cotton and okra.

Biology and Life Cycle

Adult moths lay eggs at night, singly, on shoots, buds and young fruit. Eggs are light blue-green, round, and about 0.5 mm across. They gradually change to brown just before hatching.

Eggs hatch into caterpillars in the early morning, after 3-7 days. The caterpillars may move some distance before settling to feed on soft growing parts of the plant. Feeding happens during the day, and caterpillars are full-grown after 9-17 days. They are grey-brown with orange spots and a black head. The body is up to 18 mm long and 3 mm wide, with two pairs of fleshy bumps on each body segment (photo, top right).

Mature caterpillars spin a silken cocoon, which is brown, felt-like, and shaped like an upside-down boat. Cocoons are fastened to the plant, to debris on the ground, or within cracks up to 30 cm deep in the soil. Inside the cocoon, the caterpillar turns into a pupa that is about 13 mm long, with three small spikes on its tail. The pupa lasts for 1-2 weeks, before it splits open and an adult moth comes out.

Adults live for up to 1 month, feed on nectar, and lay up to 500 eggs. Adult bodies are 12 mm long, with a wingspan of about 2 cm (photo, lower right). They are mostly white, with a central green wedge pattern running along their front wings.

Detection and Inspection

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Look at the stem tips and leaves; look to see if the tips or branches are wilting and dying. Look closely for small holes in the stem below the dying tip. The caterpillars push their waste out of these holes. This is often very noticeable. Break the stem near this hole to find the caterpillar in its tunnel.

Management

NATURAL ENEMIES

- Small wasps attack the eggs, caterpillars and pupae;
- Lacewings and ladybird beetles eat the eggs;
- It is important to think about these natural enemies when considering how to control *Earias*. If insecticides are used, use ones that do not kill these beneficial insects. Preferably, use those that are allowed under organic vegetable production.

CULTURAL CONTROL

- If the *sliperi kabis* plants are severely attacked, pull them all out and stop growing the cabbage for a few weeks. Plant the crop in another garden;
- *Earias* is less abundant during wet, humid weather and, therefore, growing crops during the wet season may be effective;
- There are no known resistant *sliperi kabis* varieties in Solomon Islands. Look carefully to see if some types are less attacked and, if they are, plant more of those.

BIOLOGICAL CONTROL

In other countries, introduced wasps have been used to control populations, with rates of parasitism at over 25% in eggs and 35% in pupae. Lacewings are used as egg predators. A female sex pheromone has been identified, and synthetic formulations have shown promise, disrupting mating and achieving season-long control. This is not available in Solomon Islands.

CHEMICAL CONTROL

Since populations of *Earias* tend to build up slowly, only two or three applications of chemical pesticide may be needed to reduce numbers in a crop. In Honiara and nearby village, Orthene is commonly used to control *Earias*. The following alternatives, made from bacteria, are recommended (they are sometimes sold in Honiara):

- Spinosad, also known as *Success;*
- Bt, also known as *Bacillus thuringiensis kurstaki*.

Pyrethrum and derris insecticides can also be used; pyrethrum is a member of the daisy family and derris is a shrubby legume, and contains rotenone. They are fast acting against insects and less harmful in the environment compared to many synthetic products. They are broken down quite quickly by sunlight. BUT they will kill natural enemies, too. A variety of *Derris*, brought many years ago from Papua New Guinea, is effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

Neem seed extract can be used; see Kastom Gaden Association for seedlings.

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Spider Mites

Extension Fact Sheet **24**

Common name: Spider mites
Scientific name: *Tetranychus* species. The different species are difficult to tell apart because they are so small and require examination using a high power microscope. One group, known as two-spotted mites, is the most common, infesting over 200 species of plants.

Hosts: Many crops are host to spider mites in Pacific Island countries, among them okra, papaya, sweet potato, cassava, tomato, squash, eggplant, beans, taro, *sliperi kabis*, cucumber and other cucurbits.

Damage

Spider mites are common plant pests. They have needle-like mouthparts and use them to suck juice from the leaves. This destroys the cells, and the leaves show a characteristic white to pale yellow speckling, usually between the main veins. When infestations are severe, the speckling is seen all over the leaf. Two-spotted mites make webs (like spiders) on the under surface. As the infestation advances, the leaves turn yellow and die prematurely.

The extent of the damage caused by mites often depends on rainfall. When rainfall is low, mite populations are high and often effect yields. On taro, for instance, yellowing and early maturity of plants occurs and corm size is reduced. Damage is particularly severe during droughts and, presumably, outbreaks will increase with climate change.

Biology and Life Cycle

The eggs are round and relatively large in comparison to the size of the adult; they are laid in the webbing near the veins, on the underside of leaves.

The eggs hatch in about 3 days, producing larvae that have six legs and are colourless. From these, nymphs develop, which have eight legs; they moult once and within a few days become adult. The adults are about 0.5 mm long, with males smaller than females, and narrower towards the back end. Each female lays about 100 eggs.

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Under tropical conditions the life cycle takes only 7-10 days depending on temperatures. Populations develop rapidly, especially during periods of drought when damage can be considerable. The adults live for 2-4 weeks.

Two-spotted mites vary from light yellow to dark green or brown.

Mites produce fine silken webs - from a pair of glands near the mouth. When infestations are high, this webbing covers all or part of the leaf and becomes very noticeable. The webs allow the mites to travel from infested to non-infested leaves; also, the webs are caught by the wind and help the mites to disperse.

Detection and Inspection

Look at the underside of leaves, particularly near the veins for the presence of mites, using a hand lens and/or a microscope. Look for webbing, which can be seen when mites are present in large numbers. The tiny spots on the upper leaf surface and the presence of webs are signs of their presence. Look for spots on the mites; the spots are reddish-brown to yellowish-green, depending on the species.

A good way to detect if mites are present is to place a sheet of white paper beneath the leaves and strike the leaves sharply. The mites fall onto the paper and can be more easily seen than on the green leaves.

Management

NATURAL ENEMIES

Predatory mites keep populations of spider mites in check, as do ladybird beetles, lacewing larvae, pirate bugs, big-eyed bugs and predatory thrips. Managing mites requires preserving natural enemies; in most cases this means doing nothing to harm them. It also means not using pesticides.

CULTURAL CONTROL

- A regular spaying of leaves with water will keep spider mites in check. This technique helps conserve natural predators;
- Check that cuttings, tops, etc. are free from infestation before planting in a new garden.

CHEMICAL CONTROL

- If pesticides are used, they should be applied carefully. Rotate between different chemical groups, to prevent resistance developing to any one of them;
- Not all insecticides kill mites, and those that do may not kill all the stages. Eggs are particularly resistant to pesticides and so, too, are larvae and nymphs, especially when moulting, as they do not feed. More than one application is needed at 5-10 days apart;
- Horticultural oil and soaps are effective. If used, test them on a few plants first, to see if they cause damage. It is better to use them than synthetic pesticides, since they are less toxic to people, other non-target organisms and the environment. However, their effect may depend on the plant and the species of mite;
- Water-stressed plants stimulate mite outbreaks, and hosing plants with water can suppress mite populations, but this is not a practical solution for large plantings.

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Spiraling Whitefly

Extension Fact Sheet **25**

Common name: Spiraling whitefly
Scientific name: *Aleurodicus disperses.*

Hosts: This whitefly has a very wide host range, such as banana, cassava, citrus, papaya, mango, custard apple, guava, taro, tomato, capsicum, eggplant and also many ornamental species, shade trees and weeds. The adult makes distinctive spiraling patterns when laying eggs on the under surface of the leaf (photo, left); this gives the insect its name.

Damage

Damage is caused by the whitefly piercing the leaf and sucking the sap; this leads to early death when whitefly numbers are high. Damage is also caused by build up of sooty mould. Sooty moulds (fungi) grow on the honeydew produced by the whiteflies and their nymphs as they feed. The mould weakens the leaves, as they cannot get sunlight for normal growth

Biology and Life Cycle

The eggs are smooth, yellow to tan, oval, 0.3 mm long. They are laid in a spiral pattern within a trail of white wax. The eggs hatch after 7-10 days.

After hatching, crawlers (nymphs or larvae) move to the leaf veins to feed. As they mature, they develop waxy tufts. There are four nymph stages, with moults between each. At first, the nymphs are mobile, but later, after they moult, they become attached to the leaf and stay there. The last nymph stage feeds at first and then stops, undergoes internal rearrangement, and then moults to become an adult. The four nymph stages take 20-35 days depending on temperature.

The adults (photo, right) live for about 2 weeks. Males are 2.2 mm long; females, 1.7 mm. Adults are able to fly. The forewings have two characteristic dark spots. Egg laying begins a few days after emergence.

Populations decrease during cool, rainy days, and increase again when days are warm and dry.

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Detection and inspection

Look for the small (2 mm long), white and moth-like adults on the undersides of the leaves. When populations are high, look for the heavy coating of white, curly 'wax' produced by the whitefly nymphs. Look for the whitefly eggs that are laid in the silken spirals produced by the females. These spirals are more noticeable initially, when numbers are low. They are also noticeable on the skin of fruits and the surface of vegetables.

Look for the whiteflies at dawn and dusk, calm times of the day. The whiteflies can be seen flying in large circular patterns around the host plants. They can be made to fly by shaking the plant, after which they quickly resettle.

Management

NATURAL ENEMIES

A wasp parasite, *Encarsia ?haitiensis*, lays its eggs in immature whiteflies, killing them. Lacewings and ladybird beetles attack all stages.

When *Encarsia* is not present, spiraling whiteflies multiply at a great rate, producing thousands of individuals on a single plant. However, when the parasite is present, excellent control of the whitefly occurs. It is a very efficient biocontrol agent, and is present in Solomon Islands.

CHEMICAL CONTROL

Attempts to control the pest using insecticides are **not** recommended. Spraying with insecticides has little long-term impact on the pest; it usually makes the problem worse by destroying the biocontrol agents, and promoting insecticide resistance in the whitefly populations.

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Flea Hopper

Extension Fact Sheet **26**

Common name: Flea hopper, Sweet potato flea hopper
Scientific name: *Halticus* sp. (either *H. tibialis* or *H. minutus*).

Hosts: The flea hopper has many host plants, including crucifers (cabbages), cucurbits (watermelons, cucumbers, pumpkins, etc), beans, peanuts as well as sweet potato. In Papua New Guinea*, H. minutus* is considered a serious pest of cucumbers.

Damage

Nymphs and adults of the flea hopper use their piercing-sucking mouthparts to feed on the leaves. As a result, the cells die and small whitish spots appear. When populations are high, the spots develop in irregular-shaped patches scattered on the leaf surface. When populations are very high, patches join and the entire leaf becomes greyish-white or silver (photo, left).

Biology and Life Cycle

The adult is black or dark brown about 2 mm long. It has long and slender antennae. The hind legs are large, allowing the flea hopper to jump when disturbed. At such times, they often move quickly to the underside of the leaves. Eggs are inserted in leaf tissues; they are white to yellow and less than 1 mm long. In other species, they are placed in feeding punctures.

The eggs hatch in about 2 weeks, and the nymphs emerge. The nymphs are green at first, later becoming shiny black as they moult to become adults. A distinguishing feature of the adult (other than the long hind legs) is the length of the antennae, which are longer than the length of the body. The life cycle takes about 3-5 weeks.

Detection and Inspection

Look for the white dots on the top surface of the leaf, and black dots of excreta on both sides. Look for the small, black insects with large hind legs that move rapidly to the under surface of the leaf or jump when disturbed.

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Management

NATURAL ENEMIES

No natural enemies are known from Solomon Islands, but, elsewhere, tiny wasps lay their eggs inside the nymphs and adults.

CHEMICAL CONTROL

- When infestations are high, do not take planting material from the plots in order to establish new plantings. Eggs of the flea hopper might be taken at the same time;
- In Guam, populations of the flea hopper were reduced when head cabbage was grown with radish, Chinese cabbage or mustard as a trap crop;
- As *Halticus* breeds on weeds, wild *Ipomoea* species in particular, it is important to keep fields free of weeds; otherwise, the pest will breed on them and migrate to sweet potatoes.

CHEMICAL CONTROL

- Malathion is one of the recommended chemicals available in Solomon Islands. It is likely that synthetic pyrethroids will also be effective.
- Derris (rotenone) is known to be effective against the flea hopper. A variety of *Derris*, brought many years ago from Papua New Guinea, is effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

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Sweetpotato Hornworm

Extension Fact Sheet 27

Common name: Sweet potato hornworm
Scientific name: *Agrius convolvuli.*

Hosts: Sweet potato is the main host, but it may also occur on eggplant, pepper, tomato and legumes.

Damage

The caterpillars do the damage. They eat the leaves, often right down to the leaf stalk. Frequently, they are found at the shoot tip, preferring young succulent leaves. If populations are high, they will eat all the leaves. Severe defoliation will affect yield, especially if it occurs when plants are young. Outbreaks are not common; *Agrius* is usually under control by its natural enemies.

Biology and Life Cycle

The greenish eggs, which are spherical, measuring 1-2 mm diameter, are laid singly on the leaves and stems. They hatch in about 4 days, producing caterpillars that vary from green to brown, occasionally yellow, with diagonal pale yellow lines along their sides, prominent spots and a distinctive horn (photo, left). They reach 95 mm in length. There are five stages; the later stages do the most damage, feeding at night. The caterpillars are mature in 25 days or less, depending on the temperature.

The pupae (photo, lower right) are found in the soil under the plants. They are reddish brown with a prominent proboscis or "trunk", which is curved downward and looks like a jug handle.

Adults emerge from the pupae in 25 days or less; they are large greyish-brown hawk moths, with black lines on the wings and pink markings on the abdomen (photo, above right). The wingspan is 8-12 cm.

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Inspection and Detection

Look for large holes in the leaves, and faeces (droppings) of the caterpillar on the young leaves. The size of the mature caterpillars and the horn are distinguishing features of this species.

Management

NATURAL ENEMIES

Populations of the sweet potato hornworm are usually kept in check by a number of parasitoids and predators. Among the important egg parasites are minute wasps, *Trichogramma* spp., while *Sycanus* sp., a large reduviid (predatory insect), and a tachinid fly feed on the larvae.

CHEMICAL CONTROL

- Handpicking of the larvae can be quite effective in small areas;
- If there are large numbers, allow chickens into the garden.

CHEMICAL CONTROL

Pesticides are not recommended as they disrupt the action of the egg and larval parasites. The hornworm is usually controlled by natural enemies, and pesticides may kill these and make matters worse.

If they are needed, it is best to use synthetic products that contain disease-causing organisms, such as spinosad (Success) and Bt - *Bacillus thuringiensis*. Spinosad and Bt are sold sometimes in Honiara.

A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

Preparations using neem seed extract can be used; see the Kastom Gaden Association for seedlings.

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Produced with support from IPPSI: *Improved Plant Protection in Solomon Islands,* funded by ACIAR, Canberra

Sweetpotato Leaf Folder

Extension Fact Sheet **28**

Common name: Green leaf folder[1]
Scientific name: *Herpetogramma hipponalis.*

Hosts: Sweet potato (*Ipomoea batatas*) is a major host in Solomon Islands. The caterpillars also occur on other *Ipomoea* species and *Mikania cordata*.

Damage

The caterpillar does the damage. It folds the leaf, holding the folded parts together with webbing. The young caterpillars eat the surface of the leaf (photo, above); later, when larger, they eat through the leaf creating small windows. Often, the damage looks severe with all the youngest leaves folded, and they may turn brown, but there is no information on the effect of leaf damage on storage root yield.

Biology and Life Cycle

The moth (photo, right) lays eggs singly or in groups on the upper surface of the leaf near the midrib. About 90 eggs are laid in a day. The eggs are shiny green, oblong, and covered with a scale-like gelatinous material. The eggs hatch after 3–5 days and the caterpillars are at first greenish-yellow, turning darker green with age. They have a dark brown head. The caterpillars moult four times over 15-30 days and when matures are about 13 mm long. Only the larger caterpillars fold the leaves. In most cases, there is one caterpillar per leaf fold.

[1] Information on this pest comes from two sources: a) T Ames, NEJM Smit, AR Braun, JN O'Sullivan , LG Skoglund (1997) Sweet potato: Major pests, diseases, and nutritional disorders. International Potato Center (CIP), Apartado 1558, Lima 12, Peru; and b) Sweet potato Diagnotes: A Diagnostic Key and Information Tool for Sweet potato Problems. http://www.lucidcentral.org/keys/sweetpotato/key/Sweetpotato%20Diagnotes/media/html/FrontPage/FrontPage.htm

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The caterpillars turn into yellowish-white pupae, which later turn reddish brown. The adults emerge from the pupae in 4–8 days; they are yellowish-brown with dark brown zigzags markings on the wings (photo, right). The female moth lives for about 3 days.

Detection and Inspection

Look for folded leaves, unfold them and look for caterpillars and faecal pellets (droppings). Look at the surface of the leaf; you should see small windows between the veins caused by the caterpillar eating the top surface of the leaf (photo, above). Webbing may be present. The adult moth is brown with zig-zag markings on the wings.

Management

NATURAL ENEMIES

Tiny (braconid) wasps are common and these control the leaf folder populations. They are seen rarely as they are so small. Earwigs and other predators are also important in maintaining natural control.

CHEMICAL CONTROL

The use of uninfested planting material is an effective means of reducing the incidence of leaf folders. Take care when taking cuttings for replanting; remove folded leaves or choose only those cuttings without them.

CHEMICAL CONTROL

The leaf folder is usually under natural control by its enemies. Pesticides are rarely needed. If they are, then use either pyrethrum or a synthetic pyrethroid, such as permethrin or lambda cyhalothrin. Another good choice is *Bacillus thuringiensis kurstaki*, known as Bt; this contains a bacterium that produces a toxin that kills the caterpillars. A wetting agent will be needed to ensure that the chemical reaches the caterpillars in the leaf folds.

A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

Preparations using neem seed extract can be used; see the Kastom Gaden Association for seedlings.

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Sweetpotato Weevil

Extension Fact Sheet **29**

Common name: Sweet potato weevil
Scientific name: *Cylas formicarius.*

Hosts: Sweet potato (*Ipomoea batatas*) and many types of morning glory.

Damage

Damage is done by the adult beetles (photo, left) and grubs (photo, right). The adults feed on the buds, leaves, vines and storage roots. However, grubs cause most damage by tunnelling through the stems and storage roots.

Biology and Life Cycle

Female beetles lay eggs singly in the base of the vines, or crawl through cracks in the soil to reach the storage roots. The eggs are white, oval, and about 0.5 mm long. They are sealed in with a protective grey faecal plug. Several hundred eggs are laid over a lifespan of about 4 months.

The grubs or larvae are legless, white, with a brown head and reddish-brown gut. At maturity, the grubs are up to 8 mm long; they then pupate. Pupae are creamy white, up to 6 mm long. This stage lasts about a week. After coming out of the pupa, the adult beetle stays in the tunnel for about a day before cutting through to the outside.

Adult weevils are small and ant-like (photo, left). They are 5-7 mm long, with a smooth and slender body and snout. Their head and rear are metallic blue or black, and their middle, legs and feelers are red. The full lifecycle takes just over a month.

Detection and Inspection

Look at the base of the plant for small holes and damage to the stem. Break the stem to see if there are tunnels, rot and larvae. Dig up a storage root and look for damage to the skin, and feeding tunnels of the larvae inside. Adult beetles are most active at night, but can sometimes be seen on plants during the day.

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Management

NATURAL ENEMIES

Predatory ants, beetles, spiders and earwigs attack adult weevils. Some tiny wasps attack them. They also become infected by *Beauveria*, a fungus. Bacteria and nematodes kill the grubs.

CHEMICAL CONTROL

- Crop rotation: Grow sweet potatoes in a field only once every 3-4 years. Avoid planting sweet potatoes in the same area 2 years in a row, and plant well away from infested crops;
- Hill up and mulch: Weevils usually access roots by cracks in the soil. Prevent the soil from cracking by hilling soil around the plant. Also, prevent cracking by spreading mulch to keep the soil moist. Plant cuttings deep in the soil, use deep-rooted varieties, and harvest the crop as soon as it has developed sizeable roots;
- Sanitation: Destroy any crop residues left in the field after harvest, since weevils survive in the roots and stems.
- Selection of planting material: Select clean cuttings (25-30 cm long) from fresh young growth to reduce the spread of weevils.

BIOLOGICAL CONTROL

The fungus, *Beauveria bassiana*, is produced in large quantities and used intensively for the control of sweet potato weevil in Cuba. Sprays of the fungus have largely replaced the use of chemical insecticides. Also in Cuba, predatory ants (*Pheidole megacephala*, the big-headed ant) have also been used effectively to control weevils. Research on both these potential biological control organisms is being done in PNG.

CHEMICAL CONTROL

- Before planting: Treat vine cuttings with insecticides to kill weevils and prevent infestation in new plantings. There are no recommended pesticides for use in Solomon Islands. This is a better use of insecticides than post-plant applications, especially if combined with proper sanitation and the other measures listed under cultural control;
- Inspect the crop regularly, at least once a week: Check the base of the vines, looking for damage and holes;
- Post-plant application:
    - Use the male pheromone to monitor weevil populations. Spray with insecticide (e.g. bifenthrin) when numbers reach a pre-determined threshold level. (A pheromone is a chemical released by insects to bring the sexes together);
    - Alternatively, spray routinely with bifenthrin, every 14 days.

These treatments would only be suitable for commercial growers. See your MAL extension officer for details.

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Taro Beetles

Extension Fact Sheet 30

Common name: Taro beetles
Scientific names: *Papuana* species. There are 18 species in Papua New Guinea, 11 of which damage taro; there are six species in Solomon Islands. Common species are: *Papuana woodlarkiana*, *Papuana huebneri*, *Papuana trinodosa*, *Papuana biroi*, *Eucopidocaulus tridentipes* and *Papuana szentivanyi.*

Hosts: Common hosts of *Papuana* beetles are seedlings of oil palm and coconut, *Alocasia* (giant taro), banana, *Cryrtosperma* (giant swamp taro), sugarcane, *Pandanus* and taro.

Damage

Adult beetles do the damage by burrowing into the underground parts of their hosts. Oil palm and coconut seedlings, and taro plants wilt and die when the tunnels reach the growing point. More commonly, plants remain alive, but grow poorly. Holes bored in the corms of taro make them unfit for market, and where damage is considerable they are not even fit for home use.

Estimates of the amount of damage are hard to come by, but in Papua New Guinea it is put at about 15%, with losses as high as 80% in individual gardens. In many parts of Solomon Islands, taro is very difficult to grow because of *Papuana* beetles, and they are one of the reasons why farmers have abandoned this crop. This is serious, because loss of taro means a loss of genetic diversity, and this may impact food security. It may also undermine cultural traditions, many of which are dependent on taro.

Biology and Life Cycle

The adult is a shiny black beetle, 15-25 mm long. The beetles have horns on the head, but the number and size differs among species. Those of the male are generally larger. Eggs are laid about 7 weeks after the female emerges from the soil. The eggs are laid singly; they are white, oval and 2-3 mm long. Grubs emerge after about 2 weeks. These are white, and 'C' shaped at rest. They moult three times and when mature are 25-40 mm long. The grubs last about 90 days before they pupate for 3-4 weeks and the adult emerges. The entire life cycle takes 4-5 months.

Male beetles are less mobile: they colonise the taro corms, awaiting the arrival of the female. After mating, the female flies to find a breeding site, usually places with decaying organic matter, e.g., rotten logs/stumps, manure, saw dust, along river banks and in the fibrous roots

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of grasses. Each female lays up to 300 eggs during a lifespan of about 20 months. The adults are capable of flying up to a kilometre, and they are attracted to lights.

When the forest is disturbed, for instance due to logging or cyclones, taro beetles are common in taro gardens. In the forest, ferns (*Angiopteris* species) are a common host.

Detection and Inspection

Look for young oil palm, coconut and taro plants that are wilting and , if found, check if Papuana beetles are present by pulling the plants out of the ground. More sophisticated methods include the use of light traps and sampling of breeding sites (compost heaps, sawdust, rotting logs) and wild hosts, such as grasses (*Paspalum* species and *Brachiaria mutica*), bananas and sugarcane.

Management

NATURAL ENEMIES

Several natural enemies have been recorded, including the fungus *Metarhizium,* a tachinid fly and the cane toad, but none are considered effective in controlling populations sufficiently well to stop corm damage.

CHEMICAL CONTROL

Several cultural control measures have been suggested, including crop rotation, clean planting material (i.e., free from soil), and destruction of breeding sites near gardens, but these are impractical, and are unlikely to be effective, even if farmers tried to implement them.

BIOLOGICAL CONTROL

Although much work has been done using the fungus *Metarhizium anisopliae*, and it has been shown to work under experimental conditions, as yet there is no practical recommendation for farmers. It is difficult for farmers to maintain stocks of the fungus, which has to be grown on, for example, rice grains and applied to each planting hole as well as likely breeding sites.

The virus that infects *Oryctes rhinoceros*, the dynastid beetle of coconuts, has been tried against *Papuana*, but without success.

CHEMICAL CONTROL

Use imidacloprid (sold under the trade name of Confidor), or a pyrethroid (Mustang); both are effective in controlling *Papuana* beetles in Fiji, and also in trials in Solomon Islands. Confidor is available in Honiara.

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Cluster Caterpillar

Extension Fact Sheet **31**

Common names: Taro cluster caterpillar, Taro armyworm
Scientific name: *Spodoptera litura.*

Hosts: Taro cluster caterpillar has a wide host range, attacking many vegetables - cabbages, tomatoes, okra, chilli, cassava, corn, sweet potato, rice, eggplant, watercress and, especially, taro.

Damage

It is the caterpillar (or larva) that does the damage. The young caterpillars radiate from the egg masses (photo, lower left), stripping the leaf surface and eating the leaf between the veins (photo, upper left). Later, they become solitary and eat all the leaf, including the petioles. Mostly, they feed at night. Normally, the caterpillars are well controlled by their natural enemies, but occasionally, especially after natural disasters or where gardens are isolated, outbreaks occur, and these can be severe.

Biology and Life Cycle

The cream to golden-brown eggs are laid in masses (4-7 mm diameter) covered with hairy scales from the tip of the abdomen of the female. After hatching, the caterpillars stay together (hence the name 'cluster caterpillar'). They vary in colour: pale green at first, then later, dark green to brown (photo, upper right). There have bright yellow stripes along the top of their body. The caterpillars moult five times during 15-30 days, depending on the temperature. Afterwards, they pupate in the soil for 7-10 days.

If the eggs are laid on a plant that is inedible, the young caterpillars drop silken threads and are carried on the wind to other potential hosts.

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The body of the moth is grey-brown, 15-20 mm long, with a wingspan of 30-40 mm (photo, lower right). The forewings are grey to reddish brown with a strongly variegated pattern. The hind wings are greyish-white with grey margins. The moths can fly up to 1.5 km a night. They are attracted to light.

Detection and Inspection

Look for the egg masses: they are relatively easily seen against the dark green of the leaves. Look for the 'scratch' marks left by the newly hatched larvae on the leaf surface. The older caterpillars are night-feeders. They chew large areas of the leaf and, when numerous, can defoliate a crop. In such cases, the larvae migrate in large groups from one field to another in search of food (hence the name 'armyworm').

Management

NATURAL ENEMIES

These include egg parasites - *Telenomus nawaii*; and larval parasites - *Apanteles marginiventris* (wasp), *Peribaea orbata* (a fly), *Chelonus* sp. (wasp), *Palexorista* sp. (a fly), and many more.

CULTURAL CONTROL

- Remove leaves with egg masses or young caterpillars – this is an effective control measure. In most cases the entire leaf does not have to be destroyed, only that part containing the eggs or caterpillars;
- Destroy the eggs and/or caterpillars as soon as they are seen by rubbing them with a hand or another leaf;
- If there are many caterpillars, and damage looks likely, let chickens into the garden.

CHEMICAL CONTROL

Pesticides are not normally recommended for the control of this moth on taro. They are only needed when the natural enemies have been destroyed by cyclones, droughts, or when plantings are in isolated places. In these situations, it is best to use natural insecticides, such as chilli, derris, neem, pyrethrum, or those containing bacteria, such as spinosad (Success) and Bt – *Bacillus thuringiensis kurstaki*. Spinosad and Bt are sometimes sold in Honiara.

A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

Preparations using neem seed extract can be used; see the Kastom Gaden Association for seedlings.

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Taro Hornworm

Extension Fact Sheet 32

Common name: Taro hornworm
Scientific name: *Hippotion celerio.*

Hosts: It is recorded from taro, sweet potato and noni (*Morinda* sp.)

Damage

The caterpillars do the damage. They eat the leaves, leaving only the main veins (photo, above left). Sometimes even these are eaten and only the petioles are left. Outbreaks are not common as the caterpillars are under control from natural enemies; otherwise, the caterpillars can be very damaging.

Biology and Life Cycle

The eggs are laid singly on both sides of the leaf and on the petioles. They vary from round to oval, and from clear to bluish-green. Just before the emergence of the caterpillars they are green-yellow. The caterpillars moult four times: at first they are pale yellow, then, as they age, they become green and dark brown (photo, above right). Some remain green. The eyespots and a yellow line running almost the entire length of the caterpillar develop after the first moult. When mature, the caterpillars are 80-90 mm long. At this stage, they move to the soil, form a cocoon or cell in the leaf litter or just below the soil, and pupate. The pupae are grey-brown, 45-50 mm long, with dark brown specks. This period lasts 15-18 days.

Adults have wingspans of 40-90 mm; they are streamlined, with large heads and eyes (photo, above). The forewings are long, narrow and much larger than the hind wings. The forewings have an oblique silver stripe across a generally grey background, while the hind wings may have pink or brown and black areas. At rest, the wings are 'tented' over the body. The moths are capable of flying long distances and are attracted to light.

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READ THE INSTRUCTIONS BEFORE USING ANY PESTICIDE

Detection and Inspection

The damage done to taro is characteristic of this hornworm. Look for the way that the leaves are eaten between the veins. Also, the caterpillars can be found on the leaves during the day, especially on the underside. Look for a large caterpillar with eyespots at the front end, with a line along the sides, and a horn at the end.

Management

NATURAL ENEMIES

These include egg parasites – *Trichogramma* sp. (a wasp); and larval parasites *Palexorista* sp. (a fly), *Snellenius hippotionus* (a wasp), and there are probably many more. The cane toad may also feed on the larvae.

CULTURAL CONTROL

The caterpillars are large, and handpicking is an option if the numbers and area of infestation are small. If they are large, chickens are often a good way of managing outbreaks.

CHEMICAL CONTROL

Pesticides are not recommended as they disrupt the activities of the egg and larval parasites. Natural enemies usually control the hornworm. If pesticides are used they will kill them and make matters worse.

If they are needed, it is best to use natural products, such as chilli, derris, neem, pyrethrum, or those synthetic products containing bacteria, such as spinosad (Success) and Bt – *Bacillus thuringiensis*. Spinosad and Bt are sometimes available in Honiara.

A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

Preparations using neem seed extract can be used; see the Kastom Gaden Association for seedlings.

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Cucumber Moth

Extension Fact Sheet 33

Common names: Cucumber moth. Other common names include, Melon moth, Pumpkin caterpillar, Cucurbit caterpillar and Watermelon 'worm'
Scientific name: *Diaphania indica.*

Hosts: The moth attacks cucurbits and eats their leaves. Cucurbits are watermelon, cucumber, melon, pumpkin and snake gourd.

Damage

The caterpillars do the damage. After hatching, they roll the leaves with silken threads and eat the leaves between the veins. They also attack the flowers and reduce the number of fruits set. Young fruits are also attacked: the caterpillars damage the skin and cause the fruits to rot.

Biology and Life Cycle

The eggs are oval, about 0.7 mm long and 0.4 mm wide, thin walled and whitish. They are laid in small groups on the growing parts of the shoot, usually on the underside of the leaves or on buds and flowers.

The eggs hatch and the caterpillars emerge. They are almost clear, but soon become green. Large caterpillars have two white lines along the back (photo, left). When fully grown, they are about 20 mm long: some may be smaller, some larger.

After a while, the caterpillars turn into pupae, green at first then brown. The pupae are in folds of the leaves. They are about 12 mm long and 3 mm wide. The adults hatch from the pupae after about 8-12 days.

The adult is very obvious (photo, right). The wings are white with a wide brown border. When the wings are spread, they are about 25 mm wide. At the end of the body is a group of hairs, rather like a brush. The females wiggle this brush, possibly to send out a chemical to attract the males. The life cycle from egg to adult is about 25 days.

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Detection and Inspection

Look at the young leaves: look for leaves where the veins are still there, but the parts between have been eaten. Inspect the young fruits: look for signs of caterpillar damage. Look for caterpillar faeces or droppings.

Management

NATURAL ENEMIES

- Tiny wasps that are hard to see with the naked eye attack the caterpillars;
- Lacewings eat the eggs;
- It is important to think about these natural enemies when considering how to control *Diaphania*. If chemicals are used, it is best to choose those that do not kill these natural enemies. Preferably, use chemicals that are allowed under organic vegetable production - see below.

CULTURAL CONTROL

- Make regular inspections of the crop, at least once a week. Check the young leaves, looking for those that are stuck together and those where only the veins are left. Look for faeces on the leaves. They are the signs that the caterpillars are present;
- Hand picking should be the first method of control. Look for rolled leaves: remove them, or squeeze and kill the caterpillars inside. Check the flowers and the fruits for damage. If it is severe, consider using chemicals. But consider carefully which ones to use.

CHEMICAL CONTROL

Orthene (acephate) is being used by many farmers for the control of this worm, but it is not the best choice. Orthene is good for sucking insects as it has systemic activity; that means it enters the plant and moves inside it. It will kill the caterpillars, but it will kill all other insects, too, whether they are good or bad.

The following alternatives, made from bacteria, are recommended:

- Spinosad, also known as *Success*;
- *Bacillus thuringiensis kurstaki*, also known as Bt.

Pyrethrum and derris insecticides can also be used; these, too, are made from natural products. Pyrethrum comes from a member of the daisy family and derris is a shrubby legume. They are fast acting against insects and less harmful to the environment compared to many synthetic (commercial) products. They are broken down quite quickly by sunlight. BUT they will kill natural enemies of *Diaphania*.

A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

Preparations using neem seed extract can be used; see the Kastom Gaden Association for seedlings.

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Puccinia Peanut Rust

Extension Fact Sheet **34**

Common name: Peanut rust
Scientific name: *Puccinia arachidus.*

Hosts: The fungi infect peanuts, and some other plants belonging to the genus *Arachis*.

Damage

Infection causes leaves to turn yellow (photo, left), dry, curl and drop. It is not known what losses occurs in Solomon Islands, but it is likely that yields are reduced by 50%, probably much more. Infected plants mature 2-3 weeks early.

Once infections occur, rust develops very rapidly, faster than the diseases caused by early and late leaf spots (**see Fact Sheet No. 36**).

Biology and Life Cycle

The rust infects leaves, petioles, pegs (the shoots that grow into the ground) and stems. On the leaves, the spots are at first yellow, rapidly turning orange and then red-brown as masses of spores develop and break through the leaf surface (photo, right). The lower surface produces the most spores.

The spread of rust depends on wind to disperse the spores, and humidity to provide conditions for infection at the leaf surface.

Detection and inspection

Inspect plants regularly, at least once a week, looking for the red-orange spots.

Management

CULTURAL CONTROL

Cultural control is important, but note that rusts only survive in living plants; they do not survive in crop remains or in the soil. Spores are spread in moist, warm air, and periods of

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cloudy wet weather favour outbreaks of the disease; these are common conditions in Solomon Islands.

The following should be done:

- Remove any volunteer plants from the last crop;
- Plant new crops as far away as possible from older crops, especially those with rust infections;
- If it is not possible to avoid planting near older crops, do not plant down wind from them; otherwise, spores will easily spread to the new crops.

RESISTANT VARIETIES

There are varieties that differ in resistance to rust, but there is no information about the resistance of those grown in Solomon Islands. Varieties from Papua New Guinea are under test in Solomon Islands. See MAL for information.

CHEMICAL CONTROL

- Carry out regular inspections;
- Begin to spray as soon as rust spots are seen, even if they appear on only one or a few plants. Spray at regular intervals: 10-14 days is best, continuing until 14 days before harvest;
- Spray more often if the first treatment is late, and there are many plants with rust spots. In most cases, spraying should begin no later than 30-35 days after planting;
- Use chlorothalonil (the trade name is Bravo). It is effective against rust, and also leaf spot diseases.

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Rats

Extension Fact Sheet **35**

Species present: Polynesian rat (*Rattus exulans*), the Ship rat (*R. rattus*), and the Brown rat (*R. norvegicus*). None of these species are native to Solomon Islands.



Description

Polynesian rat:

- Slender body, pointed snout, large ears; relatively small, delicate feet;
- Red-brown back and white underneath;
- Body weight 40-80 g; up to 15 cm long - tip of the nose to the base of the tail;
- Tail has prominent fine, scaly rings, about the same length as the head and body;
- Females have 8 nipples.

Ship rat:

- Slender body, large hairless ears;
- Grey-brown on the back; either a similar colour or creamish-white underneath or all black;
- Body weight 120-160 g, but it can exceed 200 g; up to 22 cm;
- Tail is one colour; it is always longer than the head and body length combined;
- Females have 10 nipples.

Brown rat:

- Small ears - which usually do not cover the eyes when pulled forward;
- Brown on the back, pale grey beneath;
- Body weight 150–300 g, but can reach 500 g; up to 39 cm long;
- Tail is shorter than the head-body length;
- Females have 12 nipples.

Damage

All three damage crops, and are a threat to the country's biodiversity. Apart from fruits, grains and other plant material, these rats eat insects, reptiles and young birds. They are pests of agriculture crops, including rice, maize, sugarcane, coconut, cacao, pineapple, peanuts and root crops. They eat stored foods, and spoil them by urinating and defecating on them. Rats carry a scrub typhus in Santa Cruz, which is transmitted via the fleas that they host.

Note, damage in coconuts is not directly related to the number damaged; it occurs early and palms compensate for about 50% of the loss. In cocoa, this is not the case as damage occurs when pods are near maturity.

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Habitat

All three species can be found in grasslands, scrub, forests and urban areas. The Polynesian rat does not burrow, but digs small holes and nests mainly on the ground. The Brown rat makes burrows and nests underground. The Polynesian and Ship rat climb, the Brown rat rarely does. Ship rats often nest in trees. The Brown rat swims well, and favours wet habitats. In Solomon Islands, it is probably more common in ports and towns than village gardens.

Life Cycle

If food is available, rats breed. Females can reproduce several times a year. Sexual maturity is 2-3 months, gestation (period between fertilization and birth) is 21-24 days and average litter size is 6-10. Life expectancy is 12-15 months.

Management

CULTURAL CONTROL

- Band coconut trunks with an aluminium strip (30 cm wide at least 2.5 m from the ground) to reduce rat damage in plantations;
- DO NOT leave household waste for rats to eat; otherwise, populations will remain high. Good sanitary practices are essential in villages and towns.

PHYSICAL CONTROL

Snap-traps are efficient, especially if they are left with food but unset for a few days before being set properly. Bait shyness can be a problem. The traps should be put where children and pets cannot get to them.

CHEMICAL CONTROL

- Use anticoagulants (prevent blood clotting), warfarin and brodifacoum made into baits with coconut, wheat or maize. Warfarin is less toxic;
- Prevent baits from being taken by other animals, cats and dogs in particular, and also by birds. Put baits in pipes or bamboo sections. Ideally, collect baits in the morning and put them out in the evening. Resistance to warfarin is known;
- Make warfarin (0.025-0.05% w/v) into waterproof blocks (80 g) with paraffin wax and bait, and tie to branches of trees. Place 25-30 sites per ha;
- Use brodifacoum (0.005% w/v) as ready-made pellets containing bait. Less is needed per station. Read the label or seek expert advice.

Gliricidia (the shade tree). Pound young leaves and mix with cooked rice, maize or other bait. Bacteria convert chemicals in the leaves to substances similar to brodifacoum. These are less toxic than brodifacoum, so larger amounts must be eaten. Try using the bark. Change the bait daily, and protect from pets.

In Reef Islands, the white inner flesh of *Barringonia asiatica* fruits (4-sided on trees along seashore) are scraped, added to cooked rice or shredded coconut, and used as a rat poison.

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Peanut Leaf Spots

Extension Fact Sheet **36**

Common name: Peanut leaf spot
Scientific names: *Mycosphaerella arachidis* (Early leaf spot) and *M. berkeleyi* (Late leaf spot). These are the names of the fungus that produce sexual spores. Where only asexual spores are present, the fungus is known as *Cercospera arachidicola* and *Cercosporidium personatum*, respectively.

Hosts: The fungi infect peanuts, and other plants belonging to the genus *Arachis*.

Damage

Infection causes early death of the leaves and yield loss. It is not known what losses these diseases cause in Solomon Islands, but it is likely that they reduce yields by 50%, probably much more.

Biology and Life Cycle

It is difficult to tell the two leaf spot diseases apart, except that one appears later than the other. The Early leaf spot (photo, left) is supposed to have a more obvious yellow margin around the brown spot, but this is not always the case. The Late leaf spot (photo, right) is black rather than brown on the underside of the leaf, but this is not always obvious. Examination of the spores under a microscope is needed to tell the fungi apart.

The first sign of the diseases are spots on the older leaves. These spread rapidly to leaves of all ages. Spots also occur on the petioles. The brown or red-brown leaf spots are roughly circular up to 10 mm diameter – but usually smaller - often with a yellow margin. The spots are darker on the under surface of the leaf.

Masses of spores are produced on the spots, but a hand lens is needed to see them. These are spread by wind and rain splash. The spores germinate in water on the leaf surface, infect and

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produce more spots and spores. The life cycle takes 10-14 days. The fungi survive in crop remains.

Detection and inspection

Inspect plants regularly, at least once a week, looking for spots, especially on the older leaves, where infections first occur.

Management

CULTURAL CONTROL

Cultural control is important. The following should be done:

- Leave at least 1 year between crops planted on the same land, so that the remains of the old crop decomposes before another crop is planted;
- Preferably, remove and burn or bury the remains of the crop after harvest;
- Plant new crops as far away as possible from old crops, especially those with leaf spots;
- If it is not possible to avoid planting near old crops, do not plant down wind from them; otherwise, spores will easily spread to the new crop.

RESISTANT VARIETIES

There is no information on the differences between varieties grown in Solomon Islands. There are varieties with resistance in Papua New Guinea, and these are being tested in Solomon Islands.

CHEMICAL CONTROL

- Carry out regular inspections;
- Spray as soon as spots are seen, even if they appear only on one or a few plants;
- Spray regularly: 10-14 days is best, continuing until 14 days before harvest.

Spray more often if:

- The first treatment is late and there are many plants with spots. In most cases, spraying should begin no later than 30-35 days after planting;
- Rainfall is high and control is poor.

Use chlorothalonil (the trade name is Bravo). It is good for leaf spots and also rust disease. Copper fungicides can also be used.

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Bean Pod Borer

Extension Fact Sheet 37

Common name: Bean pod borer
Scientific name: *Maruca vitrata*; it used to be known as *M. testulalis.*

Hosts: Many species of beans are hosts, including cowpeas, pigeon peas, and yardlong beans.


Damage

The caterpillars do the damage. They bore into the pods and eat the seeds. There is also damage to the buds, flowers and leaves - they may be eaten and bound together by webs made by the caterpillars; however, damage to these parts is not large in comparison to that done to the pods.

Biology and Life Cycle

Eggs are pale cream, translucent (that is, they allow light through), and laid singly on the stems, young leaves, flowers and pods. They hatch and the caterpillars feed inside the flowers for about a week; then they move to the pods. They are pale cream, with two rows of markings on their backs (photo, left[1]). They grow to 18 mm before they exist the pods and pupate in the soil. The moths (photo, right) have brown front wings, with white patches. The hind wings are mostly white with a brown border.

Detection and Inspection

Look for damaged flowers, and leaves and pods tied together by webs made by the caterpillars. Look for frass - chewed remains of the pods - around entry holes. Look for caterpillars inside the damaged pods: they are pale with two rows of black markings on their backs. The moth is brown with a white patch on the front wings.

[1]Image citations: Merle Shepard, Gerald R Carner, and PAC Ooi, I*nsects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia*, Bugwood.org (left); Gerald McCormack, Cook Islands Biodiversity Website: http://cookislands.bishopmuseum.org/ (right)

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Management

The Bean pod borer is difficult to control, especially on yardlong beans. Pesticides are not recommended. They are:

- Likely to kill natural enemies;
- Not very effective as the caterpillars are hidden for most of the time inside the pods; and
- Expensive, and have to be used often.

There are lures for this insect, but they are used to monitor populations before insecticides are used. Alternatively, look for early signs of webbing of the flowers by the caterpillars.

CHEMICAL CONTROL

If insecticides are necessary, use weekly sprays of a synthetic pyrethroid (for example, lambda cyhalothrin) to kill caterpillars as they move from the eggs to the pods. If the number of plants is small, inspect daily and hand pick the eggs and young caterpillars on the flowers.

Avoid the use of broad-spectrum insecticides to avoid killing natural enemies.

Preparations using neem seed extract can be used on the young caterpillars before they move into the pods; see the Kastom Gaden Association for seedlings.

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Aphids

Extension Fact Sheet **38**

Common names: There are many aphids attacking a wide range of crops; here, we describe one that is common in Solomon Islands, the Melon or Cotton aphid
Scientific name: *Aphis gossypii.*

Hosts: Aphids occur on many crops and weeds; they are common on cucurbits (cucumber, melon, watermelon) and taro. They are also found on chillies, capsicum and eggplant.

Damage

Aphids cause direct and indirect damage:

- **Direct damage**: Damage due to feeding. Aphids have fine, needle-like mouthparts and they use them to suck sap from plants. When they are numerous, young leaves become curled, wrinkled, cup-shaped and smaller than normal. Leaves may wilt, dry up and die early. When populations are high, plants, especially seedlings, become stunted;
- **Indirect damage**:
    - Sooty moulds grow on 'honeydew' - a sweet, sticky liquid produced by aphids as they feed - leaves go black and plant growth is poor;
    - They spread viruses on their mouthparts, such as the viruses of cucurbits - *Cucumber mosaic, Papaya ringspot* (watermelon strain) and *Zucchini yellow mosaic*; taro - *Dasheen mosaic*; and beans - *Bean common mosaic*.

Biology and Life Cycle

Males are rare or not produced in tropical countries. Eggs are not laid. Females give birth to living young without mating. The young are adult in 4-7 days, after moulting four times. They then produce 4-6 young a day, up to 50 each. Because of this method of reproduction, populations grow rapidly, with many generations in a year.

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Detection and Inspection

Look for groups of round, green (some may be light green, others dark green, almost black) insects on the underside of young leaves, on shoots and buds (photo, left). They are about 1 mm long, with long antennae about the length of the body, and two tubes at the rear called conicles. Sometimes winged forms occur, up to 2 mm long with prominent veins. It is difficult to see the detail of the body with the naked eye. Look for ants, they are often present; they come for the honeydew.

Management

NATURAL ENEMIES

Aphid predators and parasites usually keep populations low (photo, right). The most common are lady beetles (adults and larvae), syrphid flies (hover flies) larvae, lacewing larvae, and tiny parasitic wasps that lay their eggs in the adult aphids. The wasp larvae develop in the aphids eating the inside parts and turning the aphids into empty shells, called 'mummies'.

CULTURAL CONTROL

- Remove weeds from within and also outside the crop, but note that there are several hundred hosts of this aphid worldwide;
- Burn or bury the remains of crops after harvest;
- DO NOT plant down-wind from crops with aphids. Some aphids have wings, but they are not strong fliers and are more likely to be blown in the wind onto new crops ;
- Inspect crops often and regularly; destroy leaves heavily infested with aphids;
- Mulch the crop. With some mulches, aphids find it more difficult to distinguish the crop plants than if they were growing in bare ground.

CHEMICAL CONTROL

- If ants are present, kill them with boiling water, without damaging the crop plants. Without the ants, predators and parasites will bring about natural control;
- If insecticides are necessary, use any of the following:
  - Soap sprays (5 tablespoons of soap in 4 litres water);
  - Vegetable oil (1 cup cooking oil; 2 cups water; 1 teaspoon dishwashing liquid. Dilute the mixture at 3 teaspoons per half a litre of water and spray on the infested leaves);
  - Commercial products with petroleum oil: follow the instructions with the product;

  These sprays work by blocking the breathing holes of insects causing suffocation and death. Spray underside of leaves: the oils must contact the aphids.
- Use synthetic pyrethroids (for example, lambda cyhalothrin or cypermethrin).
- A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.
- Preparations using neem seed extract can be used; see the Kastom Gaden Association for seedlings.

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Sliperi Kabis Leaf hopper

Extension Fact Sheet 39

Common names: Sliperi kabis leafhopper or Sliperi kabis jassid
Scientific name: *Amrasca.* The species reported on okra worldwide is *A. biguttula biguttula* (another name is *Amrasca devastans*), and this may be the same as that attacking *sliperi kabis* in Solomon Islands. It has not yet been identified.

Hosts: In Solomon Islands, the jassid has been found only on sliperi kabis (*Abelmoschus manihot*), but elsewhere this jassid is known from okra, peanut, soybean and other legumes, cotton, eggplant and a number of minor hosts.

Damage

The jassids (photo, right) cause the leaves to turn yellow in patches and even turn white at the edges (photo, left). In Solomon Islands, the number of insects per leaf is small in relation to the damage, so it is possible that the jassids inject a toxin as they feed. In Papua New Guinea, large numbers occur on the leaves and cause the leaves to dry up, beginning at the leaf margins, and die prematurely, especially during times of low rainfall. The damage reduces the number of leaves available for consumption, and may also reduce their nutritional content, although this has not been tested.

Biology and Life Cycle

Eggs are laid in the leaves and the leaf stalks. The egg hatch in 8-10 days, and the yellow-green nymphs look similar to the adults except in size, and the fact that they are wingless. They moult four times before they are mature; they are then about 2 mm long. Both nymphs and adults are wedge-shaped. It is likely that the life cycle is complete within 2 weeks.

Jassid populations are influenced by rainfall. High rainfall causes many deaths of nymphs and adults.

Detection and Inspection

Look at the leaves and see if they have light yellow to white patches. Look at the underside of the leaf and find the jassids. There may not be many present on each leaf. The leaves may be

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more crinkled than normal, but remember that leaves of some varieties of *sliperi kabis* are crinkled even when healthy. It is easier to see the jassids if dark paper is put beneath the leaves, and they are then shaken or given a sharp tap.

Management

NATURAL ENEMIES

A number of natural enemies of jassids have been reported worldwide. The larvae of lady beetles and lacewings, spiders and other predators attack both adults and nymphs. Tiny wasps are also reported that attack the eggs of jasssids. Bacteria, *Bacillus thuringiensis kurstak*i, have been recorded infecting nymphs and adults. Whether or not these or other natural enemies are present in Solomon Islands, and attack jassids in the same way, is not known.

RESISTANT VARIETIES

One variety appears to have resistance (photo, right). This is a variety from the Western Province. It may be an introduction from Papua New Guinea. The leaves are deeply dissected into long narrow leaflets, with a waxy green surface and dark leaf stalks; the plant is tall and narrow. See Kastom Gaden Association for details and planting material.

CHEMICAL CONTROL

Use insecticides that have fast action and low residual effect, that is, they break down quickly. The aim is to do the least harm to the natural enemies. Note the following:

- In Papua New Guinea, Derris (*Derris ellipica*) is recommended. Derris contains rotenone, an insecticide. Derris is planted within or around *sliperi kabis* plots, ready for use when required. The roots are used to make a spray. Solomon Islands has a variety from PNG that also has a high rotenone content. See MAL and KGA for a supply of plants and the way to make the spray.
- Alternatively, use synthetic pyrethroid, such as lambda cyhalothrin or permethrin, which are available in Honiara.
- For experimental use, try those products that contain disease-causing organisms, such as spinosad (Success) and Bt – *Bacillus thuringiensis kurstaki*. Spinosad and Bt are sometimes sold in Honiara. Note, under Natural enemies above, Bt has been found to kill nymphs and adults.

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Pumpkin Beetle

Extension Fact Sheet **40**

Common name: Plain or Red pumpkin beetle
Scientific name: *Aulacophora indica.*
Hosts: It occurs on many crops in the cucurbit family: cucumber, melon, pumpkin, watermelon and gourds. Similar species are pests of these plants in India, the Philippines, Japan and Australia.

Damage

Adults (photo, right) feed on leaves, chewing large holes (photo, left). Seedlings are particularly susceptible, and so are young plants after planting out. The damage to young plants can delay crop maturity. Damage also occurs on flowers and small fruit.

The larvae damage roots, stems and fruits, but evidence of this has not been looked for in Solomon Islands. Such damage allows entry of other organisms, for example, fungi.

Biology and Life Cycle

The life cycle has been studied under the old name *Aulacophora similis*. Females lay yellow, oval eggs singly or in batches in soil around the base of the host. After 5-15 days, they hatch, and the cream-white young (called larvae) burrow into the soil to feed primarily on the roots. Four moults occur over 14-25 days, and then the larvae enter the pupal stage in an earth chamber; this lasts another 7-20 days before the adults emerge.

Females lay up to 500 eggs, and live as long as 10 months. This means there are several overlapping generations each year.

Detection and Inspection

Look for red oval beetles, about 8 mm long, on the leaves and flying between them. They are often in groups on both young and old leaves. Look for the circles eaten by the beetles, and the large holes in the leaves between the veins. Often, the groups of beetles will attack the

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same leaf, leaving only the veins, before moving to other leaves. Adults are strong fliers, and quickly take to the wing when disturbed.

A similar coloured leaf beetle, *Monolepta*, has a dark area on the triangular piece at the base of the wing cases. It also has a smooth thorax - the part behind the head. By contrast, *Aulacophora* has a groove across the thorax (this can be seen in photo, right). (**See Fact Sheet no. 53 for *Monolepta*.**)

Management

There is little known about the natural control of these beetles. The beetles contain chemicals that visual predators do not like, and are avoided by them. The bright colours of this beetle warn predators that they are distasteful.

RESISTANT VARIETIES

- Fast growing varieties are more likely to outgrow the damage caused by the beetles.

CULTURAL CONTROL

- Avoid planting new crops next to those already infested with the beetles;
- Provide conditions for healthy plant growth, especially for seedlings; that may include manures and/or commercial fertilizers, and adequate water;
- The beetles tend to group together feeding on some plants, leaving others; plant extra seed to compensate for this;
- In the early morning or evening, it is possible to catch the beetles in flight; this is a useful control method in small gardens. Perhaps a game for children!

CHEMICAL CONTROL

- Use synthetic pyrethroid insecticides, such as lambda cyhalothrin or permethrin. The choice of chemical is important: use those that are least persistent in the environment, and have low toxicity against bees;
- Try wood ash: Add ½ cup of wood ash and ½ cup of lime in 4 litres water; leave to stand for some hours; strain; test on few infested plants first to make adjustment of the strength before going into large-scale spraying.

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Taro Plant Hopper

Extension Fact Sheet **41**

Common name: Taro planthopper
Scientific name: *Tarophagus* spp. There are three species present in the Pacific: *T. colocasiae*; *T. persephone*; and *T. proserpina*. All are present in Papua New Guinea, but whether they are all present in Solomon Islands is not known.

Hosts: On taro, but it has been recorded occasionally on *Alocasia* (edu) and *Cyrtosperma* (kakake).

Damage

Damage is done in two ways:

- **Direct damage:** The planthoppers have needle-like mouthparts, which are used to suck sap from taro leaves. When numbers are high and, especially in dry weather, the leaves wilt and new leaves are stunted. Typically, the leaf stalks bend down so that plants are wider than normal, and corms are smaller.
- **Indirect damage:** Planthoppers spread the viruses associated with Alomae and Bobone*: Colocasia bobone disease rhabdovirus* and *Taro vein chlorosis rhabdovirus*.

Biology and Life Cycle

Eggs are laid in the midrib of the leaves and in the petioles, often at the base. A slot is cut and 10-20 eggs are placed inside. The eggs hatch after about 15 days. At first, the young or nymphs are white; later, as they moult - four times over about 20 days - they become brown and then black with white markings. For most of the time, the adults develop without wings (photo, above right). Winged forms appear when the crop matures and/or when the population is high (photo, lower right). They are about 4 mm long; the wingless ones are shorter.

Heavy rains reduce populations of planthoppers. The youngest nymphs are particularly susceptible to drowning in the water that collects between the petiole bases.

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Detection and Inspection

Planthoppers group together where humidity is greatest: on the underside of leaves; inside leaves that are beginning to unfurl; and especially between the petioles at the base of the plant. The planthoppers have a characteristic way of moving sideways across the leaf or petiole. Also, nymphs and adults jump if disturbed.

Look for dirty marks on the petioles, especially on the lower parts; the plant sap oozes out as the planthoppers feed and lay eggs, and it hardens to form a red-brown crust.

Management

NATURAL ENEMIES

An egg predator, *Cyrtorhinus fulvus*, reduces the numbers of the planthopper, except in dry times when populations of both insects can be high. Often, ants tend the planthoppers, presumably attracted to the honeydew produced as they suck the sap from the leaves. Three species of parasites have been reported parasitising eggs and nymphs; and spiders and ladybeetle larvae also feed on them.

CULTURAL CONTROL

- Avoid planting new crops next to those already infested with planthoppers, otherwise the winged forms will easily find the new crop;
- Prepare 'tops' for replanting by cutting off all leaves with dirty marks on them to avoid taking planting material with eggs to new gardens. Use of 'clean' planting material in this way is an important method of control.

CHEMICAL CONTROL

- Chemical control is rarely needed, except during extended dry periods, when populations can build up to damaging levels;
- If egg-eating bugs are not present, or are not effective, use: a) synthetic pyrethroids, such as lambda cyhalothrin (Karatee) or cypermethrin (Mustang); or b) imidacloprid (Confidor);
- A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

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Maize Rust

Extension Fact Sheet **42**

Common name: Maize rust
Scientific names: *Puccinia polysora* is recorded from Solomon Islands, but there is another rust, *P. sorghi*, that has **not** been recorded. *P. sorghi* is found in Australia and elsewhere. Often the two rusts occur together, requiring microscopic examination to tell them apart.

Hosts: The rust infects maize and sweet corn. It is recorded on some grasses and relatives of maize in other countries; it has only been recorded from maize in Solomon Islands.

Damage

The disease is usually of minor importance. Most spots occur on the older leaves; these dry and die earlier than those that remain uninfected, but the rust comes late in the growth of the plant, after the seeds have been filled. Maize varieties have been selected for resistance to this rust.

Biology and Life Cycle

The spots, produced in large numbers on both sides of the leaf (photo, left), and also on the stem (photo, right), are round to oval, up to 2 mm; they are brown, releasing large numbers of powdery spores. They burst open, and the spores are spread by wind over long distances. The spores germinate in water on the surface of the plants and infect through natural openings (stomata). Warm, humid weather, such as occurs in Solomon Islands, favours the development of the disease.

The disease is called 'rust' because of the powdery spores. If you wipe a finger over the leaf, it appears similar to touching rusty iron – a fine dark brown stain remains.

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Detection and Inspection

The rust usually appears late, after the appearance of the male flower or tassel. If the leaf is held against the light, the spots can be clearly seen. There is a dark centre surrounded by a yellow margin.

Management

CULTURAL CONTROL

Cultural control is important. The following should be done:

- Destroy volunteer plants as the rust can only survive on living plants;
- Plant maize during the drier times of the year;
- The rust can be seed borne, but the spores survive for only 2 months, so infection from seeds is not usually a risk.

RESISTANT VARIETIES

There are resistant hybrids of maize and sweet corn.

CHEMICAL CONTROL

The use of fungicides against this disease is not recommended as the effect on yield is probably minor and their use would not be economic. If needed, copper and mancozeb would be effective.

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Bean Virus

Extension Fact Sheet 43

Common name: *Bean common mosaic virus*. In a survey for viruses of Solomon Islands in 1987 by Alan Brunt, this virus is referred to as *Blackeye cowpea mosaic virus*.
Scientific names: *Bean common mosaic potyvirus*. Particles are shaped like flexuous rods.

Hosts: The virus has been recorded in the following legumes in Solomon Islands: *Calopogonium mucunoides*, *Centrosema pubescens*, *Clitorea ternatea*, *Desmodium heterophylum*, *Macroptilium atropurpureum*, *M lathyroides*, *Phaseolus vulgaris* (French beans), *Pueraria phaseoloides*, *Stylosanthes guianensis*, *Vigna marina*, *Vigna unguiculata* ssp. *sesquipedalis*. The last is called snake bean in Solomon Islands. It is also called long bean or yard long bean. Cowpea and soybean are also hosts.

In a 2007 survey, the virus was recorded in wild passion fruit, *Passiflora foetida*.

Damage

The virus is important on long bean, especially when infection comes from planting diseased seed. In this case, symptoms appear early: plants are dwarfed, pods are shorter and fewer than normal and, consequently, yields are low.

Biology and Life Cycle

Seed infection can be high, over 30%. Spread from these plants is by aphids, and it can occur very quickly. The virus can remain alive in bean seeds for many years. The virus is also spread in pollen. However, seed transmission is the most important method of spread.

If the first leaves to develop show light and dark green patches, and the leaves are misshapen (photo, right), then it is likely that the seed was infected by *Bean common mosaic virus*.

Detection and inspection

Look for patches of light and dark green on the leaves (this symptom is called a mosaic, i.e., photo, left), and for leaves that are misshapen. The leaves may be puckered, i.e., there are bumps on the surface of the leaves (photo, right).

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Management

CULTURAL CONTROL

Cultural control is important. The following should be done:

- Interplant beans with other plants, e.g., maize;
- Plant mixture of long bean varieties – a strategy used in parts of Africa. Contact MAL and/or Kastom Gaden Association for sources of seed;
- Do not plant new crops next to those that have the disease;
- The virus is seed borne, so:
    - Carefully select plants for seed that do not show symptoms of the disease;
    - If most plants show symptoms, search for a new source of seed (or contact MAL or KGA), and discard the seed that is severely infected.

RESISTANT VARIETIES

Currently, trials are being done in Solomon Islands with varieties of long beans from AVRDC (now known as The World Vegetable Centre). Contact MAL and/or KGA for a source of seed to test.

CHEMICAL CONTROL

The use of insecticides for the control of aphids that spread the virus is not recommended. The time between an aphid sucking up the virus when it feeds on a diseased plant, and spreading the virus as it feeds again on a healthy plant, is short. By the time the insecticide has killed the aphid it has spread the virus.

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Kongkong Taro Root Rot

Extension Fact Sheet 44

Common name: Kongkong taro root rot
Scientific names: *Pythium* species. *Pythium* species are soil borne pathogens that attack the roots and underground parts of many plants.
Hosts: *Colocasia* taro, edu (*Giant taro*, *Alocasia)* and kongkong taro (*Xanthosoma***)** are susceptible. Other plants infected in the field are beans, capsicum and ginger; many other plants are infected as seedlings in the nursery. *Pythium* causes a damping-off disease (**see Fact Sheet No. 47**). Note, *Pythium* is not a fungus, it belongs to the groups known as Water moulds or oomycetes, related to algae.

Damage

Root rot is the most important disease of kongkong taro worldwide. It is particularly important in West Africa and in Central America. It has been recorded in several Pacific countries. It is rare in Solomon Islands, possibly because gardens contain only a few plants at any one time.

Biology and Life Cycle

The first sign of the disease in mature plants is the drying up of the outer older leaves (photo, left). As the disease progresses, the number of leaves declines, young leaves are shorter and smaller than usual, and eventually the plant can be pulled easily from the soil. Roots are absent on these plants or only present at the very top of the corm (photo, right). In young plants, growth is slow, and plants remain with one or two leaves for months, as the roots are destroyed as soon as they are produced. Corm rots may be present, but this is a late symptom.

Pythium has a wide host range and can infect many crops and weeds. When conditions are not favourable or when susceptible hosts are not present, *Pythium* produces resistant spores - oospores - that remain alive but inactive in the soil for many years. They germinate when conditions are right and produce swimming spores in large number that infect the roots of susceptible plants. The disease is especially severe on plants grown in soils that waterlog.

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Detection and Inspection

Carefully dig up the plants, do not pull them from the ground. Look to see if roots are decayed, especially the small feeder roots; these are the roots that take water and minerals from the soil and supply the leaves. Without these roots, the leaves wilt and die.

Management

CULTURAL CONTROL

Cultural control is important. The following should be done:

- Choose sites carefully. DO NOT plant where the land is likely to flood, or where water will remain for several days after heavy rains;
- Preferably, avoid heavy clay soils; where this is not possible, make drains around the plots or plant the taro on raised beds or mounds to provide drainage;
- If planting material is taken from plants that have shown root rot symptoms, carefully remove all the roots, old leaves and soil, before planting in a new garden;
- Do not plant kongkong taro in land below where root rot occurred previously. If you do, spores of the Water mould will spread in soil or surface water during rains.

RESISTANT VARIETIES

There is no information about resistant varieties of kongkong taro. *Colocasia* taro varieties with resistance are known from Samoa, but these varieties (one of them is Tusi tusi) are susceptible to Taro leaf blight.

CHEMICAL CONTROL

Fungicides are not recommended for the control of this disease; they are unlikely to be economic. When the symptoms appear, damage to the roots has already been done. It is best to carry out the cultural control recommendations stated above.

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Black Leaf Mould

Extension Fact Sheet 45

Common names: Leaf spot, Black leaf mould, Tomato leaf mould
Scientific name: *Pseudocercospora fuligena.* Previously known as *Cercospora fuligena.*

Host: Tomato. It is also said to infect bell pepper and chilli, but it has not been found on those plants in Solomon Islands.

Damage

The fungus causes plants to lose their leaves. If infection occurs before the fruit has developed, yields are low. This is the most important disease on tomato in Solomon Islands.

Biology and Life Cycle

The disease starts on the older leaves and spreads upwards. The first signs are irregular yellow patches, mostly at the edge of the leaves (photo, left). The patches turn brown rapidly, and the leaves dry, curl, hang down and later fall off. On the underside of the dry, brown leaves spores form in the patches, which appear like a brown or dark brown mould. There are no symptoms on the fruit.

The spores are spread by wind blown rain, and if windy wet weather continues for a few days, spread is fast and plants defoliate quickly.

The source of the fungus is from other infected crops, the remains of the previous crop and, perhaps, other host species. The fungus is not seed borne.

Detection and inspection

Look for the disease on the bottom leaves. Look for the brown patches, especially at the leaf margins, and the mould-like spore masses on the older dead leaves.

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Management

CULTURAL CONTROL

Cultural control is important. The following should be done:

- Remove and burn the lower leaves as soon as the disease is seen, especially after the lower fruit trusses have been picked;
- Collect and burn as much of the crop as possible when harvest is complete;
- DO NOT plant new crops next to older ones that have the disease.

RESISTANT VARIETIES

Currently, trials are being done in Solomon Islands with varieties of tomatoes from AVRDC (now known as The World Vegetable Centre). Contact MAL for a source of seed. Some varieties show resistance to the disease (photo, right)

CHEMICAL CONTROL

The warm wet conditions in Solomon Islands favours the disease such that fungicides are needed to give adequate control. The products to use are chlorothalonil (Bravo), copper oxychloride or mancozeb. Treatment should start when the first flowers appear, and continue at 10-14 days intervals until 3-4 weeks before last harvest. It is important to spray both sides of the leaves.

Azole fungicides (e.g., difenoconazole) are also recommended for control of this disease. But these are rarely, if ever, sold in Solomon Islands.

Note, there is another disease that has similar symptoms. It is called Tomato leaf mould, and is caused by the fungus, *Passalora fulva*. This fungus and *Pseudocercospora fuligena* can only be distinguished by looking at their spores under a microscope. (**See Fact Sheet no. 76 for *Passalora*.**)

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Boil Smut

Extension Fact Sheet **46**

Common names: Boil smut, Common smut[1]
Scientific name: *Ustilago zeae*; previously known as *U. maydis.*

Host: Maize, sweet corn.

Damage

The disease has been present in Solomon Islands for nearly 30 years, but the number of plants infected in any crop remains low. Presumably, this is because conditions do not favour the disease, the crop is not grown in the same land one year after another, or the varieties grown have some resistance to infection. Where infection does occur, however, the maize fruit - the ear - becomes distorted and the individual seeds swell becoming galls filled with enlarged plant cells, fungal threads and a mass of spores (photo). Thus, there is reduction in yield. Other parts of the plant - leaves and stems - are also susceptible to infection, but less so.

Early infection results in stunted plants and even death, although this is uncommon. Overall, boil smut is a minor disease of maize and sweet corn in Solomon Islands.

Note, in Mexico, maize smut, known as *huitlacoche*, is eaten. The galls are harvested while still young, and when cooked have a mushroom-like flavour.

[1]Much of the information in this Fact Sheet is taken from *Boil smut of corn*. NSW, DPI *primefacts*. Primefact 247. September 2006.

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Biology and Life Cycle

The fungus infects all the aboveground parts, especially young growing tissues. Systemic infection, i.e., the fungus infects and grows through the plant, occurs in seedlings, but not in older plants. Infection is increased by injury to the plants, such as occurs during cultivation.

Boil smut is a soil borne disease. The spores remain alive in the soil for many years. They germinate and produce a second type of spore; these are the spores that infect the plants. They are carried on the wind or splashed by water to young maize plants. The spores germinate, infect, and cause the plants' cells to grow and multiply and form the galls.

Galls form on leaves, stalks, ear and tassels. They grow to 15 cm on the ears, but those on the leaves remain smaller, 6-12 mm, become hard and dry, and produce few spores. The galls on the ears are at first enclosed in a white to light grey covering, before splitting to release dark brown to black spores. One gall may produce 200 billion spores!

Smut spores contaminate maize seeds, and this is the way that the fungus is introduced into new areas. The spores can also be spread on machinery, people, livestock and fodder.

Detection and inspection

Look for smut galls on leaves, stalks, ears or tassels. Galls are firm initially, white or grey, later bursting to release the black powdery spores. Severely infected plants may be stunted.

Management

CULTURAL CONTROL

Cultural control is important. The following should be done:

- Remove infected plants before the galls rupture, and burn the plants;
- DO NOT replant maize in land where the disease was present previously;
- Avoid over-fertilizing with nitrogen, as this increases susceptibility;
- Be careful not to injure the plants during cultural operations.

RESISTANT VARIETIES

There appears to be good field resistance to boil smut in the varieties grown in Solomon Islands, as the percentage infection is low. Sweet corn varieties are more susceptible, but the disease is not common in them either.

CHEMICAL CONTROL

In Australia, seed is treated with the fungicide, carboxin (Vitavax) and thiram.

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Seedling Damping-Off

Extension Fact Sheet 47

Common name: Damping off
Scientific names: Commonly, *Pythium* and *Rhizoctonia* are involved, but *Fusarium* and *Phytophthora* may also cause similar diseases. Note, *Pythium* and *Phytophthora* are NOT fungi but Water moulds, related to algae.

Host: Many kinds of fruit and vegetable seedlings show the disease in the nursery, with tomatoes, cabbages, and lettuces especially susceptible. The photo, left, shows damping off in taro[1].

Damage

Seedlings are attacked by damping-off fungi and Water moulds (*Pythium* is not a fungus) either before they emerge (called pre-emergence damping off) or after (called post-emergence damping off). Pre-damping off results in gaps in the rows of seedlings, whereas the post-damping off results in seedlings that fall over due to root rots and stem infections, often at soil level (photo, right). Those that survive the attack may be stunted, or grow slowly.

Seedlings that have strong stems, such as cabbages, do not always fall over; the plants have thin, twisted, discoloured stems (known as *wire stem*). If the infection girdles the stem, the seedlings die eventually.

Biology and Life Cycle

The fungi and Water moulds involved in damping off are widely distributed in soil. They live on organic matter, but also on the roots of living plants as parasites. Most prefer wet soil conditions, and some have spores that swim in soil water, e.g., *Pythium* and *Phytophthora*. *Rhizoctonia* and *Fuarium*, by contrast, do not like waterlogged soils.

[1]The photo was taken by Tolo Iosefa, University of the South Pacific, Samoa.

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Plants that are growing poorly, because the soil is waterlogged or the temperature is unsuitable, are more likely to be infected by damping-off fungi and Water moulds, in contrast to those seedlings growing rapidly.

Spread of these fungi and Water moulds occurs in water splash, on contaminated tools, in potting mixes and in infected plants.

Detection and inspection

Look for gaps in the row, and if present look to see if the seed is decayed. Look for seedlings that have fallen over due to soft rots on the stem or decayed roots. Look for lesions and cankers (open lesions) on seedlings with strong stems. Threads of the fungi involved may be present over the soil and seedlings (photo, left).

Management

CULTURAL CONTROL

Cultural control is important. The following should be done:

- Sterilise the soil mix:
    - Heat the soil in an earth oven over hot stones covered in leaves or sacks for at least one hour, or
    - Place the soil mix in boxes or place it on the ground between bamboo sections, and pour boiling water over the soil;
- Keep the treated soil in clean bags until it is used, to prevent reinfection from water splash or contaminated tools;
- If outbreaks of damping off occur in seed beds, move the beds to a different site;
- Water soil and plants with rain water, not with water from ponds, streams, etc.;
- DO NOT overwater seedlings; ensure the seed boxes have good drainage;
- Raise nursery seed boxes above ground level (at least 1 metre) to avoid rain splash from the soil;
- Always use a nutritious soil mix: rotten coconut mixed with soil is best. If using home made compost make sure it is well rotted before mixing it with the grated coconut. (See leaflet, *Growing lettuces, Chinese and English (ball) cabbage the organic way* by Joini Tutua).

RESISTANT VARIETIES

It is unlikely that in any one kind of vegetable there will be differences in the susceptibility of varieties to damping off.

CHEMICAL CONTROL

If cultural control methods fail, treat seed with a fungicide, such as thiram. Fungicides can also be used to treat seedbeds and/or seed boxes. See MAL for advice.

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Citrus Scab

Extension Fact Sheet **48**

Common name: Common citrus scab
Scientific names: *Elsinoë fawcettii*. The fungus has an asexual stage, *Sphaceloma fawcettii*; this is the stage that occurs in Solomon Islands and elsewhere in the Pacific. There are other strains of *S. fawcettii* present in other countries.

Host: A disease of lemon, rough lemon and mandarin. Other species of citrus – grapefruit, orange and pomelo - are also susceptible, but less so.

Damage.

The fungus distorts the leaves, and causes unsightly infections on the fruit. Infections may reduce market value of the fruits, but it is unlikely to affect yield. The disease is more serious on seedlings in the nursery, especially on susceptible roots stocks: sour oranges, rough lemons, Rangpur lime, *Poncirus trifoliata* and *Citrus limonia*. It may stunt the seedlings, making them difficult to bud.

Overall, scab is a minor disease in mature plantations, causing little economic damage. It is more serious as a disease of nurseries.

Biology and Life Cycle

Wart-like, raised light-brown pustules or scabs are produced on leaves, stems and fruit. The scabs are grey or pinkish at first, becoming darker as they age. The scabs join together, and their centres become depressed. Old scab lesions have a rough surface, and become cracked and fissured. Leaves become stunted, wrinkled or puckered, with irregular torn margins.

Spores are produced in the scabs and spread in wind and rain splash. Insects may also spread them. Spread over long distances is on infected nursery plants, and on fruits. The spores need a wetting period of 4 hours for germination and infection to occur
The leaves, twigs and fruit are infected when they are young, becoming resistant to infection when full size. Fruit is susceptible to infection until 3 cm diameter.

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Detection and inspection

Look for the raised scabs on leaves, twigs and fruit. On young leaves they are surrounded by a bright yellow margin. Look for twisted, out-of-shape leaves.

Management

CULTURAL CONTROL

The following should be done:

- Establish nurseries for production of rootstocks and budwood at distance from commercial orchards where the disease may be present;
- Prune trees regularly to keep the canopy open and free of deadwood; this is to remove sources of spores and to improve air movement.

CHEMICAL CONTROL

Fungicides should be applied to plants in nurseries at the beginning of the leaf flush to prevent infection leading to stunted, bushy plants that are difficult to bud. Copper (copper oxychloride) or chlorothanonil (Bravo) are suitable choices.

Treating mature lemon trees is not recommended. They produce multiple crops, meaning that fruit forms throughout the year and several spray treatments would be required, especially in the high rainfall of Solomon Islands. Such treatments are unlikely to be economic.

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Broad Mite

Extension Fact Sheet **49**

Common names: Broad mite, Chilli mite. Note, mites are not insects; they are related to spiders, and have eight legs
Scientific name: *Polyphagotarsonemus latus.*

Hosts: Chilli, pepper. This is a common mite worldwide, infesting many crops. It is possible that additional crops, e.g., bean, eggplant, papaya, and tomato are attacked in Solomon Islands, but have yet to be recorded.

Damage

The mite causes a common problem on chilies and bell pepper in Solomon Islands. The symptoms - distorted, crinkled, young leaves and stunting - look as if they have a virus infection or, perhaps, suffering the effects of herbicide damage (photo, above). Later, there may be flower drop, distorted fruits, loss of yield and death of the plants.

Biology and Life Cycle

The mites infest the youngest leaves of the bud; they are too small (less than 0.25 mm) to be seen with the eye, and a microscope or powerful hand lens is needed.

The eggs are laid singly on the underside of the leaves or fruit. There are larval (which has 6 legs) and pupal stages before the adults (which have 8 legs) are formed. Whereas the larvae feed close to where the eggs were laid, the adults migrate to the young leaves to feed. The males are yellowish brown whereas the females are yellowish green. The life cycle takes a week or less.

The outer cells of the leaf are damaged by the mouthparts of the mites so that they can suck up the sap. The result is that the leaves, apart from becoming distorted, are bronzed, stiff, and rolled under at the margins. Dieback is also a common result from the mites infesting chilies and bell peppers.

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Broad mites spread by walking short distances; they are spread over long distance by wind as well as on the bodies of insects.

Detection and Inspection

Look for the distorted, stiff, discoloured leaves, on stunted plants showing dieback and early death.

Management

In many parts of the world, predatory mites control broad mites, but the situation in Solomon Island is unknown.

CULTURAL CONTROL

- Avoid planting new crops next to those already infested with mites, otherwise the mites will spread to the new crop at an early age, and plants may become severely damaged;
- Avoid planting new crops downwind from those infested with mites, as the mites will spread to the new crop on the wind;
- When infestations are severe, pull out the plants, burn them, and plant a new crop.

CHEMICAL CONTROL

Miticides are available for the control of broad mite, but mostly these chemicals are not available in Solomon Islands. The best is abamectin, a compound derived from the soil bacterium, *Streptomyces* spp. Other chemicals that are affective are difocol, sulfur and dimethoate (Rogor).

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Giant African Snail

Extension Fact Sheet 50

Common name: Giant African snail
Scientific name: *Lissachatina fulica*, previously known as *Achatina fulica.*

Hosts: Usually, the snail eats rotten vegetation and animal wastes; however, a wide range of vegetables, ornamentals and tree crops are also eaten.



Damage

The snail attacks more than 500 types of plants, but it prefers breadfruit, cassava, cocoa, papaya, peanut, rubber and most species of legumes and cucurbits. Cuttings and seedlings are especially vulnerable. Damage is greatest when outbreaks first occur in a new area. Population explosions result in hundreds of snails per square metre.

The rat lungworm parasitises the snail, and if the snails are not cooked thoroughly before being eaten by human beings, the lungworm can cause meningitis.

The economic impact of the snail is unclear. When first introduced, populations soar, but population explosions are often followed by population crashes. It then becomes a minor pest of agriculture and human health. But it does have an impact on the environment: a) dead snails are places where flies breed; and b) it causes loss of biodiversity: native plants are eaten, and it competes with local snails.

Biology and Life Cycle

The snails vary considerably in size and colour. Some grow to 15 cm in length and 5-8 cm wide, whereas others grow only to 6.5 cm in length. Commonly, the shells are light brown with darker brown and cream bands.

The snail feeds at night or during the day when the weather is overcast and rainy; it avoids the sun by sheltering under stones, logs or in crevices. If dry weather lasts, the snail seals the opening of the shell awaiting a return to favourable conditions.

Each snail has male and female sex organs (hermaphrodite), but reproduction requires cross-fertilization. Eggs are first laid when females are about 6 months' old. The eggs are cream, about 5 mm diameter, laid below the soil surface or on the sides of logs, in batches of 200 to

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300. The eggs hatch within 1 to 2 weeks. Up to a 1000 eggs are laid each year and snails live for up to 5 years.

The snails can travel up to 50 m in a night, moving on the slime made by the soft part known as the 'foot'. Long distance travel is by human beings: the eggs and young snails may be in soil of pot plants or sawdust; the adult snails may be taken and raised for food, kept as pets, or transported as hitchhikers on boats or land vehicles.

Detection and Inspection

Conduct surveys at night looking for signs of rasping on leaves or defoliated plants, ribbon-like excreta and slime trails. Look for snails much larger than any indigenous ones of Solomon Islands; look for the typical colour banding on the shell.

Management

NATURAL ENEMIES

Predatory snails, such as *Euglandina rosea and Gonaxis quadrilateralis*, and flatworms, e.g., *Platydemus manokwari*, have been introduced to control the snail, but the effects have been a disaster for local snail populations. Environmental impact studies are essential before the introduction of these predators because of their non-specific nature.

Ducks will attack the snail; they are the only type of livestock that will do so. Although population explosions can be immensely destructive immediately after spread to a new area, invariably snail population will decline. The problem is how to deal with the snail until that happens, which may be months or years.

CULTURAL CONTROL

Cultural control is important. The following should be done:

- Make a strip of bare earth about 1.5 m wide around cultivated areas. Bands of sand are also effective;
- Collect the snail regularly, preferably by mobilising the community – schools in particular, then bury the snails or feed them to pigs after boiling for an hour;
- Conduct awareness campaigns: a) snails should not be kept as pets; b) they are a threat to human health; and c) community action is needed to control them.

CHEMICAL CONTROL

The usefulness of metaldehyde or methiocarb (pellets containing 1.5-1.8 % of poison) over large areas is not encouraged, although they are probably effective in the cultivation of small areas of vegetables. Take care to prevent livestock, pets and children from eating them: put the pellets in tins or bamboos in the evening and collect them in the morning. Chemical control needs to be combined with cultural methods to be effective. Poisoned snails should never be fed to pigs or other livestock.

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Sooty Mould Fungi

Extension Fact Sheet **51**

Common name: Sooty mould
Scientific names: A number of sooty mould fungi have been identified in Solomon Islands:
*Aithaloderma citri (*grapefruit*)*
Capnodium mangiferum (mango)
Capnodium sp. (pawpaw)
Chaetasbolisia microglobulosa (chilli)
Chaetothyrium setosum (coconut, kongkong taro)
Limacinula samoenesis (coconut)
Microxiphium spp. (chilli, coconut, oil palm)
Trichomerium spp. (coconut, oil palm)
Tripospermum fructigenum, (*Pometia pinnata*)
Tripospermum gardneri (oil palm, cocoa)
Tripospermum sp. (chilli)
Triosporiopsis sp. (pawpaw)

Hosts: Many plants develop sooty moulds when colonised by insects that produce honeydew (photos below are: left, soursop; right, coconut). The sooty mould fungi recorded in Solomon Islands and the host plants are given above. Most were recorded from living leaves.

Damage

The fungi grow on the sugary substances that are produced by insects – mostly, aphids, scale insects (photo, right: remains of the infestation on upturned leaf – lower right corner), and whiteflies - as they suck the sap of leaves. The secretions are known as honeydew.

The insects that produce honeydew are the real problem. They cause direct damage by sucking plant sap, and often cause poor growth, and indirect damage by encouraging sooty moulds. The fungi do little direct harm to the plant, apart from blocking sunlight and causing the leaves to yellow. They do not infect the leaves, and rarely stunt the plants.

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Biology and Life Cycle

Insect populations increase rapidly when ants protect them from their natural predators and parasites. Large populations of insects mean large amounts of honeydew, and heavy coverage of leaves, and other parts, by sooty mould fungi.

Detection and Inspection

Look for sooty mould on new growth and leaves, since the insects involved in sooty mould growths prefer soft tissue.

Management

All the methods used for treating sooty mould are aimed at controlling the insects that secrete the honeydew. Without honeydew, there can be no sooty mould. However, the insects may be protected from their natural predators and parasites by ants, so removing the ants should be the first step, if they are present.

CULTURAL CONTROL

- If ants are present, kill them with boiling water, without damaging the crop plants. Without the ants, predators and parasites will bring about natural control;
- For trees, prune low branches and remove weeds to stop ants reaching the leaves.

CHEMICAL CONTROL

- Use soap sprays (5 tablespoons of soap in 4 litres water), or white oil to kill the sap-suckering insects. These sprays work by blocking the breathing holes of insects causing suffocation and death. Spray the undersides of leaves: the oils must contact the insects.
- Use white oil (petroleum jelly), which can be obtained as a commercial product or made by mixing together: 1 cup cooking oil; 2 cups water; 1 teaspoon dishwashing liquid. Dilute the mixture at 3 teaspoons per half a litre of water and spray on the infested leaves. The addition of malathion is useful against scales insects;
- To kill ants use synthetic pyrethroids (for example, lambda cyhalothrin or cypermethrin); these insecticides may also be tried against scale insects as they are likely to be effective against the crawlers – crawlers are the young active nymphs which spread infestations to new plants or new gardens.

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White Peach Scale

Extension Fact Sheet 52

Common name: White peach scale
Scientific name: *Pseudaulacaspis pentagona.*

Hosts: Chilli, pepper, *sliperi kabis*, cassava in Solomon Islands. It has also been found causing heavy infestations on paper mulberry (*Broussonetia* sp.) on Guadalcanal. Worldwide, there are many other hosts.

Damage

The scale is most often seen in large numbers on the bottom of stems; there are often so many that farmers think a white fungus affects the plants (photo, right).

The scale feeds on plant sap, and infestations cause leaves to yellow with a loss of healthy growth. Fruit size may be reduced and premature drop is likely. Heavy infestations can result in stunting (cassava), and the death of branches and dieback (chilli and bell pepper). Severe infestations on cassava have been reported from the weather coast of Guadalcanal.

Biology and Life Cycle

The life cycle, which lasts about 45 days, is complex. Females are covered by a roughly circular scale (photo, left), about 2-2.5 mm across; beneath the scale is the insect itself, 0.8-0.9 mm long, pink to yellow, and without legs. Egg laying begins 2 weeks after mating, and about 100 eggs are laid over 8-9 days. The first eggs laid become female, those later, male. Crawlers emerge after 3-4 days.

The crawlers have three pairs of legs and prominent antennae. The females are more active and wander further than the males. After about 12 hours they settle down to feed, and go through two moults before they become adult. The males stay around the mother, moulting five times, but as adults last only 1 day. They are orange with wings, eyes, legs, long antennae, but no mouthparts; they do not feed. Their task is to find females and mate, attracted by chemicals (pheromones) produced by them.

Spread is by crawlers on the wind, and infested cuttings.

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Detection and Inspection

Look for the heavy infestations that occur as thick crusts on stems or tree trunks. The leaves and fruits are not usually infested. The large white colonies of females and males that make up a heavy infestation are easy to recognize.

Management

NATURAL ENEMIES

Species of ladybird beetles and lacewings are known to feed on white peach scale in other parts of the world and probably these insects do the same in Solomon Islands. *Encarsia diaspidicola*, a wasp, has been successfully released in Samoa and more recently in Hawaii with good results.

CULTURAL CONTROL

- Cut out stems of plants infested by white peach scale and burn them;
- Do not plant cuttings from plants infested with white peach scale;
- Avoid planting new crops downwind from those infested with white peach scale, as the crawlers will spread to the new crop on the wind.

CHEMICAL CONTROL

Insecticides should be avoided, unless control by natural enemies is ineffective. Note, too, insecticides are not always effective against females; they live under a protective scale.

- Use soap sprays (5 tablespoons of soap in 4 litres water), or white oil to kill the sap-suckering insects. These sprays work by blocking the breathing holes of insects causing suffocation and death. Spray the undersides of leaves: the oils must contact the insects.
- Use white oil (petroleum jelly), which can be obtained as a commercial product or made by mixing together: 1 cup cooking oil; 2 cups water; 1 teaspoon dishwashing liquid. Dilute the mixture at 3 teaspoons per half a litre of water and spray on the infested leaves. The addition of malathion is useful against scales insects;
- To kill ants use synthetic pyrethroids (for example, lambda cyhalothrin or cypermethrin); these insecticides may also be tried against scale insects as they are likely to be effective against the crawlers – crawlers are the young active nymphs which spread infestations to new plants or new gardens.

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Red Sweet Potato Beetle

Extension Fact Sheet **53**

Common names: Red sweet potato beetle, Sweet potato red leaf beetle
Scientific name: *Monolepta semiviolacea.*

Hosts: Sweet potato and *kangkong* (*Ipomoea aquatica*), and related *Ipomoea* species (plants in the morning glory family). The beetle occurs commonly on other crops, but does not appear to feed on them.

Damage

Adult beetles (photo, right) feed on leaves, chewing holes, especially in the middle of the leaf (photo, left). The damage to young plants can delay establishment, early growth and crop maturity. Damage also occurs to flowers.

The larvae probably damage roots and stems, but evidence of this has not been looked for in Solomon Islands. Such damage allows entry of other organisms, fungi and nematodes especially.

Biology and Life Cycle

The biology and life cycle has not been studied for *M. semiviolacea*. The following information is from a similar pest species in Australia.

Eggs are laid under the soil surface. The white cylindrical grubs or larvae feed on roots and pupate in the soil. The life cycle takes about 2 months. There may be three to four generations a year. If larval populations in the soil are high, the emerging beetles will form a swarm that migrates into nearby crops.

Detection and Inspection

Look for red oval beetles, about 6 mm long, on the leaves and flying between them. They have a small black triangular spot at the base of the wing cases, and are black underneath. They are often seen in groups on young and old leaves. Look for numerous small holes in the leaves between the veins. Adults are strong fliers, and quickly take to the wing when disturbed.

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A similarly coloured leaf beetle, *Aulacophora*, is entirely red. It also has a groove across the base of the thorax - the part behind the head. By contrast, *Monolepta* has a smooth thorax. Also, *Aulcophora* is larger than *Monolepta*. (**See Fact Sheet no. 40 for *Aulcophora.***)

Management

There is little known about the natural control of the Red sweet potato beetle. There are no known predators or parasites effective against high populations. The beetles contain chemicals that visual predators (birds and lizards) do not like, and they avoid them. The bright colours of this beetle warn predators that they are distasteful.

RESISTANT VARIETIES

- None known, but fast-growing varieties are more likely to outgrow the damage caused by the beetles. Look for differences in damage between varieties.

CULTURAL CONTROL

- Avoid planting new crops next to those already infested with the beetles;
- Harvest the affected crop, collect and destroy the vines, and then plant a new crop;
- Provide conditions for healthy rapid plant growth, especially for cuttings; these may include manures, mulches, commercial fertilizers, as well as adequate water;
- In the early morning or evening, it is possible to catch the beetles in flight; this is a useful control method in small gardens. Perhaps a game for children!

CHEMICAL CONTROL

- Ashes may be effective against Red sweet potato beetle. Apply them to the crop as soon as the pest is seen; do not wait until the population is high. [See Fact Sheet no. 56d on PDPs, Plant Derived Pesticides, for details of how to make and apply the ash.] Alternatively, add ½ cup of wood ash and ½ cup of lime in 4 litres water; leave to stand for some hours; strain; test on few infested plants first to make adjustment of the strength before going into large-scale spraying.
- Use synthetic pyrethroid insecticides, such as lambda cyhalothrin or permethrin. The choice of chemical is important: use those that are least persistent in the environment, and have low toxicity against bees;
- As infestations are often patchy, consider spot spraying or perimeter spraying where numbers are highest, leaving most of the crop unsprayed;
- Derris (rotenone) may be effective against the beetle. A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

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Sweetpotato Tortoise Beetle

Extension Fact Sheet **54**

Common names: Sweet potato tortoise beetle; sometimes known as Golden tortoise beetle
Scientific name: *Cassida papuana.*

H**osts:** Feeds on sweet potato, *kangkong* (*Ipomoea aquatica*), and related *Ipomoea* species (plants in the morning glory family). Possibly, the beetles feed on crops and weeds in other families.

Damage

Adults feed on leaves, making small to medium-size holes (photo, left). The larvae at first eat the leaf surface; latter they eat their way through the leaf. The effect on storage root yield is not known in Solomon Islands, but it is unlikely to be large.

Biology and Life Cycle

The oval eggs (1-2 mm long) are laid individually on the leaves in a small papery parcel. The larvae have spines, and an anal fork. The anal fork is made up of long spines near the tip of the abdomen, and these hold the old skins - which are not shed completely - mixed with excreta (faeces or droppings). The 'tail' of old skins is carried over the back of the body, and can be moved about by the anal fork, probably to deter predators. The larvae pass through five moults, before a pupal stage develops. The pupae are attached by the tail end to the underside of the leaf.

The adults are about 5 mm diameter, oval and slightly flattened and squared at the shoulders (photo, right). The head and appendages of the adult are mostly hidden by transparent parts of the thorax and the wing covers.

Detection and Inspection

Look for the golden round beetles, and the clear, wing margins that cover most of the head and thorax, and extend beyond the body, covering legs and other appendages.

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Management

NATURAL ENEMIES

Tortoise beetles are attacked by (chalcid) wasps in other countries, parasitic flies, and lady beetle larvae. It is likely that these parasites and predators attack Tortoise beetles in Solomon Islands, but this is not known for certain. However, it is not common for Tortoise beetles to become a serious pest.

CULTURAL CONTROL

- Avoid planting new crops next to those already infested with the beetles;
- Harvest the infested crop, collect the vines and destroy them, and then plant a new crop;
- Provide conditions for healthy, rapid plant growth, especially for vine cuttings after planting; these may include manures, mulches and/or commercial fertilizers, and adequate water;
- Remove weeds (especially those in the Convolvulaceae family) around the gardens to reduce the beetle numbers.

RESISTANT VARIETIES

- None known, but fast-growing varieties are more likely to outgrow the damage caused by the beetles.

CHEMICAL CONTROL

Ashes may be effective in the control of the Tortoise beetle. Apply them to the crop as soon as the pest is seen; do not wait until the population is high. (**See Fact Sheet no. 56 on PDPs, Plant Derived Pesticides, for details of how to make and apply the ash.**)

- Ashes may be effective against the Sweet potato tortoise beetle. Apply them to the crop as soon as the pest is seen; do not wait until the population is high. (**See Fact Sheet no. 56d on PDPs, Plant Derived Pesticides, for details of how to make and apply the ash.**) Alternatively, add ½ cup of wood ash and ½ cup of lime in 4 litres water; leave to stand for some hours; strain; test on few infested plants first to make adjustment of the strength before going into large-scale spraying.
- Use synthetic pyrethroid insecticides, such as lambda cyhalothrin or permethrin. The choice of chemical is important: use those that are least persistent in the environment, and have low toxicity against bees.
- Derris (rotenone) may be effective against the beetle. A variety of *Derris*, brought many years ago from Papua New Guinea, may be effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

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Sweetpotato Little Leaf

Extension Fact Sheet 55

Common names: Sweet potato little leaf, Sweet potato witches' broom
Scientific name: *Candidatus* Phytoplasma *aurantifolia*.

Hosts: Sweet potato and probably wild *Ipomoea* species, but the disease has not been seen on wild hosts in Solomon Islands.

Damage

Severe outbreaks of the disease have occurred in Solomon Islands (and Papua New Guinea) in areas with low rainfall, and where there is a distinct dry season - Guadalcanal Plains and Santa Ana. Yield losses of 30-90% have been reported.

The disease also causes stunting of the root system, and affected plants produce few, if any, storage roots.

Biology and Life Cycle

One of the first symptoms of the disease is a yellowing of the small veins, so that they are clearly seen as a network throughout the leaf (photo, right). This is followed by the development of side shoots, which are normally dormant, giving the vines a bushy appearance (photo, left). New leaves on these shoots become progressively smaller, until they are about an eighth the size of healthy leaves. Also, the leaves change to a light green and the shoots are generally more erect than normal.

Phytoplasmas (before they were called mycoplasma-like organisms, or MLOs) are bacteria-like, single celled organisms. They are obligate parasites, confined to the phloem of their hosts and transmitted by phloem-feeding insects. In this case, the phytoplasmas are spread by leafhoppers, *Orosius lotophagorum ryukyuensis*. Phytoplasmas reproduce asexually by budding.

The leafhoppers acquire the phytoplasmas after feeding on infected plants for several hours or days. After a period of approximately 20 days they are then able to transmit the phytoplasmas

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to healthy plants as they feed. Once a leafhopper becomes infected with phytoplasmas it can transmit it for the rest of its life.

A number of wild species of *Ipomoea* are hosts of the phytoplasma. However, it is not known how important they are in outbreaks and spread of the disease.

Detection and Inspection

Look for the yellowing of the veins, which is the first symptom, then the production of many shoots with small leaves, giving the plant a typical bushy appearance.

Management

CULTURAL CONTROL

Cultural control measures are important to reduce the disease:

- Remove plants with signs of the disease as soon as they appear, and burn them;
- Little leaf is spread mostly in infected planting material. If possible, take planting material from gardens where the disease has not been seen;
- If that is not possible, carefully select planting material from plants that are free of the disease. Look for symptoms after planting;
- If that is not possible, collect disease-free cuttings from neighbours, if their gardens are healthy.

RESISTANT VARIETIES

- No resistance was found among more than 200 varieties screened in Solomon Islands, although one variety, WV5, had greater resistance than others. See MAL for a source of planting material of this variety. It was reimported from SPC, Fiji.

CHEMICAL CONTROL

Chemical control should only be considered under exceptional circumstances. In dry times, the population of the leafhopper may become very high, and the disease may reach epidemic levels. This has occurred in Santa Ana. Treat crops with an insecticide, but also remove infected plants to take out the source of the disease. Use the following:

- Synthetic pyrethroid insecticides, such as lambda cyhalothrin or permethrin. The choice of chemical is important: use those that are least persistent in the environment, and have low toxicity to bees.
- Derris (rotenone) may be effective against the leafhopper that spreads Sweet potato little leaf. A local variety of Derris that has a high concentration of rotenone is being multiplied by MAL and the Kastom Gaden Association. The variety came originally from Papua New Guinea. [See these organisations for cuttings, and the method of using it.]

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Natural pesticides against insects

Extension Fact Sheet **56a**

General instructions

- Select fresh, healthy plant parts to use as pesticides; reject plants with moulds on them;
- Dry plant parts properly for future use. Keep in an airy container (no plastic containers) in a shady place;
- Do not use household cooking tools for preparing plant extracts, or containers used for drinking water. Clean all tools well after using them;
- Avoid contact with crude extracts during preparation; wear protective clothing when applying.
- Keep plant extracts away from children and house pets
- Harvest all mature and ripe fruits on trees before spraying
- Always test the plant extract on a few infested plants before large-scale spraying
- Wash your hands after handling the plant extract and wash your clothes, too

See other fact sheets (56b,c,d) for how to prepare plant extracts.

PLANT PESTICIDE AGAINST: **non-sucking insects (chew, bite)**

Control	Ants	Beetles	Caterpillars	Grasshoppers
ASH				
CHILLI				
DERRIS				
FU'U	Possibly a rat poison, but may also be useful as an insecticide			
GARLIC				
GLIRICIDIA				
HORTICULTURAL OIL				
HOT WATER				
MARIGOLD	Insect repellent, and when used as a cover crop reduces root knot nematodes			
NEEM				
PAPAYA				
SOAP				
SOURSOP				
TOBACCO				

PLANT PESTICIDE AGAINST: **sucking insects**

CONTROL	Aphids	Mealybugs	Planthoppers	Scales	Spider mites	Thrips	Whiteflies
ASH							
CHILLI							
DERRIS							
FU'U	Possibly a rat poison, but may also be useful as an insecticide						
GARLIC							
GLIRICIDIA							
HORTICULTURAL OIL							
HOT WATER							
MARIGOLD	Insect repellent, and when used as a cover crop reduces root knot nematodes						
NEEM							
PAPAYA							
SOAP							
SOURSOP							
TOBACCO							

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Preparing natural pesticides 1

Extension Fact Sheet **56b**

See Fact Sheet 56a for more information on target pests.

General instructions

- Select fresh, healthy plant parts to use as pesticides; reject plants with moulds on them
- Dry plant parts properly for future use. Keep in an airy container (no plastic containers) in a shady place.
- Do not use household cooking tools for preparing plant extracts, or containers used for drinking water. Clean all tools well after using them
- Avoid contact with crude extracts during preparation; wear protective clothing when applying
- Keep plant extracts away from children and house pets
- Harvest all mature and ripe fruits on trees before spraying
- Always test the plant extract on a few infested plants before large-scale spraying
- Wash your hands after handling the plant extract and wash your clothes, too

See other fact sheets (56a,c,d) for more information on natural pesticides.

Chilli

Neem

Soursop

Tobacco

CHILLI: active against *ants, aphids, caterpillars, mealybugs*

- Take one cup dry or 2 cups fresh chillies
- Smash to a fine paste
- Put into bucket with 1 litre water and rub with hands (cover hands with plastic bag)
- Soak of at least 1 hour; squeeze and strain
- Make up to 1 litre with water
- Add 1 teaspoon of soap

NEEM: active against *caterpillars, grasshoppers, and many more; also fungi and nematodes*

For leaves:

- Put 1 kg of leaves plus 5 litres water in a bucket and leave overnight
- Remove the leaves, retain the water and pound the leaves
- Squeeze the leaves and add the 5 litres of water used for soaking them overnight
- Add about 20 ml of diluted soapy water and use

For mature seeds:

- Wash and remove the husk and dry
- Take 12 handfuls of dry seeds (or use 500 grams per 10 litres water)
- Grind them into a fine powder
- Mix the powder in 12 litres water and soak overnight
- Strain, and add 4 teaspoons soap

SOURSOP OR CUSTARD APPLE: active against *aphids, caterpillars (diamond back moth), planthoppers, grasshoppers*

- Take 500 g of fresh leaves; boil leaves in 2 litres water until water is reduced to 0.5 litre
- Dilute to 10 litres with water
- Strain, and add 10 teaspoon soap

Also:

- Take two handfuls of seeds and grind into a fine powder
- Mix with 4 litres of water and soak overnight; strain, and add 4 teaspoons soap

TOBACCO: active against *caterpillars, aphids, and more*

- Smash 5 large leaves
- Add 1 litre water and leave overnight
- Make up to 2 litres with water
- Strain, and add 4 teaspoons of soap

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READ THE INSTRUCTIONS BEFORE USING ANY PESTICIDE

Preparing natural pesticides 2

Extension Fact Sheet **56c**

See Fact Sheet 56a for more information on target pests.

General instructions

- Select fresh, healthy plant parts to use as pesticides; reject plants with moulds on them;
- Dry plant parts properly for future use. Keep in an airy container (no plastic containers) in a shady place;
- Do not use household cooking tools for preparing plant extracts, or containers used for drinking water. Clean all tools well after using them;
- Avoid contact with crude extracts during preparation; wear protective clothing when applying;
- Keep plant extracts away from children and house pets;
- Harvest all mature and ripe fruits on trees before spraying;
- Always test the plant extract on a few infested plants before large-scale spraying;
- Wash your hands after handling the plant extract and wash your clothes, too.

See other FS 56c for more information on natural pesticides.

Garlic

Derris

Gliricidia

Marigold

GARLIC: active against *caterpillars, mites, thrips, and possibly some fungal diseases*

- Scrape 4 garlic cloves and soak in small amount of vegetable oil
- Leave overnight
- Make up to 2 litres with water, strain, and add 4 teaspoons soap
- Also, scrape 4 cloves in hot water; add several ground chillies, and 2 tablespoons pure soap. Use spray when water is cool

DERRIS: active against *caterpillars, grasshoppers, aphids, spider mites, plant hoppers; beetles*

- Take 2 roots of Derris (20 cm long and as thick as a small finger) and smash well
- Put roots in a bucket overnight and cover with water
- Make up to 2 litres with water
- Strain, and add 4 teaspoons soap

GLIRICIDIA: active against *aphids, caterpillars, whitefly*

- Grind or pound 0.5 kg leaves
- Soak overnight in water
- Make up to 20 liters with water
- Strain, and add 10 teaspoons soap

Note: *Gliricidia* is also a rat poison. Mix the amounts above with boiled rice. But may need to make up fresh ever day. Place the 'food' in a bamboo to protect it from children, pets and domestic animals. Bacterial action converts chemicals in the leaves to brodifacoum-like substances.

MARIGOLD: active against insects and is a repellent

- Collect 2.5 kg leaves/flowers; pound and mix with enough water to cover material
- Filter and make up to 18 litres water; Add soap

PAPAYA: active against *thrips*

- Shake 1 kg leaves in 1 litre water and squeeze through cloth
- Add 4 litre soap solution (100 g soap/25 litres water

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READ THE INSTRUCTIONS BEFORE USING ANY PESTICIDE

Preparing natural pesticides 3

Extension Fact Sheet **56d**

See Fact Sheet 56a for more information on target pests.

General instructions

- Do not use household cooking tools for preparing plant extracts, or containers used for drinking water. Clean all tools well after using them;
- Avoid contact with crude extracts during preparation; wear protective clothing when applying;
- Keep plant extracts away from children and house pets;
- Harvest all mature and ripe fruits on trees before spraying;
- Always test the plant extract on a few infested plants before large-scale spraying;
- Wash your hands after handling the plant extract and wash your clothes, too.

See other fact sheets (56a,b,c) for more information on natural pesticides.

Soap

Hot Water

Ash

Horticultural Oil

SOAP: active against *scale insects, mealybugs and aphids*

- Use soap (pure soap, not detergent)
- 5 tablespoons of soap in 4 litres water; **OR**
- 2 tablespoons of dish washing liquid in 4 litres water

HOT WATER: active against *ants, nematodes in yams and sterilise nursery soil*

- ANTS Use to destroy nests, but be careful not to pour hot water onto the roots of small plants that might be growing close to the nests. You will kill the plants!
- SOIL Use hot water to sterilise soil: pour over the soil that you have placed in seed boxes or soil spread thinly on the ground containing the nursery soil
- YAM Use hot water to kill nematodes in yams with dry rot before cutting and planting. Dip whole yams in hot water at 51^{0}C for 10 mins (use a thermometer and clock – do NOT guess)

ASH: active against *grasshoppers and beetles*

- Take ash from fire (make sure it is cool!)
- Beat to make fine
- Put in coarse cloth or into a strainer
- Shake thinly over each leaf

HORTICULTURAL OIL: active against *powdery mildew fungi and also many sucking insects, especially scales, aphids*

- 3 tablespoons (1/3 cup) cooking oil in 4 litres water
- ½ teaspoon detergent soap
- Shake well and use

MILK: active against *powdery mildew fungi*

- Use milk, diluted to 10% (1 part milk, 9 parts water);
- Add soap if milk does not spread over leaf surface.

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READ THE INSTRUCTIONS BEFORE USING ANY PESTICIDE

Melanesian Coconut Beetle

Extension Fact Sheet **57**

Common names: Melanesian rhinoceros beetle, Coconut rhinoceros beetle, Scapanes
Scientific name: *Scapanes australis.* Different sub-species (*S. australis australis* and *S. australis grossepunctatus*) exist in Papua New Guinea, but the situation in Solomon Islands has not been studied.

H**osts:** The main hosts are coconut, oil palm and betel nut, but the beetle is also found on banana, sugarcane and wild palms.

Damage

The adults bore into crowns of coconut, oil palm and other palm species, as well as pseudostems of bananas. Damage to coconuts is considerable, especially up to 5 years' old. The emerging fronds show V-shaped cuts, twisting, spiraling and truncated leaflets. If the growing point is damaged, the palms die. The damage allows entry of other organisms: termites and, especially, *Rhynchophorus*, the Black palm weevil.

Damage can be severe when coconuts are planted in land cleared from forest, where the rotting logs provide breeding sites. All the palms may be damaged within 5 years, discouraging farmers from planting or replanting the crop. However, as the logs rot away so the attack decreases.

Biology and Life Cycle

The egg is creamy-white, about 5 mm long and 3 mm diameter, and is laid singly in soil near rotting logs or other decaying matter that is food for the larvae. In Papua New Guinea, breeding sites occur in cocoa and coconut plantations associated with rotting stumps of shade trees (*Gliricidia sepium*). Breeding sites have also been found in old nests of magapodes, when these were near breadfruit trees.

Eggs hatch after about 30 days producing C-shaped larvae (photo, left), with heads of reddish brown to brown. As the larvae grow, they moult twice, reaching 10 cm in length and 2 cm thick, before pupating at 9 months or more. Adults are black, 4-6 cm long, and are strong fliers. Males are horned (photo, right), while females have small double horns on their heads. Adults live for about 4 months. Males and females have been seen in the same tunnel in the crown of a coconut, but it is the male alone that is seen most commonly.

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Detection and Inspection

Look for the larvae beneath rotting logs. However, they need to be bred to adults, as they are similar to other beetles in the scarab family. Keep them in a sterilised cowdung and sawdust mixture. Look for the horns on the adult males beetles, they are characteristic, whereas females may be more difficult to recognize.

Oryctes is not present in Solomon Islands, so confusion with that insect is unlikely; also, *Oryctes* attacks much older palms.

In the field, inspect the crown of the palms, looking for V-shaped cuts in the leaves, distorted fronds and fibre pushed from the tunnels into the crown. Follow the tunnel to find the beetle.

Management

Control of *Scapanes* is difficult as the number of adult beetles is relatively low per hectare, albeit they can cause substantial damage.

NATURAL ENEMIES

A pheromone has been isolated and used in mass trapping trials in Papua New Guinea. It is said to be easy to make and is cheap. It attracts both males and females. It is still to be put to use in smallholder and estate plantations.

RESISTANT VARIETIES

- None known in Solomon Islands, but fast-growing varieties are more likely to outgrow the damage caused by the beetles. In Papua New Guinea, fewer coconuts of Gazelle Tall died from attack compared to Rennell Tall or Malayan Dwarf.

CULTURAL CONTROL

- Remove or burn breeding sites, logs in particular (a difficult practice for small holders when clearing sites from forest);
- Plant *Pueraria phaseolodes* or other legume species as soon as the trees have been felled to cover the logs and stumps in order to interrupt egg laying.

CHEMICAL CONTROL

Chemical control of this pest is very difficult and not recommended under small-scale production systems. If it is required:

- Put granules of insecticide in the axils of the fronds. Lindane and BHC have been used in the past, but the production and use of these chemicals is banned by international agreement. Furadan granules have been used as an alternative.

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Plant-eating Ladybeetles

Extension Fact Sheet **58**

Common name: Eggplant ladybird beetle; 26-spotted ladybird
Scientific name: *Epilachna* (*Henosepilachna*) *vigintisexpunctata.* Note, the number of spots is variable and cannot be used to identify the ladybird beetles.

H**osts:** This fact sheet concerns *E. vigintisexpunctata* (photos, above) on eggplant. It is likely that it feeds on other members of Solanaceae, including tomato and weeds. Another species, *E. signatipennis*, has been identified recently from long beans, and most likely can be found on other legumes. Other species of *Epilachna* occur in Solomon Islands on these and other crops, including cucurbits and maize. All have similar life cycles.

Damage

The ladybirds eat the surface of the leaves (photo, right); the larvae graze the under surface, leaving the upper surface intact; adults feed on both sides of the leaf, sometimes making holes as they chew. Seedlings may be killed by the attack, and growth and yield of more mature plants reduced.

Biology and Life Cycle

The adults are like typical ladybirds with wing cases of dull orange and black spots; however, close inspection shows that the upper surface is covered in short downy hairs. This distinguishes these plant-feeding ladybirds from their beneficial bug-feeding relatives. The oval yellow eggs (1 mm by 0.4 mm) are laid upright in batches of 10-20 on the underside of a leaf. They hatch in about 4 days. The pale yellow larvae have long, dark-tipped branched spines on their backs; they grow to 6 mm through three moults in the next 18 days, before attaching themselves to the undersides of the leaves and developing into pupae. This stage lasts another 4 days.

The adults fall to the ground when disturbed, pretending to be dead. They also produce a yellow fluid that wards off predators.

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Detection and Inspection

Look for the distinctive grazing on one side of the leaf, often leaving the surface of the other side intact. Look for the larvae, mostly on the underside, and the adults on the top of leaves, but always check that the beetles are leaf eating, i.e., they are feeding on the leaf, and are not beneficial species feeding, for instance, on aphids (green flies).

Management

NATURAL ENEMIES

There have been no studies of the natural enemies of *Epilachna* species in Solomon Islands. Elsewhere, species of a parasitic wasp (*Pediobius*) have been introduced, achieving successful control of *Epilachna*. There are different species of the beetles, so identification needs to be done carefully. Also, care should be taken to ensure that any *Pediobius* introduced are specific to the pest species, and not likely to attack beneficial members of the family.

RESISTANT VARIETIES

- None known in Solomon Islands, although comparative resistance of some varieties of eggplant is known in India.

CULTURAL CONTROL

- Handpick the larvae, and perhaps the adults. If attempted, it should be done when the beetles are first seen in the crop;
- Remove weeds in the Solanaceae family from around the crop. However, it has been suggested these might act as trap crops, so some experimentation is needed.

CHEMICAL CONTROL

- Use contact insecticides, such as malathion, or synthetic pyrethroids, such as lambda cyhalothrin or permethrin. The choice of chemical is important: use those that are least persistent in the environment, and have low toxicity against bees.
- A variety of *Derris*, brought many years ago from Papua New Guinea, is effective as a spray. It contains rotenone, an insecticide. Plants are being multiplied by MAL and KGA for evaluation by growers. Contact those organisations for plants to test.

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Coconut Hispine Beetle

Extension Fact Sheet 59

Common names: Coconut hispine beetle, Coconut leaf hispa
Scientific name: *Brontispa longissima.*

H**osts:** Coconuts are the most important crop attacked, but the beetle also infests betel nut, sago palm, oil palm, and a number of ornamental and wild palms.



Damage

Palms of all ages are attacked, but the damage done to seedlings in nurseries and young palms after planting out is often severe. The adults (photo, left) and larvae graze the leaflets of the unopened spear leaf, forming narrow red-brown streaks parallel to the midrib. As the leaf unfolds, these streaks enlarge, forming irregular greyish blotches (photo, right); when severe, this gives the palm a scorched appearance (photo, centre).

Severe attacks may kill the palm, and those that survive are more susceptible to drought and disease. Yield of bearing palms is reduced considerably.

Biology and Life Cycle

The entire life cycle of the beetles takes place in the unopened spear leaf. Eggs are laid in grooves chewed into the leaflets and covered by excreta. The eggs hatch after 4-5 days, and the larvae pass through several moults during the next 4 weeks before they pupate. Six-days' later the adults emerge. They are 8-10 mm long and 2 mm wide (photo, above left), and live for about 7 months. The females lay 100 eggs or more.

Detection and Inspection

Look for the narrow brown streaks on the leaflets, and red and black beetles between them. Look for fronds with ragged leaflets, with those still green bearing large dry dead blotches parallel to the length of the leaflets.

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Management

NATURAL ENEMIES

Brontispa is mostly under control by its natural enemies. *Tetrastichuss brontispae* was introduced successfully into the Russell Islands in the 1960s, making the spraying of young palms unnecessary. The wasp lays its eggs in the late larval and pupal stages. Another parasitoid, *Asecodes hispinarum*, attacks the 4th stage larvae, and following its introduction into Asia in 2003, has been responsible for controlling serious outbreaks of *Brontispa*.

Earwigs (*Chelisoches morio*) are reported to feed on the larvae of *Brontispa* in other countries, and the fungus, *Metarhizium anisopliae*, also causes high mortality. Whether the organisms are present and provide control in Solomon Islands is not known.

RESISTANT VARIETIES

- In Solomon Islands, there is evidence that the Local Tall and Rennell varieties are more resistant than Federated Malay States and Malayan Dwarf. The hybrid between Rennell Tall and Malayan Dwarf is susceptible.

CHEMICAL CONTROL

Occasionally, insecticides are needed in the nursery and on young palms after planting out, especially where susceptible varieties of coconuts are planted in areas that have dry seasons, e.g., the Guadalcanal Plains.

- Use contact insecticides, such as malathion, or synthetic pyrethroids, such as lambda cyhalothrin or permethrin. The choice of chemical is important: use those that are least persistent in the environment, and have low toxicity against bees.
- Derris (rotenone) may be effective against the beetle. A local variety of Derris, originally from Papua New Guinea, with a high concentration of rotenone, is being multiplied by MAL and the Kastom Gaden Association. [See these organisations for cuttings.]

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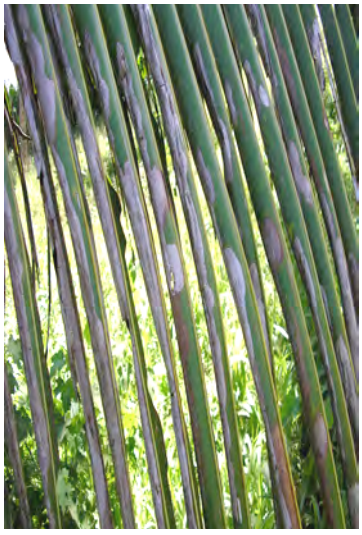
Coconut Leafminer

Extension Fact Sheet 60

Common names: Coconut leafminer, Coconut leaf hispid
Scientific name: *Promecotheca* spp. Several species are recorded from Solomon Islands. (The photos are from an outbreak in Vanuatu[1]).

H**osts:** Coconuts are the most important crop attacked, but the beetle also infests betel nut, sago palm, and a number of ornamental and wild palms. It is not a pest of oil palm.



Damage

The adults feed on the lower surface of the furthest third to a half of the leaflets, leaving narrow furrows (photo, centre); the larvae mine the leaflets, leaving large areas of damage (photo, left). The youngest three to fours leaves are first attacked. In general, the beetles are more damaging to mature palms, 25 m or more in height, although seedlings may become infested. Occasionally, the green tissue on all leaflets is destroyed and, consequently, young nuts fall, yield is severely reduced, flower production ceases, and palms may die. Entire coconut plantations turn brown (photo, right). Severe outbreaks set back nut production for at least 2 years. Such events are rare, however.

Outbreaks appear to be cyclical, every 10-15 years or so, and may be brought about by droughts. If this is the case, more frequent outbreaks of *Promecotheca* can be expected in future, as El Nino events intensify due to climate change.

Biology and Life Cycle

Eggs, about 1.5 mm long, are laid on the underside of the leaflets of younger fronds, either singly or 2-3 together – depending on the species – and covered with digested leaf fragments cemented together. The larvae hatch after 2-3 weeks (depending on the temperature), and penetrate the leaflets and form a mine parallel to the midrib. More than one larva can be

[1]Information on the insect is taken from FW Howard *et al.* (2001) *Insects on palms*. CABI Publishing, UK. The photos were kindly provided by Jean-Pierre Labouisse, CIRAD, Montpellier, France.

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present in each mine. The larvae moult 2-3 times, and during this time the mine enlarges from 1 to 5 mm wide. The mines are 80 to 400 mm long, depending on the species and the number of larvae in the mine. The larval stage is up to 40 days; it also varies depending on the species. The pupal stage occurs in the mine, and lasts about 12 days.

After emergence, males and females fly to younger leaflets on the same palm or to a young leaf of a palm nearby, grouping together on the underside of the fronds. The beetles are not strong fliers; but they prefer the tallest trees, especially ones in sunlight. The adult is about 1 cm long. Colours vary, but they are often colourful. One species from the Santa Cruz group has a black head with wings of orange nearest the front and brilliant bluish purple to metallic green behind. About 2 weeks after emergence, they mate. The adults live for about 4 weeks.

Detection and Inspection

On mature coconuts, look for signs of adult feeding on the lower parts of young fronds; the adults eat the lower epidermis making long grooves into the leaf, parallel to the veins. Hold the leaflets to the light to see these grooves as fine white lines. The leaflets become brown, then grey, and almost white, and the tips shrivel and curl under. Look for the beetles during the day, 7-9 mm long, and brightly coloured. Look for signs of the larvae in the upper part of the leaflet. The older larvae should be visible at the end of the mines, which are straight, parallel, and similar in shape, when the leaflet is held to the light.

Management

NATURAL ENEMIES

Promecotheca is under natural control in Solomon Islands, as it is elsewhere, and only rarely do outbreaks occur. Several parasitoids, mostly minute wasps, that parasitise eggs and larvae, and parasitic fungi, have been reported from other countries. The ant, *Oecophylla smaragdina* was found to be of the greatest importance in controlling one species in Papua New Guinea, which also occurs in Solomon Islands. And the ants, *Pheidole* and *Technomyrmex*, are also known to attack egg masses.

CULTURAL CONTROL

- Hand pick *Promecotheca* eggs and adults on seedlings in nurseries, and young palms in the field;
- Prune and burn infested fronds. Burning of infested leaflets while still on the palm is reported. Whether these are good practices is unclear, as they will also destroy any parasitoids present.

CHEMICAL CONTROL

- The use of insecticides to control this insect is not recommended. Not only is it difficult to spray mature coconuts, and probably uneconomic to do so, but it will harm the parasitoids and delay the re-establishment of natural control. If sprays are needed in the nursery, use malathion or synthetic pyrethroids, such as lambda cyhalothrin or permethrin.

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Cocoa Weevil Borer

Extension Fact Sheet 61

Common name: Cocoa weevil borer
Scientific name: *Pantorhytes* species. *P. biplagiatus* is a serious pest of cocoa in Solomon Islands[1].

H**osts:** Cocoa and several commercial forest trees, e.g., *Eucalyptus* and *Terminalia*.



Damage

The larvae do the damage. They bore into the sapwood of trunks and branches, making tunnels 1-3 cm deep (photo, centre). Often the tunnels are made at or near the jorquette, the junction of branches and trunk. Damage at the jorquette has the potential to do considerable harm. The overall effect of the damage is to weaken the trees, causing tip dieback, death of branches due to ring barking, and even death of the tree if splits occur at the jorquette. Consequently, pod yields may be reduced considerably.

The wounds made by larvae may allow entry of the bark canker Water mould, *Phytophthora palmivora* (**see Fact Sheet no. 6**), and also termites.

Biology and Life Cycle

The white, oval eggs, about 2 mm long, are laid singly in crevices in the trunk and main branches, particularly near the jorquette. They hatch after 2-3 weeks. The larvae bore into the wood, feeding for 3-9 months through nine instars, and then pupate beneath the bark for about 2 weeks.

The adults are black and red (photo, left), wingless weevils about 1.5 cm long. They feed for 4-6 weeks before mating; afterwards, the female lays about two eggs a day throughout a life of 1-2 years. Adults feed on the bark of young cocoa shoots, flowers and, occasionally, pods, but the damage is not sufficient to affect pod production.

[1]The photos of the adult and larvae are from The World's Worst Cocoa Problems: http://www.dropdata.org/cocoa/cocoa_prob.htm. The photo of the crazy ant is taken from the Japanese Ant Image Database: http://ant.edb.miyakyo-u.ac.jp/E/P/PCD1050/43.html.

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Detection and Inspection

Look for holes in the trunk and branches, particularly at the jorquette; look for the jelly-like substance that exudes from the holes where the larvae feed. Look for the adult beetles, that have a red abdomen with white spots, and are relatively slow moving, sufficient to be handpicked.

Management

NATURAL ENEMIES

Biocontrol of *Pantorhytes* is possible using the crazy ant, *Anoplolepis gracilipes*, or *Oecophylla smaragdina*. The ants make colonies in soursop trees, so these should be planted between cocoa trees to encourage the ants to colonise them. The Little fire ant, *Wasmannia auropunctata*, too, may be antagonistic to *Pantorytes*.

The yellow-brown crazy ant has long legs and antennae (photo, right). Its total length is about 4 mm. It kills its prey by spraying formic acid. *Wasmannia* is smaller.

CULTURAL CONTROL

- Hand pick *Pantorhytes* adults (they do not have wings) during the middle of the day when they come down from the canopy to find cooler places;
- In severely infested plantations, find the larvae by looking for frass pushed out of the entrance of the larval tunnel and/or the jelly-like substance. Remove the frass with a stiff brush and apply a solution of Dichlorvos, white oil, Ridomil and water with a small 2 cm brush onto the bark around the entrance hole. (Ridomil is added to control *Phytophthora*). Repeat every 2 weeks;
- For smallholders, find the tunnels made by the larvae, and kill them with a piece of wire;
- If possible, plant cocoa beneath coconuts as *Pantorhytes* numbers are less than under forest trees, *Leucaena* or *Gliricidia*; possibly, the lower numbers are associated with higher ant populations under coconuts.

CHEMICAL CONTROL

The use of insecticides – other than as 'paints' to kill larvae - is not recommended. The difficulty of bringing the chemical into contact with the larvae inside their tunnels, and the low populations of beetles makes their use uneconomical.

Clean the entrance of tunnels and apply Dichlorvos, white oil, Ridomil and water. Applying insecticides in any other way has little or no effect.

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Coconut Spathe Bug

Extension Fact Sheet 62

Common name: Coconut spathe bug
Scientific name: *Axiagastus cambelli.* [Note that the photo, right, is provided for reference only; it was not taken in Solomon Islands, and may not be a pest of coconuts[1].]

H**osts:** Coconut and betel nut.

Damage

The damage done by the bug is uncertain. There is some loss of young nuts when populations are high, and outbreaks in Santa Cruz (Nendo Island) have occurred on coconuts that have produced dry, banana-shaped nuts. However, it has not been proven that *Axiagastus* is the cause of the condition: it is still only an association. Nutritional deficiencies have also been suggested as well as poor fertilisation of the flowers.

Both adults and nymphs have long piercing mouthparts and they can insert these into young coconuts to suck sap. It is this feeding that is presumed to cause the young nuts to fall, and those that remain become long and thin, without 'meat' and 'milk'. Whether or not the bug injects a poison as it feeds is not known, but it is thought unlikely.

Biology and Life Cycle

The barrel-shaped, white eggs are laid in clusters on the flowers, on the fibrous sheath at the base of the fronds and, more rarely, on the leaflets. Eggs hatch in 6-8 days, and the nymphs, which are white at first then orange with black markings, moult four times before they become adults. The time from egg to adult is about 45 days.

The adults are dark brown with yellow marks, about 15 mm long. They give out a strong unpleasant smell when held or disturbed.

[1]The photo of the bug was taken from the National Taiwan University Insect Museum Digital Archives Project.

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Detection and Inspection

The bugs occur in large numbers on the newly opened spadices, feeding on male and female flowers. The smell when disturbed is also a characteristic of the bugs.

Management

NATURAL ENEMIES

In Papua New Guinea, surveys have found egg, nymph and adult parasitoids (e.g., the wasps, *Trissolcus painei* and *Anastatus* sp., as well as the fly, *Pentatomophaga bicincta*), and it is likely that there are related species in Solomon Islands. *Oecophylla smaragdina* (Weaver ant, Green ant, Green tree ant) is said to reduce populations of this pest as it does for those of *Amblypelta* (**see Fact Sheet no. 19**). Thus, planting soursop and other fruit trees that host colonies of *Oecophylla* within coconut plantations, and then helping the ant to establish on these trees, by placing 'nests' in the canopy, may help to reduce *Axiagastus* numbers.

It is likely that the recently introduced fire ant, *Wasmannia auropunctata*, will also provide control, although this is only speculation.

CHEMICAL CONTROL

The use of insecticides is not recommended. The bug is usually under control naturally, and outbreaks only occur occasionally. Insecticides would only increase the time before the balance between the pest and its parasitoids was re-established. Additionally, there is the difficulty of spraying mature palms, making the application of insecticides difficult as well as uneconomical.

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Cucurbit Powdery Mildew

Extension Fact Sheet 63

Common name: Cucurbit powdery mildew
Scientific name: In Solomon Islands, and other Pacific Island countries, only the asexual state has been found; this is known as *Oidium*. The *Oidium* or asexual state of many different powdery mildews looks the same. However, from research elsewhere, it is known that Cucurbit powdery mildew belongs to one of two sexual states: *Sphaerotheca fuliginea* or *Erysiphe cichoracearum.*

Hosts: Cucurbits: cucumber, melon, pumpkin, squash and zucchini. Some legumes and ornamentals are also susceptible to infection.

Damage

The disease can be a major problem. Powdery mildews seldom kill their hosts, but use their nutrients, reduce photosynthesis, impair growth and reduce yields. The size and number of fruits is reduced, or plants die early. Early death of the leaves lowers market quality because fruit become sunburned, ripen prematurely, do not store well, or have poor flavour. In addition, plants with powdery mildew are more likely to become infected with other diseases, Gummy stem blight in particular (**see Fact Sheet No. 7**).

Biology and Life Cycle

The fungus is unusual in that it cannot survive in the absence of a living host. It is also unusual in that it grows over the leaf surface, and that is the reason why the leaf appears white (photo, right: cucumber & left: pumpkin). In order to feed, the fungus sends special cells into the leaf and these extract the food it needs for growth. Spores, called conidia, are produced in chains on single strands of its cottony growth that stand erect from the leaf surface. The spores are spread in the wind; they need high humidity to germinate, but not water. The time between infection and symptoms is short, 3-5 days (depending on temperatures). Spread is fast, especially if plants are close together, humidity is high, and there is no rain.

Detection and Inspection

Look for white, powdery fungal spots on upper leaf surfaces, petioles and stems. Look for the fungus on the shaded older leaves. Infection on the under surface is often not as clear because

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of the lighter colour of the leaf; although on the pumpkin (photo, left) it is exceptionally clear. The fungal spots expand and multiply rapidly, so look for leaves that gradually turn yellow, then brown, dry out and die.

Management

CULTURAL CONTROL

Cultural control measures are important to reduce the disease:

- Plant in sunny places, and, if possible, choose areas with good air circulation;
- Do not plant successive crops of cucurbits in the same gardens;
- Do not plant new crops next to those that have the disease; otherwise spread of the disease to the new crop will be rapid and devastating;
- Remove weeds from within and around the crop: many weeds are hosts of powdery mildew, so make sure they are controlled.

RESISTANT VARIETIES

- There are varieties of cucumber and melon with resistance. Check company descriptions of varieties of pumpkin and squash, and choose those with resistance.

CHEMICAL CONTROL

If fungicides are used, inspect the crop regularly to detect when infections first occur. Start spraying immediately, and spray routinely, every 7-10 days depending on the severity of the disease. Do the following:

- If following an organic regime, use products containing horticultural oil, potassium bicarbonate or wettable sulphur. The last two are best applied before disease symptoms appear. Oils are eradicants, meaning they can cure plants that are already infected, but also have some protectant activity;
- Wettable sulphur has been used for many years for powdery mildew control. Apply in the early morning or evening, at the coolest times of the day. Never spray sulphur within 2 weeks of the last application of an oil spray. Also, sulphur can burn the leaves, so read the label carefully before applying;
- Where the number of plants is small, use milk: normal strength diluted 1 part in 10 parts of water;
- For large commercial plantings, apply wettable sulphur products, chlorothalonil (also useful for Gummy stem blight control) or check availability of other products (e.g., triazoles), and seek advice from MAL extension officers.

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Brown Plant Hopper

Extension Fact Sheet 64

Common name: Brown planthopper
Scientific name: *Nilaparvata lugens.*

H**osts:** Rice and wild grasses.



Damage

Both adults (photo, centre) and nymphs (photo, left) do the damage. They have piercing mouthparts that they insert into the leaf blades and leaf sheaths ('stems') of rice plants to suck the sap. Also, egg laying blocks the water and food channels inside the plant.

Symptoms depend on variety, number of planthoppers, and plant age: tiller and panicle number, and plant height, are reduced; grains are unfilled; injury from feeding and egg laying allows entry of fungi and bacteria, and sooty mould fungi blacken stems. Severe infestations cause plants in the 'milk' or 'dough' stages to gradually yellow from the tip, brown, dry out and collapse - a wilt, known as 'hopperburn'; photo, above right. The most susceptible time is from tillering to flowering. Hopperburn is more common in paddy than dryland rice.

Biology and Life Cycle

Eggs are laid in the midrib of the leaf blades, 4-10 in an egg mass; they are cylindrical, slightly curved, 1 mm long, white at first, darker when about to hatch, with two spots - the eyes of the nymph. The eggs hatch in 4-8 days. Nymphs are creamy white with a pale brown tinge, later becoming dark brown. There are four to five moults. The final nymphs are nearly 3 mm long, with a line from the top of the head to the middle part of the body where it is widest. Adults are brownish black with a yellowish-brown body. There are two forms, long winged and short winged.

Infestations start with the arrival of the winged form, which lay eggs and produce the wingless form. Winged form develops when numbers are high; females are about 4 mm and males 4.5 mm; wingless forms are smaller. After harvest, the planthoppers migrate to grasses, or spread to new crops of rice. Brown planthoppers live for up to 20 days.

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Detection and Inspection

Look at the base of the plants, where it is shady and humidity is high, for the nymphs and winged and wingless adults. Look for the sooty mould fungi that often accompany large numbers of the insects. More than 3-5 insects per tiller is considered high, needing more intensive observation and possibly insecticide treatment.

Management

Over use of insecticides is the main cause of outbreaks of Brown planthopper. IPM programs stress the need to main biological control – natural enemies – and also include resistant varieties. The routine use of insecticides should be avoided.

NATURAL ENEMIES

There are a number of natural predators of the Brown planthopper: spiders eat the nymphs and adults, as do coccinellid beetles, dragonflies and damselflies. There are two species of mired egg-sucking bugs in Solomon Islands - *Cyrtorhinus chinensis* and *C lividipennis* - and there are likely to be wasp parasitoids that attack eggs, as well as fungal pathogens and mites.

CULTURAL CONTROL

- Drain the paddies for 3-4 days during the early stage of infestation;
- Apply split applications (three times) of nitrogen fertilizer;
- Avoid staggered planting, preventing planthoppers moving from older to younger crops;
- Remove volunteer plants;
- Rotate rice with other crops.

RESISTANT VARIETIES

Egg laying and survival of nymphs differs between rice varieties. Many varieties have been bred for resistance to Brown planthopper; unfortunately, there are many cases when changes in the insect have overcome the resistance.

CHEMICAL CONTROL

Insecticides should only be used when plantshopper populations are likely to reach an economic injury level; otherwise natural enemies will be destroyed and planthopper populations will return greater than before. The systemic insecticide, Orthene (acephate), has been used for many years against the Brown planthopper in Solomon Islands. Check for current recommendations from MAL Research/Extension officers, as well as the timing and method of application.

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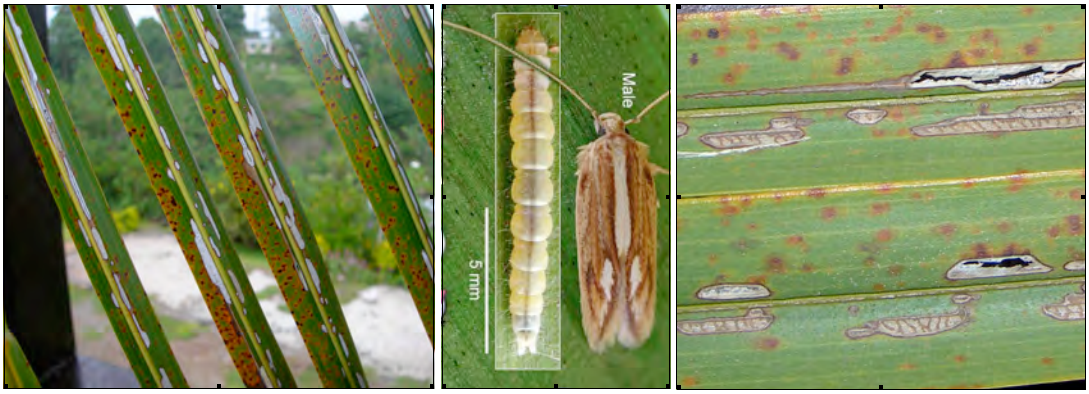
Coconut Flat Moth

Extension Fact Sheet 65

Common name: Coconut flat moth
Scientific name: *Agonoxena* sp. The main pest species of other Pacific Island countries is *A. argula* (photo, centre[1]); but this is not present in Solomon Islands. *A. pyrogramma* is present. It is native to Solomon Islands.

H**osts:** Coconuts and other palms.



Damage

The larvae of the flat moth (photo, centre) do the damage by eating mainly the lower surface of the leaflets. They make lines 1-2 mm wide and 2-3 cm long near the mid-rib; the damaged lines are light grey (photos, left & right). There is no evidence that coconut production is affected by the damage, although the leaves can look ragged. However, it is possible that the growth of seedlings may be slowed by the attack.

A. pyrogramma does not do nearly as much damage as *A. arguala*, and is heavily attacked by parasites. Both species are more abundant during periods of dry weather; this is because of the impact of the weather on the natural enemies of the moths. Symptoms of *A. pyrogramma* damage are common in and around Honiara, as they are elsewhere in Solomon Islands.

Biology and Life Cycle

A. pyrogramma is said to be similar in appearance to *A. arguala*. The adult is 5-9 mm long; the female is yellowish brown, and the males have white stripes on the forewings (photo, centre). Eggs are laid on the underside of the leaflets, near the tips and along midribs, singly or in rows. Larvae or caterpillars, are green and up to 2 cm when mature; they spin a fine web and shelter under this, feeding on the top layers of the leaflets, parallel to the veins. They become active when disturbed, moving backwards or forwards or dropping to the ground. When mature, they spin a white web and pupate, either on the leaflets or on the undergrowth.

[1]The photo (above left) is from the Cook Islands Diversity Database. The use of the photos is gratefully acknowledged.

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Detection and Inspection

Look for long, thin, grey patches of feeding on the leaflets; these are characteristic of the pest. Look for the larvae under a thin web covering the leaflets.

Management

NATURAL ENEMIES

A tachinid fly has been reared from *A pyrogramma* in Solomon Islands, and Waterhouse in the book *Biological Control Pacific Prospects* quotes others that "parasite introductions against *A pyrogramma* have been successful", without giving details. Many insects have been introduced in other countries of the region to control *A. arguala*; these are mostly wasps, belonging to the Braconidea and Chalcididae families that attack larvae or pupae. These have come from Fiji, India, Indonesia, Papua New Guinea and Samoa. Introductions have to be done carefully because of the common presence of hyperparasites; they are insects that attack the natural enemies of the flat moth.

Ants are reported to destroy *A. arguala* pupae and may eat eggs, and spiders sometimes attack adults. In Fiji, a fungus destroyed a high proportion of the pupae, and also killed the larvae and adults. Although the natural enemies are not known in Solomon Islands, they are likely to be similar to those of *A. arguala* elsewhere.

CULTURAL CONTROL

None recommended.

RESISTANT VARIETIES

None reported.

CHEMICAL CONTROL

- Insecticides are not recommended for the control of this insect, although they may be useful on seedlings. In the normal situation, natural enemies of the flat moth keep the pest under control. If serious outbreaks do occur, the use of pesticides might be tempting, but are more likely to delay a return to biological control. Additionally, insecticides are difficult to apply to mature palms as well as being ineffective.
- If insecticides were required on, say, seedlings in the nursery, use malathion or synthetic pyrethroids, such as lambda cyhalothrin or permethrin.

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Saissetia on Soursop

Extension Fact Sheet 66

Common names: Hemispherical scale, Brown coffee scale
Scientific name: *Saissetia* sp. There are three species of *Saissetia* recorded from Solomon Islands, so it is not possible to be sure about the one on *Annona* pictured below. However, the species most often recorded on *Annona* in the South Pacific is *S. coffeae*, and this species is recorded on that host in Solomon Islands. The description below is for *S. coffeae*.

Hosts: *S. coffeae* has a very wide host range, other than *Annona*, including coffee, citrus, guava and ornamental plants, especially cycads and ferns. In Hawaii, it is reported on orchids.

Damage

Damage is done in three ways:

- Injection of a toxin as the scale feeds causing spots on the foliage;
- Direct feeding causes leaves to be deformed, die early, or wilt, depending on the host. Infested fruits of soursop, for instance, are smaller than normal due to the scales' feeding;
- Sooty moulds develop which reduce photosynthesis, and plant vigour. Sooty moulds are fungi that grow on honeydew, the sugary substance discharged by sap-sucking insects, for instance aphids and some scale insects, as they feed (**see Fact Sheet no. 51**).

Biology and Life Cycle

Females do not mate, males have not been found. About 500 eggs are laid under the body of the female, so they are protected. After hatching, the first immature stage, the crawlers, walk about to find a place to feed. Crawlers can also spread on the wind, as well as planting

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materials, and even on animals, including human beings. There are two other immature stages before the adult stage. All stages are capable of movement, until the time when eggs are laid. The adults live for about 8 days. The scale is said to prefer hot, dry conditions, so climate change may favour it.

Detection and Inspection

Look for the shiny, brown, dome-shaped adult scales, round to oval, about 2 mm across, most noticeable on the midrib on the undersides of leaves, on the stems and fruits. They also occur on fruit stalks. Look for sooty moulds on leaves, and especially look for ants.

Management

The scale remains attached to stems, branches and fruits even after death. So, it is important to find out if the scales are alive or not. Look to see if the infestation is spreading before applying any management practices.

NATURAL ENEMIES

There are a large number of parasitoids and predators known that attack S coffeae, but which ones are present in Solomon Islands is not known. Most of the parasitoids are tiny wasps, too small to be seen easily by the naked eye. (A parasitoid is like a parasite - which lives off its host – but in this case it eventually kills its host).

CULTURAL CONTROL

- Prune infested stems, branches and fruits and destroy them;
- Apply mulch, manure or synthetic fertilizers to assist plant vigour;
- Destroy ant nests with boiling water, without damaging the plants infested with the scale insect; without the ants, parasitoids and predators will bring about natural control of the scale insect;
- For trees, prune low branches and remove weeds to stop ants reaching leaves and fruits.

CHEMICAL CONTROL

Chemical control is not recommended because of the waxy surface of the scale. Also, insecticides are likely to kill any parasitoids and make biological control ineffective. However, if they are needed, either to kill the scale or ants, do the following:

- Use soap sprays (5 tablespoons of soap in 4 litres water), or white oil to kill the scale insects. These sprays work by blocking the breathing holes of insects causing suffocation and death. Spray undersides of leaves: the oils must contact the insects;
- White oil (petroleum jelly) can be obtained as a commercial product or made by mixing together: 1 cup cooking oil; 2 cups water; 1 teaspoon dishwashing liquid. Dilute the mixture at 3 teaspoons per half a litre of water and spray on the infested leaves. The addition of malathion is useful against scales insects;
- A second application of soap or white oil may be necessary after 3-4 weeks;
- To kill ants, use synthetic pyrethroids (for example, lambda cyhalothrin or cypermethrin); these insecticides may also be tried against scale insects as they are likely to be effective against crawlers, but only after other measures have failed, because they are more likely to kill the scale insects' natural enemies.

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Betel Nut "Disease"

Extension Fact Sheet **67**

Common name: There is none; this disease occurs only in Reef Islands, and only recently. It has not been reported elsewhere in Solomon Islands, or in other parts of the world
Scientific name: There is none, as the cause of the death of betel nuts is uncertain.

Hosts: Betel nut (*Areca catechu*). The susceptibility of other *Areca* species and related palms in the Reef Islands is unknown.

Damage

The disease appeared in about 1975, perhaps earlier. It causes a lethal condition, commonly found on mature palms about to bear fruit, some younger. Consequently, betel nut production in the Reef Islands is low, and nuts are imported from adjacent islands to satisfy local demand.

Biology and Life Cycle

Palms as small as 2 m show the disease, but usually they are older and taller. Small yellow spots occur on the leaves, first on leaves six or seven (photo, top left). As the leaves age, the spots become irregularly oval, approximately 1-2 cm wide, longer parallel to the length of the leaf, and faintly zoned. Spots on the oldest leaves join together and the leaf becomes yellow and dies prematurely.

Affected palms show one or several, red, vertical lines of rot, 1-2 cm wide, of varying length below the oldest leaf sheath (photo, top right). These decayed areas, which often have yellow margins, extend internally through the vascular tissues to the pith (photo, top centre). The

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lines of rot gradually narrow from one leaf to the next and end as faint red line at the base of the youngest leaf. Where the lines of rot extend to the soil they attract colonies of termites.

As the condition progresses, leaves become fewer and shorter, and then production ceases. Often, the last leaf is seen like a short fan at the top of the palm (photo, lower left). At this stage, the inner, unexposed leaves show extensive decay, including cavities filled with large amounts of gum (photo, lower centre). Continued deterioration of the shoot and young leaves results in death of the palm. On mature palms, flower buds rot while still in the axils of unopened leaves (photo, lower right), and those that have grown normally are shrunken and without nuts.

Isolations from the shoot tips yielded various fungi, with *Colletotrichum* being common. However, this was not thought to be the cause of the disease. In the early 1980s, Three samples of betel nut were sent to the Department of Crop Protection, Waite Campus, University of Adelaide, together with samples of coconuts (9) and sago palm (1). All were tested using molecular probes for *Cococnut cadang-cadang viroid*, and all were found to contain CCCVd-related bands when their nucleic acids were analysed, but it was not possible to relate the bands with symptoms because of the small number of samples. Cause of the disorder remains unknown.

Detection and Inspection

Look for dead and dying palms. Look for red streaks on the trunks below the leaf sheaths, some extending to soil level. Look for inner trunk decay extending to the pith, signs of black, decayed, flower buds, and often, but not always, spotting on the older leaves. If in doubt, trace the red streaks to the shoot tip by removing the leaves, and notice the necrosis and gum.

Management

QUARANTINE

There are no internal laws restricting the movement of planting material between islands of the country. However, as there is little knowledge about the cause of this disease and its spread, people in Reef islands should be advised not to transfer propagating material - seed as well as seedlings - to any other part of Solomon Islands.

RESISTANT VARIETIES

None are known. Coconuts seem unaffected by the disease. Speculation that the disease was the same as that causing Coconut foliar decay (associated with a virus) in Vanuatu, was not borne out by investigation, although the vector of the Vanuatu disease, *Myndus taffini*, was found on coconuts in the Reefs Islands, the only place outside Vanuatu where it is known to occur. The idea was that CFD was the reason for the absence of betel nut in Vanuatu, and had now spread to further along the Vanuatu-Solomon Islands archipelago, destroying betel nut in the process. To check this, three varieties susceptible to CFD - Malayan Dwarf, Rennell and Malayan Dwarf x Rennell hybrid, plus the local tall of Reef Islands - were planted at Otello village in 1980. No symptoms of CFD were recorded on these coconuts.

CHEMICAL CONTROL

Chemical control is not appropriate for this disease in the absence of any knowledge of its cause or method of spread.

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Cassava Green Mottle

Extension Fact Sheet **68**

Common name: Cassava green mottle virus
Scientific name: *Cassava green mottle 'nepovirus'*.

Hosts: It is only known from cassava, and only from Choiseul, nowhere else in the world. In the lab, several plant species have been infected with this virus; these species are known as 'indicator' plants and are used to identify and characterise viruses: *Chenopodium*, *Nicotiana* (tobacco), *Phaseolus* (French bean), *Cucumis* (cucumber), *Ricinus* (castor oil) and *Solanum* (potato). Interestingly, *Ipomoea* (sweet potato) was also infected in these tests, giving a 'symptomless, systemic infection'. But whether or not infection occurs in the field is unknown.

Damage

Surveys on Chosieul showed that the disease is present in most plantings, but the number of infected plants is low. Cuttings taken from diseased plants are much slower to develop than those from plants without symptoms during the previous 9 months; differences in height can be seen at 4 months, but they are much less at harvest at 8 months. Weight of stems and edible roots of diseased plants are half those planted with healthy cuttings. However, farmers usually plant three cuttings per mound, so any that stay healthy have more space and nutrients and make up for the loss in yield from those that are diseased.

Biology and Life Cycle

Young leaves are puckered with faint (photo, right) to distinct yellow spots and green patterns (mottles), and twisted margins (photo, left). Usually, the shoots recover from the symptoms and appear healthy. Occasionally, plants become severely stunted, edible roots are absent or, if present, small and woody when cooked.

In the lab, the virus can be passed between plants in sap, and also in seed. Thirty percent of the seed of infected tobacco plants was infected. Whether it also spreads in seed of cassava is unknown. Seed is not used for growing cassava, so spread on Choiseul is most likely in diseased cuttings. However, there are other possibilities.

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In a trial on Choiseul, 4% of plants grown from cuttings taken from Guadalcanal became diseased within 250 days from planting. How infection occurred is not known, but there are several possibilities. The collision of plants caused by wind may have transferred sap between those infected and healthy. There is also the possibility of spread by nematodes and pollen. The virus is thought to be a member of the nepovirus group, and members of this group are spread in these ways.

Detection and Inspection

Look for yellow patterns on the leaves, from small dots to irregular patches of yellow. Look for leaf margins that are distorted. The plants may be stunted.

Management

QUARANTINE

Surveys carried out in adjacent Shortland Islands in the late 1970s failed to find the disease, and people were made aware of the danger of planting cuttings taken from Choiseul. There are no internal laws restricting the movement of planting material between islands of the country, so compliance is voluntary. However, raising people's awareness about the disease, its potential and method of spread, should be done from time to time.

CULTURAL CONTROL

Cultural control is very important, and is the main method of reducing the impact of this disease:

- Take cuttings for propagation only from plants that are free from symptoms and which, at harvest, produced high yields of edible roots;
- Remove plants with symptoms as soon as they are seen, and burn them. DO NOT wait until harvest, as by then the plants may have recovered from symptoms and, unless marked, difficult to identify as infected.

RESISTANT VARIETIES

None are known.

CHEMICAL CONTROL

Chemical control is not appropriate for this disease, especially as the method of spread is not known.

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Coconut Basal Stem Break

Extension Fact Sheet 69

Common names: Coconut basal stem break in Solomon Islands, Lethal bole rot in Kenya and Tanzania
Scientific name: *Marasmiellus cocophilus*.

Hosts: Coconut, *Cynodon dactylon* (Bermuda grass), *Echinochloa colona* (junglerice), *Eleusine indica* (goose grass), found in the nursery of Levers Pacific Plantations Ltd., Russell Islands.

Damage

Only one outbreak has been recorded in Solomon Islands, but the consequences were considerable. The fungus was first observed in August 1978 when a few 8-9-month-old Malayan Dwarf x Rennell coconut seedlings in the Yandina nursery snapped at the junction of stem and nut. In March the following year, about 7,000 seedlings were affected.

Some 6000 seedlings that appeared healthy were transplanted to the field, but many developed symptoms similar to those in the nursery. Small leaves developed which started to unfurl before they were fully emerged. However, few of the transplanted palms died. Most began to recover 5-6 months after planting when new uninfected roots were produced and new leaves developed which were progressively more normal in appearance.

In East Africa, death of palms up to 8 years old was reported in the late 1960s, with seedlings being highly susceptible on transfer to the field, with losses of over 90 per cent in some areas.

Biology and Life Cycle

Premature death of the oldest two or three leaves is the first symptom; later, white fungal threads and toadstools appear at the base of the petioles, on top of the seednut (photo, left). As the fungus progresses, successively younger leaves are infected, brown rots and cracking occurs in the leaf bases, and isolated rots, 1-1.5 cm deep, with shallow, reddish-brown margins, extend into the bole. Root decay is not extensive, although new roots that penetrate the decayed leaf junction of the petioles and the seednut.

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Similar symptoms occurred in those seedlings planted in the field. Rots were also present in the swollen leaf bases, roots decayed, mycelium and toadstools were present, and because the roots were destroyed, leaves were small.

In East Africa, root infections of seedlings leads to rapid infection of the stem and death. On older palms, leaves wilt, and remain as a 'skirt' around the trunk, the spear leaf dies and a foul-smelling soft rot develops. A dry, reddish-brown rot with a yellow margin is typically present at the base of the bole. Cavities within these areas of rot are lined with mycelium in young palms, 2-4 years old, but this is rare in 4-6-year-old palms, and they are absent in mature palms. Toadstools commonly occur on exposed roots, leaf bases of seedlings and on the soil surface around holes where diseased palms had been removed 2 years previously.

Little is known about the method of infection and spread of the fungus in Solomon Islands. On one occasion, toadstools were detected on seednuts taken from the outbreak area to another destination within the country, suggesting the fungus is seedborne. By contrast, in East Africa, spread is said to occur through soil, root contact between palms, infected coconut debris and probably by air-borne spores. Infection also occurs via wounds.

Detection and Inspection

Look for outer leaves of seedlings that are dying early, swollen leaf bases, with cracks, rots, fungal threads and small white toadstools, leading to a stem break between leaves and roots.

Management

QUARANTINE

After the outbreak in Yandina, and because the fungus was reported to cause a lethal disease, the movement of seednuts from the Russell Islands was prohibited. In 1986, the situation was reassessed, and the quarantine removed. The reasons for this were as follows:

- Basal stem rot had not occurred in Solomon Islands since 1979 (although toadstools could still be found on grasses in the nursery);
- The condition had not been consistently reproduced experimentally;
- Palms planted in the field from the 1979 Yandina nursery continue to appear normal;
- In East Africa, diseases similar to Coconut lethal yellowing (caused by a phytoplasma) have been found where *M. cocophilus* was reported previously.

CULTURAL CONTROL

- The complete removal of the husk is effective in preventing the fungus from colonising seedlings, but some varieties (e.g. the Malayan Dwarf x Rennell hybrid) do not tolerate this treatment and rot when planted;
- Control weeds in the nursery and trim roots that extended beyond the polythene bags to prevent infection as they grow into the soil.

CHEMICAL CONTROL

Seed treatment should always be considered as a precautionary measure whenever seednuts are being moved between countries, or between areas within countries if coconut diseases are not well distributed. Seednuts should be taken directly from the palm, partially dehusked by trimming at the top and three sides and dipped in an appropriate fungicide for 15 minutes. The addition of a wetting agent is considered beneficial. The fungicide Calixin (tridemorth) was used in Solomon Islands.

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Marasmiellus rots

Extension Fact Sheet **70**

Common names: Coconut pre-emergence shoot rot, Coconut embryo rot, Banana sheath rot, Taro corm rot
Scientific name: *Marasmiellus inoderma* (previously known *as M. semiustus*).

Hosts: A number of crops - banana, coconut and taro - are attacked by this fungus, which causes minor diseases.

Damage

On banana: Outer leaf sheaths and leaf bases wither and decay, leaves are slow to emerge and are stunted (photo, top centre). White or pink fungal growth commonly occurs in large irregular patches between the leaf sheaths. In wet weather, toadstools develop on the lower parts of the stem (photo, top right), and on decaying leaves and other debris on the soil. The roots may also be attacked. Overall, the damage is minor.

On coconut: The fungus attacks the shoot as the seednuts germinate. Early infection destroys the embryo, leading to entry of the nut cavity and the development of a pinkish-white fungal growth floating on the liquid endosperm – the milk. Foul-smelling secondary rots often develop. Where shoots survive early infection, brown rots occur at the base of the leaves and stems often associated with large amounts of white fungal growth (photo, top left). Usually, seedlings overcome the attack, but growth may be slow. Sometimes, the plants may be killed if growing conditions are poor. Toadstools form on the nut and at the base of the seedlings.

In Solomon Islands, 15% of Malayan Red Dwarf seednuts germinate on the palm, and 1-2% are infected or killed by *M. inoderma*. Overall, losses are not high, and vary between varieties. By contrast, in Samoa, losses of 50% are reported in the nursery of the seedgarden producing Malayan Dwarf x Rennell seednuts.

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On taro: The fungus rots the outer leaves and causes a shallow corm rot, although on over-mature plants the entire corm may be decayed and filled with white mycelium (photo, lower centre). Toadstools are often seen on the decaying petioles (photo, lower left). The disease is reported from the weather coast of Guadalcanal. The number of plants damaged is low.

Biology and Life Cycle

Infection by the fungus occurs while the seednuts are attached to the palm. Most likely, it occurs as airborne spores, which grow through the stalk (or calyx) end of the seednut, colonise the fibrous husks and grow beneath the brown cap as it is raised for germination. Possibly, other seednuts become infected in the nursery, either by airborne spores or from the fungus growing in the soil. Whatever the case, infection of the seednut leads to the fungus entering the nut, and feeding on the endosperm, that is, the 'milk' and 'meat'.

Infection of banana and taro may also occur from spores landing on the older bottom parts of leaves as they start to die or through wounds. It is more likely that fungal threads of the fungus are carried on planting material, and grow slowly from the outer to the inner leaves as plants develop, causing leaf decay and shallow corm rots.

Toadstools are produced in wet weather, commonly on the dead seednuts in the coconut nursery, and on the outer leaves of banana and taro. Masses of spores are released from these toadstools and spread by wind.

Detection and Inspection

Look for seednuts that do not germinate, remove the husk and look for white fungal growth above the germination pore or thick fungal mats inside the cavity. Look for early death of leaves of banana and taro, and white fungal growth binding the leaves together. Look for white or light brown toadstools on seednuts, and stems of banana and taro.

Management

CULTURAL CONTROL

- On coconut, remove ungerminated seednuts from nursery before toadstools form;
- On banana, remove diseased plants and use mulches and manures to promote vigorous growth. Planting material should be selected carefully to ensure freedom from the fungus;
- Infections on taro are not sufficiently serious to need control measures, although removal of disease plants should be carried out to limit spread.

RESISTANT VARIETIES

Local tall varieties are much more resistant to the disease compared to Malayan Dwarf and hybrids between them and other varieties.

CHEMICAL CONTROL

Post-harvest dips with a range of fungicides have been tried in both Solomon Islands and Samoa, but none have improved seednut germination consistently. Best control has been obtained using phenyl mercury acetate, a product also found useful for the control of *Marasmius* bunch rot of oil palm, but less toxic alternatives, for example, benodanil, have also been used with some success (in Samoa).

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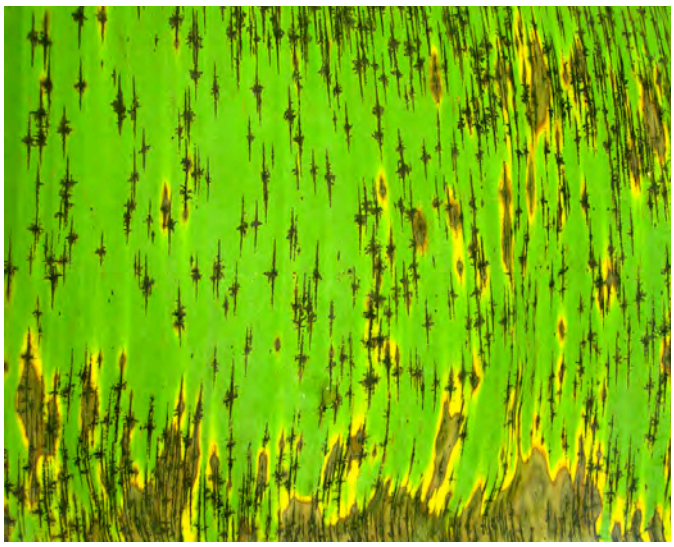
Banana Black Cross

Extension Fact Sheet **71**

Common names: Banana black cross, Black cross disease, Tar spot
Scientific name: *Phyllachora musicola*.

Hosts: Banana and plantain varieties only.



Damage

Usually, the disease is of minor importance. On susceptible varieties, it is worse when they are planted under shade. In this case, the spots are dense, covering most of the leaf surface. Further damage to the leaf occurs when the spots become infected by Diamond leaf spot, caused by the fungus, *Cordana musae* (photo, right). (**See Fact Sheet no. 72 for symptoms of *Cordana*.**)

Biology and Life Cycle

The spots are black, four-pointed stars, up to 60 mm long, most clearly seen on the lower surface of older leaves (photo, left). The long axis of the star is parallel to the leaf veins, that is, at right angles to the length of the leaf. The spots are scattered, but sometimes occur in large groups.

A velvet-like mass of spores is produced on the lower surface of the spots. The spores are spread by rain and wind. This is the asexual state of the fungus. Sexual spores are also formed in the spots, and they also spread the fungus.

Detection and Inspection

Look for the characteristic black, four-pointed stars, on the lower surface of older leaves (photo, left), with their longer axis parallel to the leaf veins. Use a microscope to see the spores on the undersurface of the spots. Look to see if the stars are associated with large diamond spots of *Cordana*.

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Management

CULTURAL CONTROL

Control measures are unlikely to be needed against this disease. If they are, priority should be given to reducing shade levels or planting the bananas in open ground.

RESISTANT VARIETIES

Cavendish varieties are resistant. The fungus usually attacks cooking and ladyfinger bananas. Some of the FHIA varieties bred in Honduras, Central America, and imported from the Secretariat of the Pacific Community, are susceptible. In lowlands Papua New Guinea, varieties FHIA 02, FHAI 17, FHIA 18 and FHIA 23 were susceptible, with FHIA 02 moderately susceptible (class 3) on a scale of 1-5, and the others less so.

CHEMICAL CONTROL

The disease is of minor importance in commercial varieties and, even in those that are susceptible, it is not thought to lower yield sufficiently to need control by fungicides.

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Cordana Leaf Spot

Extension Fact Sheet **72**

Common names: Cordana leaf spot, Diamond leaf spot
Scientific name: *Cordana musae*; there is another species, *C. johnstonii*, in north Queensland, Australia.

Hosts: Banana and plantain varieties only.

Damage

Usually, the disease is of minor importance on Cavendish bananas, but can sometimes be severe on plantains, that is, cooking bananas, but it is not likely to reduce yields to the extent that control measures are required.

Biology and Life Cycle

The spots are oval to diamond-shaped, up to 10 cm long, and at right angles to the length of the leaf (photo, left). They are brown on the upper surface, zoned, with yellow margins, and grey to brown below. The spots often merge, covering large areas of the leaf; this occurs particularly at the margin of the leaf giving a band of dead tissue with a zigzag yellow border between diseased and healthy parts.

Cordana infection often occurs on Black cross leaf spots (photo, right, and Fact Sheet no. 71). This suggests that the fungus is a weak pathogen and needs a wound to infect.

Spores are produced on the underside of the leaf in large numbers, and spread in wet, windy weather.

Detection and Inspection

Look for the diamond-shaped brown spots, with a yellow border, often common along the margin of the leaf. Look to see if the spots are centred on the star-shaped spots of *Phyllachora*.

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Management

CULTURAL CONTROL

Control measures are unlikely to be needed against this disease.

RESISTANT VARIETIES

Cavendish varieties are resistant. The fungus usually infects cooking bananas, but the damage is usually insignificant. There is no information on the resistance of the FHIA varieties bred in Honduras, Central America, and imported from the Secretariat of the Pacific Community, to this disease.

CHEMICAL CONTROL

The disease is of minor importance in commercial varieties and, even in those that are susceptible, it is not thought to lower yield sufficiently to need control by fungicides.

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Bacterial Leaf Streak

Extension Fact Sheet **73**

Common name: Bacterial leaf streak
Scientific name: *Xanthomonas vasicola* pv. *holcicola* (previously known as *X. campestris* pv. *holcicola*; *X. holcicola*. Note, positive identification awaits inoculation studies.

Hosts: Sorghum, millet, Johnson grass. Maize is a minor host.

Damage

The spots and streaks merge to form large dead areas on the leaves, usually beginning on the lower older leaves, and progressing upwards. However, the impact of the disease in Solomon Islands is unknown, but it seems that the variety used for livestock feed matures before major damage is done, and yields are affected.

Biology and Life Cycle

Narrow, reddish-brown, 2-3 mm wide, 5-15 mm long, somewhat rectangular, streaks appear on the lower leaves (photo, left). During wet weather, these merge to form long irregular streaks and blotches throughout all or much of the leaf. The leaves die and hang down around the stem (photo, right). Large, irregular reddish-brown to black blotches also develop on the leaf bases and stems.

The bacteria that cause the disease are unlikely to be seed borne from studies done in other countries. Therefore, the most likely way that the bacteria are spread is from crop debris in the soil, and also from wild grasses; the latter is the most likely way for sorghum to become infected on the Guadalcanal Plains.

The bacteria ooze from the spots during wet weather, and are spread in wind and rain.

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Detection and Inspection

Look for the reddish-brown, rectangular spots on the leaves that spread rapidly and join together, causing a blight, especially in wet weather. Identification of the bacterium requires isolation in the lab, and expert examination of the bacterial colonies using chemical tests.

Management

CULTURAL CONTROL

- After harvest, destroy all the leaves and stems by burning. DO NOT leave the trash to rot in the field, especially if another crop is to be planted on land nearby;
- DO NOT plant sorghum on the same land two crops in succession;
- Although the bacterium has not been proven to be seedborne, it is important to use 'clean' seed, that is, seed from crops that were free from the disease during the previous crop.

RESISTANT VARIETIES

There is no information on varietal resistance of sorghum in Solomon Islands, although there are reports of resistant lines from other countries.

CHEMICAL CONTROL

It is not appropriate for this disease, especially as sorghum is not grown commercially in Solomon Islands; it is grown for village poultry projects where use of chemicals would be uneconomical.

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Maize Mosaic Virus

Extension Fact Sheet **74**

Common name: Maize mosaic virus
Scientific name: *Maize mosaic nucleorhabdovirus*.

Hosts: maize and sweet corn, *Rottboellia cochinchensis* (itch grass).

Damage

Plants are stunted (photo, right), and either the cobs do not develop, or they are deformed with fewer seeds than normal. However, the number of plants infected with the disease is usually quite small, perhaps 1-2%; therefore, although individual plants may have very low yields, plot yields (that is, yields per unit area) are probably not reduced greatly. Sweet corn appears to be more susceptible than maize.

Biology and Life Cycle

Apart from stunting, the virus causes light green to yellow stripes along the leaves (photo, left). These stripes are either narrow, the width of a single leaf vein, or in bands 1-2 cm wide.

The virus particles are bullet-shaped when seen under the electron microscope. The virus is not seedborne, nor is it spread in infected plant material. It is spread by planthoppers, *Peregrinus maidis*, that live and breed on maize and *Rottboellia*. The planthoppers feed on infected maize and *Rottboellia*, acquire the virus and, after a few days, during which time the virus multiplies, the planthoppers then spread the virus until they die.

Detection and Inspection

Look for stunted plants, often present at or near the borders of the plots. Look for the yellow and green stripes, sometimes running the entire length of the leaves; these may be narrow, a single line or in bands, 1-2 cm wide. Importantly, look for populations of planthoppers in the

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'funnel' of the young leaves; this is often an indication that the symptoms are caused by Maize mosaic virus.

Another virus, Maize stripe virus, causes similar symptoms in maize and *Rottboellia*, and is spread by *P maidis*. However, this virus has not been found in Solomon Islands or anywhere else in the Pacific, but is reported from Australia. Maize stripe virus particles are long flexuous rods.

Management

CULTURAL CONTROL

Pull out plants as soon as symptoms are seen. DO NOT wait; otherwise, the insects present will breed and spread the disease. When pulling out the plants grasp the young leaves, holding them together, preventing the insects within the 'funnel' of the plants from escaping. Put the plants into a sack and burn them, destroying plants and insects.

RESISTANT VARIETIES

It is likely that varieties of maize imported into Solomon Islands are from countries where maize and sweet corn have been bred for resistance to this disease.

CHEMICAL CONTROL

It is not appropriate for this disease. Although insecticides could be used to kill the planthoppers that spread the virus, their use would not be economical as the number of plants with symptoms is usually low. Removal of infected plants is a better method of control.

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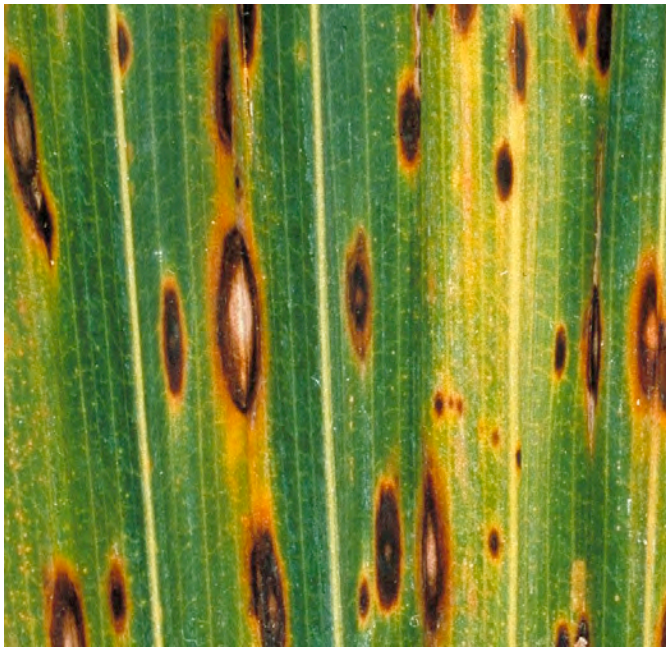
Seedling Blight

Extension Fact Sheet **75**

Common name: Coconut seedling blight
Scientific name: *Bipolaris incurvata* (previously known as *Drechslera incurvata*, *Helminthosporium incurvatum)*.

Host: Coconut.



Damage

The disease is only of importance in the nursery; after transfer to the field it is rarely important. Weak seedlings, growing under poor conditions – crowding, poor nutrition and too much shade - are most affected, but the disease also damages those in nurseries that are well maintained. Infection causes leaves to dry up and die early, and the defoliation slows growth.

Biology and Life Cycle

The leaf spots are at first small, oval and brown; later, they grow up to 15 mm long, light brown or grey in the middle with a broad dark margin (photo, left). Often the spots join together causing a leaf blight (photo, right).

Spores of the fungus, which are mostly formed on the underside of the leaf spots during wet weather, are spread by wind. The fungus needs high levels of relative humidity for sporulation, and the spores need dew or rain for infection.

Detection and Inspection

This is a distinctive disease on seedlings, especially in nurseries where they are crowded together. Look for large numbers of oval, brown, leaf spots that rapidly expand becoming light grey in the centre, join together and develop into a blight, killing large areas of the leaves.

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Management

CULTURAL CONTROL

- Make sure that the seedlings have the necessary conditions for rapid growth, that is, sufficient water, correct nutrition and enough space to grow;
- In general, nitrogen increases disease severity - it has been found to increase spore production - and can, indirectly, lead to death of the seedlings. By contrast, potassium increases leaf resistance to infection, and results in lower levels of disease;
- Plants in the nursery should be adequately spaced to allow free movement of air between them;
- Reduce the level of shade, or grow seedlings without shade.

RESISTANT VARIETIES

None known

CHEMICAL CONTROL

Fungicides should only be considered after the reduction of shade and the application of fertiliser, especially potassium. If fungicides are required, use chlorothalonil, copper oxychloride or mancozeb.

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Tomato Leaf Mould

Extension Fact Sheet **76**

Common names: Tomato leaf mould, Leaf mould, Tomato grey leaf mould
Scientific name: *Passalora fulva* (previously known as *Fulvia fulva*, *Mycovellosiella fulva* and *Cladosporium fulvum).*

Host: Tomato.

Damage

The fungus causes a serious disease in the cooler, wetter, highland areas of Solomon Islands. The loss of leaves, from the bottom of the plant upwards, is rapid. Yield reduction is related to the time of infection. If plants are infected before fruits are formed, considerable crop loss occurs. In severe cases, the flowers and, occasionally, the fruit are attacked. Infected flowers may fail to set fruit. Occasionally, the fungus causes an internal blackening of the fruit.

Note, in Samoa, fruit yields on susceptible varieties were tripled when the disease was controlled by fungicides.

The disease is less common in coastal areas in Solomon Islands, where another leaf mould disease, Black Leaf Mould, *Pseudocercospora fuligena*, occurs on tomatoes. (**See Fact Sheet no. 45 for details**.)

Biology and Life Cycle

Yellow spots and patches occur on the top surface of the leaves with brown to green spore masses on the lower surface (photos, left and right). The diseased areas join together and the leaves dry up and die.

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Produced with support from IPPSI: *Improved Plant Protection in Solomon Islands,* funded by ACIAR, Canberra

Survival between crops occurs in a number of ways. The fungus survives as spores or as mycelium (the cotton-like growth of the fungus) in dead tomato plants of the previous crop. It is spread as spores in air currents, by water splash, or on tools and clothing. There is a possibility that spread also occurs by insects and on seed.

Detection and Inspection

Look for the yellow spots and rapidly developing irregular patches on the upper surfaces of the lower leaves, with brown to green areas on the under surface. Look for plants where leaves dry up and die rapidly.

Management

CULTURAL CONTROL

- Remove infected lower leaves as soon as the first three or four fruit trusses (bunches) have been picked;
- After harvest, remove and destroy (burn) **all** plant debris;
- It is not known for certain whether seed is important in the spread of the fungus. However, hot water treatment has been used as a method of producing seed free from contamination by fungal spores. Seed is treated with water for 25 minutes at exactly 50°C. Note, this is not a method that farmers would use, because of the need for a thermometer. Also, treatment of seed by this method would only be done as a last resort, after other methods have been tried and failed.

RESISTANT VARIETIES

Leaf-mould resistant varieties are available. However, the fungus mutates readily (there are at least 12 races of the fungus), and varieties may not be resistant to them all.

CHEMICAL CONTROL

The cool, wet, conditions in Solomon Islands favour the disease such that fungicides are needed to give adequate control. The products to use are chlorothalonil (Bravo), copper oxychloride or mancozeb. Treatment should start when the yellow spots are first seen, and continue at 10-14 days intervals until 3-4 weeks before last harvest. It is important to spray both sides of the leaves.

Azole fungicides (e.g., difenoconazole) are recommended for control of this disease in other countries. But these are rarely, if ever, sold in Solomon Islands.

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Produced with support from IPPSI: *Improved Plant Protection in Solomon Islands,* funded by ACIAR, Canberra

Fiji Disease

Extension Fact Sheet **77**

Common name: Fiji disease of sugarcane
Scientific name: *Sugarcane Fiji fijidisease.*

Host: *Saccharum officinarum* (sugarcane); *S. edule* (lowland pitpit), and other *Saccharum* species.

Damage

In the past, the virus has caused severe damage to commercial sugarcane in Fiji and Australia. The epidemics of these two countries were caused by planting large areas of susceptible varieties. For instance, in 1979, 70 million plants were present with the disease in the Bundaberg district of Queensland. In Solomon Islands, the situation is different. Sugarcane is never planted in large areas; it occurs as a few plants in a garden; and, possibly, the varieties have been selected for resistance. Whatever the reason, the number of plants affected is relatively low. It is not a serious disease.

Biology and Life Cycle

Sugarcane Fiji disease is spread by *Perkinsiella*, a planthopper (photo, right), which breeds in the young leaves. The species that spreads the disease in Solomon Islands has not been identified. All stages of *Perkinsiella* are capable of spreading the virus. The insects take in the virus as they feed; the virus multiplies inside them; and then, after 2-4 weeks, the virus is ready to pass from the insects to sugarcane. The adult planthoppers have wings, allowing them to fly from diseased to healthy plants.

The disease is also spread in planting material. Farmers do not always realise that plants chosen for propagation are diseased, especially when symptoms are just beginning.

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Detection and Inspection

Look for galls (outgrowths) on the under surface of the leaves, along the midrib and large veins; they vary in size from those that can only just be seen with the eye to those that are 50 mm long, 2-3 mm wide and 1-2 mm high. The galls are characteristic of the disease, and important in distinguishing Sugarcane Fiji disease from other sugarcane diseases. Look for leaves, which are short, stiff, and horizontal (photo, left; note the disease plants on the left, and healthy plants centre and right). The diseased plants look as if cattle have eaten them. Look for stems where the buds have developed, giving bunches of leaves along the stem, called a witches' broom effect.

The virus can be detected in ELISA tests, and also by molecular tests using PCR.

Management

CULTURAL CONTROL

- Remove plants as soon as symptoms are seen, and burn them;
- DO NOT use any of the stems from a diseased plant for propagation, even if some stems appear healthy; they will develop the disease later;
- When pulling out the plants look to see if insects are present in the young leaves; if they are, hold the leaves together to stop them from escaping; otherwise they might jump or fly to healthy plants and spread the virus.

RESISTANT VARIETIES

There are commercial varieties with resistance to the disease. However, it is not clear whether there would be any advantage in introducing them to Solomon Islands. Nothing is known about the resistance of the local varieties, which is necessary before a decision can be made. If varieties were introduced, it is very important that the plants are properly treated, following the FAO/IBPGR Technical Guidelines for the Safe Movement of Sugarcane Germplasm.

CHEMICAL CONTROL

The use of pesticides is not a method of control that can be recommended for sugarcane grown for household use. Costs are high, regular applications would be needed, and farmers are not trained in pesticide use, making them uneconomic and a danger to the person applying them and the environment.

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Cabbage-heart Caterpillar

Extension Fact Sheet **78**

Common name: Large cabbage-heart caterpillar[1]
Scientific name: *Crocidolomia pavonana.*

Host: Members of the *Brassica* family - broccoli, cabbage, cauliflower, Chinese cabbage, mustard and radish.

Damage

The larvae or caterpillars do the damage. They feed on all stages of the plants, although they rarely attack seedlings. Damage is often severe as the caterpillars feed on the 'heart' or centre of plants (photo, left & right). The caterpillars often occur with those of Diamond back moth. It is second in important to DBM; even a single caterpillar is capable of causing significant damage – and therefore economic loss – at pre- and post-heading stages.

Biology and Life Cycle

Eggs are laid on the underside of the outer leaves in batches of 10 to more than a 100. They are pale green at first, becoming bright yellow, and then brown before hatching. The caterpillars are 2-3 mm at first, growing to 20 mm, with white or pale green stripes (photo, right); the later stages make thick webs over the leaves, and feed beneath them. The caterpillars pupate in the soil. The adult is light brown, just less than 20 mm long (photo, below).

The life cycle is about 22 days in the lowlands, and 35 days in the highlands.

[1]Information in this fact sheet is taken from the CABI Crop Protection Compendium, and also from a fact sheet produced by Mike Furlong, University of Queensland, Australia.

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Produced with support from IPPSI: *Improved Plant Protection in Solomon Islands,* funded by ACIAR, Canberra

Detection and Inspection

Look for the egg masses on the lower surfaces of the leaves, along the midrib and main veins. Look for caterpillars at the centre of cabbages with white or pale green stripes; look for the presence of webbing and faeces.

Management

NATURAL EMEMIES

There is no information about natural enemies in Solomon Islands. A Braconid wasp and a Tachinid fly have been recorded in Papua New Guinea, but neither was able to prevent high levels of damage. It is likely that these as well as ladybeetle and lacewing larvae occur in Solomon Islands.

CULTURAL CONTROL

- Check seedlings in the nursery for egg masses and young caterpillars; If found, remove the leaves or the entire plants and destroy them;
- Hand-pick larvae from plants in the field when numbers of insects are low;
- Where farmers have the resources, grow plants under nets or in screen houses;
- Use mustard as a trap crop, planting it as a companion crop between rows of cabbages and other *Brassica* species; mustard is a preferred host and protects the cabbages from destruction;
- Destroy crop residues after harvest, and weeds in the *Brassica* family before planting and during the cropping period.

CHEMICAL CONTROL

Use *Bacillus thuringiensis* (Bt), but note the following:

- Good plant coverage is needed as the insecticide has to be eaten by the caterpillars to kill them;
- Eggs are not susceptible to Bt;
- Use Bt as soon as damage is seen;
- Small larvae are more susceptible than fully grown ones to Bt.

Broad-spectrum insecticides (such as pyrethroids and organophosphates) should be avoided, as they will kill natural enemies.

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Hibiscus Ringspot Virus

Extension Fact Sheet 79

Common name: There is no internationally accepted common name, but Hibiscus virus is suggested here
Scientific name*: Hibiscus chlorotic ringspot carmovirus* (HRSPV)[1]. The virus has small (28 nm), spherical particles.

Hosts: *Sliperi kabis* (*Abelmoschus manihot*), and the ornamental *Hibiscus* (*H. rosa-sinensis*). A number of plant species used in lab tests for virus detection are hosts, including cotton and French bean.

Damage

Symptoms are common wherever *sliperi kabis* is grown, but there is no information on the effect of the virus on plant growth. It is probably small. Patches of light green occur, scatted amongst the normal dark green of the leaves. These areas are sometimes large, and easily seen (photo), or very faint, and difficult to detect. Patterns of pale and dark green areas are called mosaics or mottles. The word chlorotic in the name of the virus means loss of the normal green colour. Ringspots occur on Hibiscus, but are uncommon on *sliperi kabis*. The ringspots are pale green circles, 2-3 mm diameter.

Biology and Life Cycle

The virus is spread in cuttings used for planting; this is the main method of spread. However, it the virus can also spread in sap, as leaves of infected plants are damaged and sap from them comes into contact with healthy leaves. Transfer on knives and secateurs is a possibility. However, the importance of spread in sap in these ways is unknown. The virus is not spread in

[1] The virus was first found in *Hibiscus*, and then found throughout the Pacific in *Abelmoschus*, during UNDP/FAO surveys in the 1980s.

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Produced with support from IPPSI: *Improved Plant Protection in Solomon Islands,* funded by ACIAR, Canberra

seed. Other, similar viruses are spread by beetles, and also by a soilborne fungus, but their importance in the spread of HCRV is also unknown.

Detection and Inspection

Look for the pale green patterns on the leaves, but note that plants can, at times, appear symptomless; this means that the leaves can appear healthy, even though they are infection by the virus. Look for ringspots on Hibiscus.

Management

There is little information of the affect of the disease on plant growth, this and the fact that growers rarely recognise the symptoms, suggests that its impact is small. However, there is always the possibility of more severe symptoms if plants become infected by HCRSV and other types of viruses.

PATHOGEN-TESTED PLANTS

Tissue culture can be used to produce plants that are free from virus. The technique involves growing the meristem, the shoot tip where leaves and stems are formed. It is cut out, placed on a sterile tissue culture medium and use to regrow the plant. If done properly, there is a chance that the plant is free of virus, but to make sure it has to be tested.

Sliperi kabis plants from Papua New Guinea and Fiji are available from the SPC Centre for Pacific Crops and Trees. The plants from Papua New Guinea were introduced to Fiji as seed, and then tested for quality, before being treated to remove HCRSV. The plants were grown from meristems and tested for virus.

SEED

HCRSV is not seedborne, so plants from seed will be free from virus. However, flowering and seed set is not a common event in *Albelmoschus*, and even if it were, the seedlings will not be the same as its parents. Nevertheless, the large number of varieties in Papua New Guinea and other countries of Melanesia are likely to be seedlings selected by farmers. Therefore, seed offers a way of obtaining healthy plants from which selections can be made for further propagation.

Another cause of mosaic pasterns on the leaves

Note, insects called jassids also cause pale green patches on the leaves of *sliperi kabis*. The patches often occur at the leaf margins and between the main veins. **Fact sheet 39 describes the symptoms**. It is possible that the jassids inject a toxin into the leaves as they feed.

In Papua New Guinea, growers are encouraged to plant Derris (a shrub common near the sea, used as a fish poison) between the rows of cabbage or at the border of the garden. The Kastom Gaden Association is distributing Derris for farmers to use on *sliperi kabis* against the jassids, as well as the flea beetle, Nisotra. **Fact sheet 56c describes how Derris is used.**

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Southern Leaf Blight

Extension Fact Sheet **80**

Common names: Southern leaf blight, Maydis leaf blight
Scientific name: *Cochliobolus heterostrophus*; this is the name for the sexual stage; the asexual stage is known as *Bipolaris maydis* (previously it was *Drechslera maydis* and *Helminthosporium maydis*).

Hosts: Maize, including sweet corn, is the most important commercial crop. The fungus also infects sorghum and many grasses.

Damage

The fungus causes a severe disease, depending on the weather conditions, strain, and the varieties grown. Damage is worse if infection occurs before the silk - long stigmas that look like tufts of hair - stage, and temperatures and humidity are high during the development of the ear.

The spots start on the lower leaves; at first, they are oval, but become rectangular, up to 2.5 cm long and 2-6 mm wide, confined by the leaf veins (photo, left). They are light brown with a darker brown margin. The spots grow together, so that large areas of the leaves dry up and die (photo, right). There is no information on the loss of yield caused by this disease in Solomon Islands, but it is unlikely to be high, as the varieties grown will have been bred for resistance to the disease. However, in the 1970s, in the USA and elsewhere, Race (strain) T, caused an epidemic, and resulted in ear rot, ear drop and lodging, and a large loss of yield. Race O is the common strain in the tropics; it causes minor crop loss.

The Race T infects seeds, causing a dark rot, at the tip. Infected seedling die within 3-4 weeks. Race O is also seedborne, although the percentage infection is much less than Race T.

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Biology and Life Cycle

The fungus produces large numbers of spores on the leaf spots, and these are spread by wind and rain-splash between plants. The disease is worse on plants growing under shade, and when there are frequent rain showers.

The fungus survives in seed between crops (Race T), but there is no evidence for spread in seeds by Race O. Survival between crops also occurs on volunteer maize plants and grasses, although the importance of grasses is not clear. The fungus survives in infected crop debris, producing spores, which are spread in wind and rain to new crops.

Detection and Inspection

Look for the pale brown spots, at first on the lower leaves, oval, later rectangular, and rapidly joining together, destroying the leaves.

Management

CULTURAL CONTROL

- Grow maize and sweet corn in the open, and provide adequate soil fertility by adding manures (animal or plant), mulches or synthetic fertilizer;
- Remove the remains of maize harvests, and use to make compost, rather than leaving them in the field to produce spores to infect new crops;
- If not removed, then plough crop remains into the soil;
- Remove volunteer maize and/or sweet corn plants;
- DO NOT grow maize on the same land, one crop after another;
- Plant at wider than normal spacing to reduce humidity in the crop.

RESISTANT VARIETIES

Acceptable levels of resistance are available in most varieties grown in the tropics, and this is the main method of managing the disease.

CHEMICAL CONTROL

Fungicides should only be considered in the unlikely event that resistant varieties are unavailable. The fungicides should be applied when lesions first appear, and may need to be repeated depending on the weather conditions during the growing period. Mancozeb and chlorothalonil are recommended. Seed treatments are not advisable.

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Produced with support from IPPSI: *Improved Plant Protection in Solomon Islands,* funded by ACIAR, Canberra

Bacterial Spot

Extension Fact Sheet **81**

Common names: Bacterial spot of tomato and pepper, Bacterial scab, Black spot
Scientific name: *Xanthomonas vesicatoria*. Note, it was called *X. campestris* pv. *vesicatoria.* Several strains are recognised, infecting tomato or pepper, or both.

Hosts: Tomato and pepper, and weeds in the Solanaceae family, for instance, *Datura*, *Physalis* (capegooseberry) and *Nicotiana* (tobacco) species.

Damage

Bacterial spot is a serious disease. It is especially severe in wet and windy conditions, causing plants to lose their leaves. Damage to fruit occurs a) when the disease comes early as mostly young fruit are infected; and b) when leaves drop exposing the fruit to the sun.

Biology and Life Cycle

The spots are small, numerous (photo, left), sunken on the top leaf surface, and slightly raised below. Single spots are up to 3 mm; they join together, especially at the leaf tips and margins, and leaves look scorched and turn yellow; sometimes the lower leaves die and fall. Spots on the leaf stalks and stems are elliptical (photo, right). Spots occur on the young fruits as raised scabs (like the crust that forms over a cut or wound when it is healing).

The bacteria infect leaves through natural openings; fruit are infected through wounds, such as those made when fruits rub together or when bitten by insects.

There are several ways that the bacteria are spread:

- *to new plantings* - on infected seed, and also from bacteria surviving in the soil in the remains of the last crop;
- *between plants* - by rain splash, by overhead irrigation, or by hand watering when soil is splashed onto the leaves; spread is also by touching or handling wet plants;

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Produced with support from *Integrated crop management package for sustainable smallholder gardens in Solomon Islands,* funded by ACIAR, Canberra

- *between crops in different gardens* - in mists produced by wind-blown rain or irrigation water;
- *on seedlings* - infected by seedborne bacteria, or bacteria in the nursery soil.

Detection and Inspection

Look for many small (2-3 mm) irregular spots on the leaves, leaf stalks, stems and fruits. Spots on the leaf stalks and stems are elongate, i.e., longer than they are wide. Look for scabby spots on the fruits (photo, right) with transparent margins.

Management

The control of bacterial spot relies on a) growing healthy plants from seed free from infection, and b) care in handling seedlings when transplanting them from nursery to field. Cultural control is important as it is difficult to control this disease with chemicals. Not only are the chemicals expensive, but also they are easily washed off leaves and fruits in the high rainfall conditions of Solomon Islands.

CULTURAL CONTROL

- Leave 2-3 years between tomato crops grown on the same land;
- Rotate tomatoes with other crops, but not with pepper and eggplant;
- DO NOT use seed from infected plants; obtain a new source – those sold in commercial packets from reputable companies are most likely to be free from infection;
- If farmers want to use their own seed, and their crops are infected with Bacterial spot, treat the seed with hot water: 50°C for 25 mins, cool and then dry[1]. BUT this should be done under supervision by MAL extension staff using a thermometer and correctly timed;
- Make tomato nurseries far from fields with tomatoes to prevent infection of seedlings;
- Carefully inspect every seedling before taking them to the field; remove and burn any seedlings with leaf spots;
- Remove weeds within tomato crops, and at the borders; remove self-sown tomato plants;
- Overhead irrigation should be avoided in favour of flood, furrow or trickle irrigation; if not possible, make sure irrigation is done early in the day so leaves are dry before evening;
- If hand watering, avoid splashing water onto the leaves;
- Apply a thick mulch around the plants to stop water splashing bacteria from the soil onto the leaves;
- DO NOT work in the crop when plants are wet, as the disease can be spread on clothes;
- Remove tomato crop debris after final harvest, and burn it.

RESISTANT VARIETIES: There are resistant varieties of peppers.

CHEMICAL CONTROL

Use copper fungicides, or copper plus mancozeb. It is very important to have healthy seedlings free from Bacterial spot, so spraying should start in the nursery, and continue at 7-10 day intervals in the field. Spraying early, when the plants are young, is especially important as in wet, windy weather field sprays alone often fail to give adequate control.

[1] Note, soaking seed in 1.3% solution of sodium hypochlorite for 1 min, then rinsing and drying, is an alternative treatment.

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Produced with support from *Integrated crop management package for sustainable smallholder gardens in Solomon Islands,* funded by ACIAR, Canberra

Blossom End Rot

Extension Fact Sheet **82**

Common name: Blossom end rot
Scientific name: There is no scientific name; blossom end rot is not caused by insects, fungi, bacteria or other pathogens. It is a "physiological" problem due to a lack of calcium.

Hosts: It is mostly a disease of tomato, although eggplant, pepper and watermelon are also affected.

Damage

Symptoms of blossom end rot first appear when the fruits are one-third to one-half full size, and still green. Not only are the fruits unsightly, and they may have moulds growing on the black areas, but also they ripen prematurely, and are inedible. They are neither fit for the market or home use. Losses can be severe, up to 50%.

Biology and Life Cycle

The first sign of the disease is a clear or light brown area – often said to look "water-soaked", at the blossom end of the fruit, which eventually becomes dark brown or black, dry, sunken and leathery. Blossom end rot occurs at any time when plants are flowering and fruiting, but it is more common on the first fruit. Sometimes, the fungal moulds that grow on the surface of the rot after it has dried are mistaken for the cause.

Blossom end rot is caused by a lack of calcium in the plant. This may mean that there is not enough calcium in the soil, or that it is present but the roots cannot take it up. Calcium is important in the growth of cell walls. It is especially important in rapidly developing parts of plants, such as the fruits. If there is not enough calcium, cells die and tissues rot; this is what happens when plants show signs of blossom end rot.

There are several reasons why fruits show signs of blossom end rot. These are:

- *calcium in the soil* – sandy soils lack calcium;

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- *water* – if there is either too little water, or too much, plants become short of calcium. For example, when plants are grown in plastic bags or on raised beds, and given too little water, the soil around the roots dries out, then becomes water-repellent, and difficult to wet again;
- *hot and dry* – if there is increased water loss from the leaves (a process called transpiration) because it is hot and dry, then plants divert water containing calcium from the fruits, and the fruits suffer;
- pH – if the pH of the soil is too low, calcium may be unavailable by the roots;
- nitrogen – too much nitrogen fertilizer makes the problem worse; this is because nitrogen stimulates rapid vegetative growth and this requires calcium for the cell walls. The result is competition between the demands of fruits and other parts of the plant.

Detection and Inspection

Look for black areas of rot at the blossom end of developing fruits, especially on the first formed trusses; the rots might be covered in fungal moulds.

Management

The most common cause of blossom end rot is erratic watering so that the plants get too little or too much water.

CULTURAL CONTROL

- DO NOT allow the soil to dry out; try to make sure that the soil is moist at all times, particularly at the flowering stage;
- Grow tomatoes in well-drained soil that contains plenty of organic matter, especially well-rotted manure (but see use of chicken manure below); organic matter holds water, and also gives the plants the nutrients they need, including calcium;
- If there is a chance that the plants will get too much water, plant them on raised bed to improve soil drainage;
- Mulch the plants after transplanting with dried grasses, and other dried weeds, to help prevent the soil from drying out. The mulch should be at least 10 cm thick;
- DO NOT cultivate too close to the plants (nor too deeply) as this may damage the roots, and stop uptake of water and minerals, including calcium;
- DO NOT use urea or ammonium types of fertilizers. Use of chicken manure should also be avoided;
- Shade plants, or use windbreaks, when conditions are hot, dry and windy, and when the soil moisture is low.

RESISTANT VARIETIES

Varieties differ in susceptibility to blossom end rot, with plum or pear shaped varieties being the more susceptible.

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Predatory Ladybeetles

Extension Fact Sheet **83**

Common name: Ladybeetles
Scientific name: There are many genera of ladybeetles in Solomon Islands; the one below is *Phrynocaria* sp.

Prey: Aphids, mealybugs, scale insects, caterpillar eggs, mites.

Predatory ladybeetles are a farmer's best friend: they occur on many crops, feeding on colonies of aphids, mealybugs, scales and other damaging insect pests.

It is important to distinguish predatory ladybeetles from the plant-feeding ladybeetles belonging to the subfamily Epilchninae (**see Fact Sheet no. 58**). The plant-feeding ladybeetles have short soft hairs on the upper surface.

Biology and Life Cycle

Eggs are generally yellow and the shape of rice grains; they are laid on their ends in clusters, close to aphid colonies. The larvae hatch at the same time, and look like miniature crocodiles (photo, right). They have spots or patches of dark blue, with areas of red or yellow. After several weeks of feeding the larva attaches to a leaf or a branch, and turns into a pupa. The pupa looks like a curled up larva, with similar colours. About a week later, the pupa splits and the adult crawls out. As the skin starts to dry and harden, the adult becomes characteristically yellowish-orange with black markings (photo, left).

The larger species, feeding on aphids and insect eggs, are bluish-black and red or yellow; the smaller species, feeding on scale insects, are white with long waxy threads.

Detection and inspection

Look for adults with bright shiny, round bodies, which are red or orange with black markings or spots, without soft short hairs; look for the eggs, which are a creamy yellowish-orange, laid in clusters close to aphid colonies; and look for the larvae, which are long, active, dark with yellow or red spots and patches.

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Managing ladybeetles as biocontrol agents

GENERAL

Ladybeetles are very effective biological control agents, but will only appear in the crop if there is food for them, such as aphids or scales. Note, pesticides easily kill them, so if ladybeetles are present feeding on insect pests and mites, they will be destroyed by routine spray programs.

HOW TO USE THEM

(1) MOVING THEM AROUND

As all stages of ladybeetles are relatively large, it is easy to move them to where they would do most good. Adults and larvae can be handpicked, and leaves with eggs and pupae can be plucked, and placed in a collecting (jam) jar, and released onto crop plants infested with pest species.

(2) PROVIDING THEM WITH FOOD

Garden flowers and weeds provide ladybeetles with sugar from thier nectar or pollen. Planting flowering plants in the field and around the edges will encourage ladybeetles to stay in the fields to breed. Basil and marigolds are useful garden flowers. *Sonchus* (sow thistles) and *Chenapodium* (goosefoots) are weeds that are particularly good sources of food for ladybeetles, providing nectar and pollen as well as aphids.

THE DANGERS FROM USING PESTICIDES

As pesticides are harmful to ladybeetles, they should only be used to control aphids and other pests, if ladybeetles are absent or in low numbers. If pesticides are needed, use ones that stay active on plant surfaces for a few days only. For example, use Derris, pyrethrum, or synthetic pyrethroids. These are destroyed rapidly by sunlight.

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Hoverflies

Extension Fact Sheet **84**

Common name: Hoverflies[1]
Scientific name: There are several species in Solomon Islands. The one in the photos is probably *Ischiodon scutellaris*, although this still needs to be checked. Hoverflies are in the Family Syrphidae, and they are known as Syrphid flies or Flower flies.

Prey: Aphids.

Hoverflies are common and occur in many crops. They are important biological control agents. The larvae feed on aphids (photo, right), and these are their main food, but also they probably eat caterpillars, mealybugs and even their own kind.

The adults are typical flies with one pair of wings, large eyes and yellow and black-banded abdomens (photo, left). The adults are often seen hovering above flowering plants and sitting on flowers, sucking up nectar.

Biology and Life Cycle

The eggs are small, oval and white. They are laid singly near colonies of aphids, or even among them. They are easily seen with the eye. The legless larva (or maggot) is pale green at first becoming darker in colour, and has short soft spines on the sides (see photo, right). It narrows towards the head, where the mouth is used to catch and hold the aphids before sucking them dry (photo, right). As the larva grows it moults, i.e., it changes its skin. When fully grown, it is up to 10 mm long. At that time, it attaches itself to the underside of a leaf and it swells up and hardens into a smooth, teardrop-shaped puparium (not a pupa – the real pupa is inside the smooth outer skin of the last maggot stage). It is up to 7 mm long. After a few days, depending on the temperature, the adult hatches, finds flowers with nectar to feed on, and then mates.

[1] Some information in this Fact Sheet is taken from NA Martin (2010) Small hover fly – *Melanostoma fasciatum*. Insect Factsheets: Interesting Insects and other Invertebrates. New Zealand Arthropod Collection Factsheet Series. Landcare Research. http://nzacfactsheets.landcareresearch.co.nz/Browse.html

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Detection and inspection

Look for the slug-like larvae feeding among colonies of aphids. Their narrow heads are often seen moving about as the larva searches for food. They are rarely seen in populations of aphids on crops with hairy leaves such as tomato and squash. Look for flies with yellow and black-banded bodies that hover over flowers, hovering and then suddenly moving forwards or sideways only to hover again. Look for adults on flowers that look like wasps and bees.

Hoverflies may sometimes be confused with wasps. Their bodies are slender, they have yellow-black wasp-like patterns, and some have narrow waists. However, hoverflies lack a sting, have delicate legs, massive eyes, and a single pair of wings which are held out sideways at rest, whereas wasps fold their wings along their bodies at rest. Some syrphids look like bees, but the maggots of these do not feed on aphids.

Managing hoverflies as biocontrol agents

GENERAL

Hoverflies are very effective biological control agents, but only appear in the crop if there are aphids for them to eat. Note, pesticides easily kill them, so if hoverflies are present, they will be destroyed by routine spray programs.

Careful monitoring of the crop will help to determine whether the hoverflies are present and are controlling the aphids. If more than two hoverfly maggots are present in a colony of aphids, there is no need to do anything, as they will effectively control the aphids for you.

HOW TO USE THEM

PROVIDING THEM WITH FOOD

Garden flowers and weeds provide hoverfly adults with sugar as nectar. Planting flowering plants in the field and around the edges will encourage hoverflies to stay and to breed. Large open flowers, such as daisies, are particularly good sources of food, providing nectar for the adults.

THE DANGERS FROM USING PESTICIDES

Pesticides are harmful to hoverflies, and they should only be used against aphids if hoverfly larvae are absent or in low numbers. If pesticides are needed, use ones that stay active on plant for only a few days. For example, use Derris, pyrethrum, or synthetic pyrethroids. These are destroyed rapidly by sunlight.

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Sunscald

Extension Fact Sheet **85**

Common name: Sunscald[1]
Scientific name: There is no scientific name, as sunscald is not caused by insects, fungi, bacteria or other pathogens. It is called a "physiological" problem.

Hosts: Capsicum, large red chilli pepper, eggplants, tomatoes.

Damage

Sunscald occurs when fruit is suddenly exposed to sunlight, especially when it is hot and humid. The fruits affected by sunscald are unmarketable, but as the damage is only on one side, parts can still be used in the home. The damage provides entry points for pathogens that can cause fruit rots.

Biology and Life Cycle

Symptoms of sunscald appear on the side of the fruit that is suddenly exposed to the sun while it is still green. On capsicum, a white, soft, sunken area develops that later dries out and becomes papery (photo). On tomato, the damaged area is white, shiny and blistered, becoming sunken and wrinkled. Symptoms occur on fruits of any size, although maturing fruit tend to be more susceptible to damage.

[1]Some information in this fact sheet is taken from: 1) Cerkauskas R (2004) Sunscald. AVRDC-The World Vegetable Center Fact Sheet. AVRDC Publication 04-583; and 2) Black LL, Green SK, Hartman GL, Poulos JM (1991) Pepper Diseases: A Field Guide. AVRDC Publication No. 91-347.fhm. 98pp.

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Sudden exposure of the fruits to sunlight occurs if there are not enough leaves to protect the fruit. This can occur in a number of ways:

- Poor leaf development before flowering;
- Loss of leaves as a results of insect pests or diseases;
- Long periods of wilting;
- Broken stems and branches caused by rough handling, especially when harvesting;
- Destruction of leaves by heavy rainfall.

Detection and Inspection

Look on the exposed sides of mature green fruit for sunken areas that are white and papery on capsicum, or white, shiny patches becoming wrinkled on tomato. Look for signs of black fungal growth on the damaged parts.

Management

RESISTANT VARIETIES

No varieties are resistant to sunscald, but there are varieties that have good foliage cover, and these should be selected if sunscald cannot be solved by the cultural controls suggested below.

CULTURAL CONTROL

- Provide sufficient nitrogen for healthy plant growth;
- At least once a week look for signs of insect pests and diseases, which may destroy the canopy of leaves protecting the fruits;
- Water regularly in dry weather, to prevent plants from wilting;
- Remove flowers at early stage of development until plants are big enough to support fruit and have enough leaves to provide protection for the fruit;
- Support the plants to minimise damage due to wind and harvesting; this can be done in a number of ways: a) stakes; or b) string or wires running horizontally along the rows.

CHEMICAL CONTROL

Pesticides will not cure plants that show symptoms of sunscald as it is a physiological condition. However, they can prevent the loss of leaves from insect pests and diseases, and if leaves are present they will protect the fruits from sunscald.

The choice of insecticide depends on the insects that are present. The most common insect pests in Solomon Islands are *Spodoptera* caterpillars and aphids. For these, Bt - *Bacillus thuringiensis kurstaki* - some plant derived products (neem, derris and chilli), and synthetic pyrethoids are recommended (**see Fact Sheets nos. 31 & 38**). Mites are also common on Capsicum (**see Fact Sheet no. 49**). For mites, abamectin (containing a compound from a soil bacterium) and synthetic chemicals, difocol, sulfur and dimethoate are used.

The choice of fungicide also depends on the type of disease, with dithiocarbamates or copper products commonly used for those causing leaf spots, moulds and blights (**see Fact Sheets 45, 76 & 81**).

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Thrips

Extension Fact Sheet **86**

Common name: Thrips; the different species are named after the plants that they live on, e.g., tobacco thrips, onion thrips, flower thrips.
Scientific name: The thrips of Solomon Islands have not been identified.

Hosts: Tomato and capsicum are common hosts of thrips in Solomon Islands.

Damage

Thrips damage plants in two ways: first, they pierce the cells of the plant and suck out the juices; and second, they spread viruses. Damage usually starts when the leaves are still inside the buds or fruits are still inside the flowers, and is only seen when they expand. At this time, it may not be possible to find the thrips; they may have moved to feed on other leaf and flower buds. As thrips feed, the cells of the plant collapse, and this cause pits, distortions, patches of brown (photo, lower right), later with a sliver sheen, or scaring of fruits (photo, left). Fruits damaged this way may not be suitable for market, and damaged leaves may dry out and die early. In Solomon Islands, it is not known if thrips spread viruses.

Biology and Life Cycle

Adult thrips are narrow, less than 2 mm long, black (some species are yellow) with wings that have long hairs at the margins (photo, right above). The wings cover the body when they are not in use. Thrips are difficult to see without a hand lens. The eggs are bean-shaped, white,

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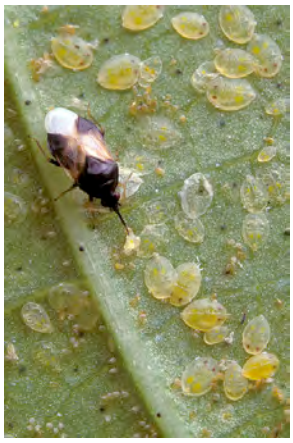
laid on or inside the plant. The lifecycle has six stages: egg, first and second larva (small, whitish and very active, found mainly on the underside of the leaf), pre-pupa, pupa (both stages occur in the soil in natural cracks), and adult. The pre-pupa and pupa are similar in shape to the larvae, but do not move, feed, and show the developing wings.

Thrips occur all year round, but are particularly active in hot, dry times following heavy rains.

Detection and inspection

Look on the underside of the leaves and inside flowers. The larvae are very difficult to see with the naked eye, but with a hand lens the long slender, black bodies of the adults are easily recognised. Look for black or brown specks where the thrips feed; these are faeces. The presence of faeces is a way of telling thrips from mites.

Managing thrips



NATURAL ENEMIES

Several natural enemies feed on thrips. There are predatory thrips, Minute pirate bugs (photo, right[1]), predaceous mites, lacewing larvae and ladybird beetles (adults and larvae). Note, it is best to avoid pesticides to manage thrips, especially those that are long lasting, as they will destroy populations of beneficial insects.

CULTURAL CONTROL

- Intercrop with a non-host plant helps to slow the movement of thrips through the crop. For example, you can grow peppers between yard long beans;
- Rotate crops with non-host plants will help to break the lifecycle. Crops that often suffer from thrips infestations are: cucurbits, crucifers, tomatoes and bell peppers;
- Destroy weeds within and around crops to prevent build up of thrips populations;
- Destroy crop remains after harvest to prevent thrips spreading from old to young crops;
- Use a hose with a strong jet of water to remove thrips from the plants.

CHEMICAL CONTROL

It is very unlikely that thrips populations will be high enough to need the use of pesticides. In any case, the use of pesticides is likely to do more harm than good, as they will kill natural enemies. In addition, thrips tend to hide in sheltered places on plants - in leaf and flower buds or under the calyx of the fruit - so it is often difficult to reach them with pesticides. In the unlikely event that pesticides are needed, use plant-derived products (botanical sprays), and always try to treat the undersides of the leaves.

- Use botanical sprays such as onion, garlic, chilli and papaya (**see Fact Sheet no. 56b,c**);
- Use horticultural oils or soap (**see Fact Sheet no. 56d**);
- Use neem to discourage adults from feeding and laying their eggs on the plants;
- Use synthetic pyrethroids (e.g., lambda cyhalothrin or cypermethrin) only as a last resort.

[1] Photo of *Orius* sp., a Minute pirate bug from http://en.wikipedia.org/wiki/Orius. It is not known if this insect is in the Solomon Islands.

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So
Good