5 Sweetpotato pests

5.1 Introduction

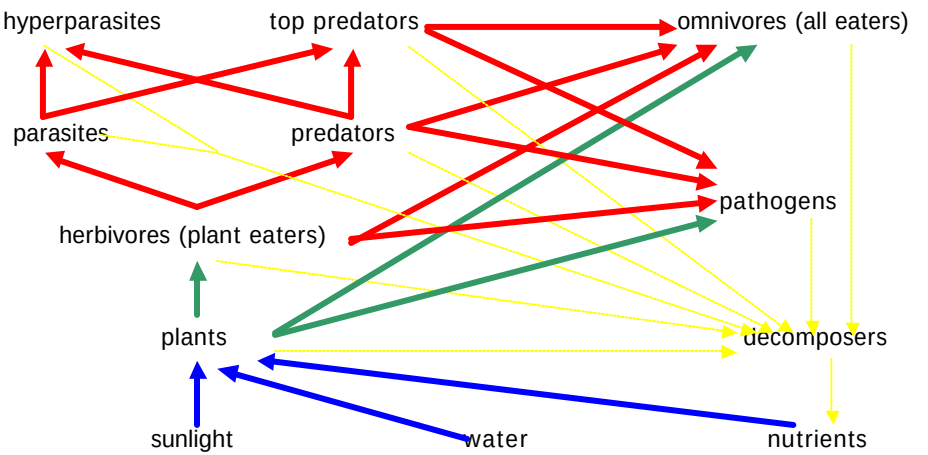
Pests are living creatures that we normally consider harmful because they attack our crops, livestock or other human property. In agricultural fields we can find many types of creatures that live on the plants. But are all of these really pests?

One way of looking at this question is to think about the myriad of life forms in a natural forest. How do the forest creatures live? Trees and other plants absorb water and nutrients from the soil and obtain energy from the sun, and transform these into leaves, stems, roots, flowers, and fruits. Of all the forms of life on earth only plants can produce organic matter from solar energy, water and nutrients. Because of this ability, plants are called *producers.* All other kinds of living things require organic matter as food and are called *consumers*.

Some consumers eat plant parts, such as leaves, fruits or seeds (many types of insects, for example); they are called herbivores. Some eat other animals, and depending on the way they eat (see Section 4.2) they are called predators or parasites. Birds that eat larvae, tigers that eat monkeys, and wasps that parasitize caterpillars are examples. Other animals have a mixed diet of both plants and animals and are called omnivores. Microorganisms that cause disease in plants and among animals are called pathogens. Finally, some life forms eat or decompose dead plants and animals. These scavengers and decomposers include birds such as vultures, insects that live on rotting plant and animals, and many types of fungi and bacteria.

Each species plays an important role to maintain the balance of the web of life. By studying natural systems like forests, which provide an enormous diversity of plants and animals, we can learn a great deal about the behavior and relationships between different kinds of plants and animals. Even though many of them are consumers and exist by eating or parasitizing others, they do not

eliminate their hosts. A perfect balance exists between the different life forms in an undisturbed forest. The figure below shows the relationship among producers, consumers, and decomposers in a natural food chain:



In an agricultural field the food chain is much simpler than in a natural forest, since there are only a few kinds of plants (the types planted by the farmer and weeds that invade the field). This narrow diversity of plant life can only support a limited range of animals. Nevertheless, the plants and animals are still linked in a food chain, just as they are in the much more complex forest.

Organisms that damage, or compete with, the crop cultivated by the farmer are normally called pests. These pests can be animals chewing or sucking plant parts, weeds, pathogens or parasites. Each pest has natural enemies, including predators, parasites and pathogens, that keep its numbers in balance. If the pest is a weed, it will have herbivores that reduce its growth, whereas a leafeating insect, for instance, will have a range of predators and parasites attacking it. The presence of natural enemies ensures that pests rarely destroy all of the crop that serves as their food source.

To maintain their life cycles, natural enemies must have some food source. This means that we have to accept the existence of at least a small number of

pests in agricultural fields, otherwise natural enemies, especially those that eat only one type of food, cannot survive. If they starve, their disappearance will lead to an explosion in pest numbers.

In a sweetpotato field, insects that eat the leaves will rarely consume so much that they cause a reduction in the yield of roots. We should not call them pests unless we can show that they inflict an economic loss. In determining whether an insect or other animal eating plant parts is a pest there are many factors to consider. These include:

- How many pest individuals appear relative to the numbers of their natural enemies?
- At what stage of crop development they damage the plant, and to what extent the plant can overcome the damage?
- What part of the plant they attack relative to the economic value of that part (e.g., insects that consume sweetpotato roots are much more likely to be pests than those that feed on the leaves)?
- How they may be controlled, how difficult this is and what it costs relative to the loss they are likely to cause?

We can classify sweetpotato pests into three major groups as follows: (1) chewing and sucking pests, (2) diseases, and (3) weeds. Each of these groups will be discussed in sections 5.2-5.4[1].

5.2 Chewing and sucking pests

The sweetpotato plant provides food for many kinds of herbivorous organisms, including human beings. Most of the animals that eat sweetpotato in the field are insects. Apart from insects, rats are also important as a potential pest of sweetpotato in specific areas. The sections below describe the life cycles,

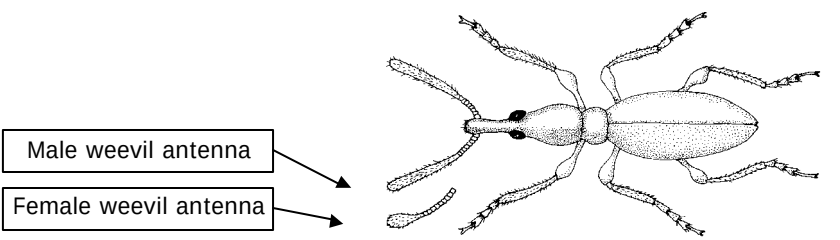
[1] *Photographs: Jesus Alcazar (JA), Merle Shepard (MS), CIP Photo Library (CIP), American Phytopathological Society (APS), Segundo Fuentes (SF); all others by Ann R. Braun (ARB).*

biology and control strategies of the main pests of sweetpotato commonly occurring in the wet tropics.

5.2.1 Sweetpotato weevil

A. Biology

The sweetpotato weevil (scientific name is *Cylas formicarius*) is a kind of beetle. The adult stage of the sweetpotato weevil is a reddish-black beetle that looks like a large ant. The male and female beetle can be told apart by the shape of their antennae. The antennae of males are straight, while those of the female are round or club-shaped. When an adult weevil is disturbed, it plays dead.



The female weevil produces a pheromone that attracts the male for mating. Male weevils are active at night; they move around on the foliage to search for females. During the day the weevils hide under leaves or in soil cracks. The females mate at night, but feed and lay eggs during the day. Their egg-laying behavior depends on the growth stage of the sweetpotato crop. The root is preferred for feeding and egg-laying. At the beginning of growing season, when the plants have not produced any storage roots yet, the adult weevils live on the stem and leaves. The adult will feed on foliage, lay its eggs on the vines and leaves, and the larvae will feed on the stem or the leaf and pupate inside the vines.

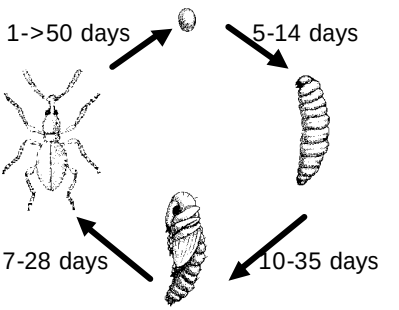
Larva *Adult weevil*

(JA) (JA)

As the plant gets older and starts to form roots, the weevils search for exposed roots. Most weevils (80-90%) can be found in the foliage from 10 cm above the soil surface to 15 cm below the soil. They cannot dig, so their penetration into the soil layer is limited, not allowing them to reach roots that are well buried. The only way to get to the roots is through cracks in dry soil. When an adult finds a root, it punctures the surface as it feeds. It lays eggs just below the surface of the root and covers them with a plug of excrement. The larva, after hatching from the egg, will bore into the tissue of the root.

B. Life cycle

The weevil has a life cycle of four stages: egg, larva, pupa and adult. After mating, the female lays its egg on the tuber or on the leaf. After 5-14 days (depending on the environmental conditions), the egg will hatch. Larvae live for 10-35 days before pupating. The pupal stage will last for 7-28 days. The development of the weevil from egg to adult takes 33 days on average. When the adult beetle emerges from the pupa, initially it is light brown in color. It takes 6-8 days for the outer surface of the weevil to harden and become dark brown. Once this has occurred, the adult leaves the root zone in search of mates. High numbers of weevils in the foliage usually indicates that there is a high number in the root zone.



The duration of each stage in the life cycle of the weevil depends mainly on temperature: the higher the temperature, the faster the development. Hot, dry weather favors weevil development, because the sweetpotato roots are more easily reached through cracks in dry soil, and the life cycle is faster. The adult weevil can survive for 94 days. Most eggs are laid in the first 50 days of the adult stage and a female can produce 50-250 eggs.

C. Damage

Weevils rarely fly and only for short distances ranging from 500 m (if there are sweetpotato plants) to 1,000 m (if there are no sweetpotato plants). The sources of weevil infestation are infested roots and residues from the previous crop, planting material infested with eggs or larvae, and alternate host plants. The sweetpotato weevil has several host plants of the same plant family as the sweetpotato, for instance the water spinach, *Ipomoea aquatica*, known in Asia as Kankong. The flowers of these plants resemble the flower of the sweetpotato. These plants can harbor weevils between planting seasons and serve as a source of weevil infestation when a new crop of sweetpotato is planted.

When the adult female finds a sweetpotato root, it will make feeding and egg-laying punctures. The punctures containing eggs can be distinguished by their dark color because the eggs are covered with weevil frass (insect excrement). Both the feeding and egg laying punctures lower the quality of the root, and can lower the market price. If roots with egg punctures are stored, they will serve as a source of infestation for the clean roots stored beside them.

After hatching from eggs on leaves and stems, larvae feed and develop in the stems of sweetpotato vines, causing thickening and malformation. Larvae emerging from eggs laid on the root surface tunnel into the roots and feed within them until they are ready to pupate. The tunnels are full of weevil frass. Sweetpotato roots react to the damage by producing a poisonous substance that has a distinctive smell. This poison can cause damage to the lungs and heart of human beings and livestock. For this reason, damaged roots should not be used as food or feed.

Black rot infection is common in weevil-damaged roots, because the roots are more susceptible to the black rot fungus after feeding or egg-laying punctures have been formed by the weevils.

D. Natural enemies

The natural enemies of the sweetpotato weevil include several kinds of predators, parasites and pathogens. The predators are the most easily observed of these. They include ants, earwigs, ground beetles and spiders. Ant nests from banana plantations can be moved to the sweetpotato field to enhance predation.

A fungus (*Beauveria bassiana*) that commonly lives in the soil can infect and kill the weevil fairly effectively. This fungus is easily cultivated on coffee residue, wheat and rice straw, and is commercially available in some countries. The fungal culture can be used for treating the planting material and the soil to reduce the weevil population.

E. Management

Chemical control is not effective because the weevils are protected for, at least part of their lifecycle by their development within roots or stems, where they are not easily reached by pesticides. Pesticides kill natural enemies that under natural circumstances quite effectively control weevil populations, and present health risks for humans and animals.

Breeders have spent many years trying to develop varieties that are resistant to the weevil. So far they have not been successful. However, varieties that form roots relatively deep in the soil are less attacked because the weevils cannot easily reach the roots to lay eggs.

Sweetpotato weevil sex pheromone is produced commercially in several countries. It is produced in a laboratory and applied to small rubber capsules that are placed in traps in the field. The rubber capsules should be placed above the foliage and covered to protect them from rain and sunlight. A container of soapy water is usually placed under the capsule. Male adults that are attracted by the sex pheromone fall into the pail of water and can easily be collected and removed from the field. These traps are useful for indicating how large the weevil population is. In some countries research has shown that mass trapping using sex pheromone traps are an effective means to control the weevil. In Cuba the sex pheromone is often used together with an application of the fungus *Beauveria bassiana*. The fungus is applied on the soil surface beneath the sex pheromone trap or sprayed on the foliage around the trap. Weevils attracted to the sex pheromone will be infected by the fungus and killed after several days. Sex pheromones, however, are not yet widely available at the farm level.

The most effective way to control the weevil is through cultivation practices aimed at preventing infestation, including:

- Sanitation of the field (removing infested plant residues).
- Flooding to drown weevils in the soil.
- Hilling up to prevent or fill soil cracks.
- Routine irrigation to prevent soil cracks.
- Mulching to keep the soil moist and prevent cracks, and provide a more favorable place for natural enemies.

The results of some experiments with cultural practices for weevil control are shown in the table below.

Method	*Where tested*	*Result*
Hilling up	Taiwan, Philippines,	Works well. Should be implemented before

	Vietnam, America, East Africa, India, Cuba, Indonesia	the adult weevil reaches the roots to lay eggs.
Early harvesting	Vietnam, Cuba, East Africa, Philippines, America	In Vietnam, harvesting two weeks earlier reduced the loss due to weevil from over 30% to less than 5%. Also good results in other locations.
Inter-cropping	Philippines, India	At AVRDC (vegetable research center in Taiwan), 103 different crops were tested as intercrops for weevil control. The best results were obtained with coriander.
Routine irrigation	Philippines, Taiwan, America, Vietnam, Indonesia	Effective because soil cracking is prevented. Most practical method for farmers with reliable water supply.
Field sanitation	Taiwan, Philippines	Field sanitation can help to reduce weevil infestation if it is practiced in a larger ecosystem area or community. Infested tubers must be buried under more than 15 cm of soil.
Flooding of the field	Indonesia	Flooding of the field for at least 48 hours can kill the larvae of weevils present in roots that have been left in the field.
Mulching	Taiwan India, East Africa, America	Mulches of plastic or rice straw have shown a reduction of weevil damage. The soil surface should be covered soon after planting and the cover should be maintained until harvest. The mulch not only helps to retain soil moisture, but also prevents the weevils from gaining access to roots through soil cracks.

5.2.2 Sweetpotato stemborer

A. Biology

Adult

The adult stage of the sweetpotato stemborer (*Omphisia anastomasalis*) is a moth (white with brownish yellow spots) that is active at night. The female produces a sex pheromone that attracts males. Once mating has occurred, the female lays eggs individually or in small groups on the leaf. The undersides of the leaves near the veins are the preferred location for egg-laying. Sometimes eggs are laid on the vines and leaf stems.

The egg of stemborer is greenish and flattened. A female produces 150-300 eggs during her lifetime.

After hatching, the tiny larva bores into the closest leaf stem (petiole). Eventually the leaf turns yellow and dies as the larva grows too large to live in the leaf stem. The larva then migrates to a vine, consuming its tissue and often migrating towards the base of the plant as it grows larger. The final length of the larva is about 3 cm. Some larvae tunnel into the base of the plant or even into the roots. A pile of excrement under the base of the plant is a typical sign of infestation by the stemborer. The pupae are formed within tunnels made in the stem and they are covered with brown webbing. When the stemborer larva is ready to pupate, it prepares a hole that will be used by the adult moth to escape from within the plant. The larva leaves a very thin layer of stem tissue covering the hole.

Larva

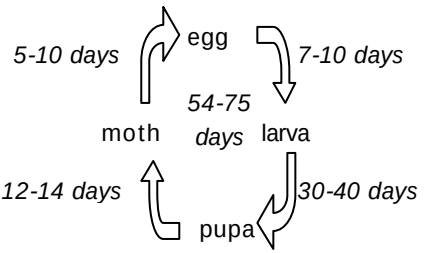
Pupa

Hole made in stem by larva before pupating

Since the adults are short-lived and nocturnal, and the larvae develop within the plant tissue, the stemborer is a difficult species to observe. However, we can deduce its presence from some signs. First, leaves that become yellowing and die may indicate the presence of newly hatched larvae. Thickening and swelling of the base of the sweetpotato plant and piles of light brown frass on the ground under the plant are typical signs of sweetpotato borer infestation.

Finally, an exit hole covered by papery thin tissue indicates the presence of a pupa in the vines.

B. Life cycle



Under normal conditions, stemborer eggs hatch after 7-10 days. The larvae feed and grow within the leaf stems and vines until they are ready to form pupae. The larval stage lasts 30-40 days and several molts occur during this period. The pupal stage, which lasts 12-14 days, is passed in a cocoon of brown webbing. After emerging from the cocoon, the adult moth lives only 5-10 days. Most eggs are laid in the first three days of adult life.

C. Damage

Sweetpotato stemborers can infest sweetpotato plants during the entire crop cycle. Planting material infested with stemborer eggs can lead to infestation of the newly planted crop. The adult moth of stemborer can move from the neighboring fields, initiating new infestations. The damage to the stem tissue interferes with the transportation of water, nutrients and organic matter within the plant. Seriously affected plants may wilt and die.

The earlier the crop is attacked, the greater the potential impact of the stemborer. If a newly planted field is heavily attacked by stemborer, yield loss can exceed 50%, since root formation is inhibited. However, the sweetpotato yield does not seem to be much affected when infestation occurs after the crop is about one month old, provided that the conditions for development are favorable.

D. Natural enemies

Earwigs, ladybird beetles, ground beetles, rove beetles, ants and spiders have been observed as predators of stemborer eggs, larvae, pupae and moths. Ants

and earwigs enter the stem through the exit hole made by a larva before pupation, and attack the larvae and pupae they find inside. In addition, there are 15 known species of larval parasites and one egg parasite that have been reported to attack the sweetpotato stemborer.

E. Management

Prevention of attack is the best way to control the stemborer, and can be accomplished by:

- The use of healthy planting material that is free of stemborer eggs and larvae. Clean planting material can be obtained by careful selection of cuttings, or by planting roots.
- Destruction of infested crop residues after harvesting.
- Rotation of sweetpotato with other crops to interfere with the life cycle of the stemborer. This must be practiced in agreement by the whole community.
- Use of light traps to catch the adult moths when they are active at night.

Once the stemborer attacks the plant, it is a difficult pest to manage. Most pesticides do not kill the stemborer, because it is protected within the vines during most of its life cycle On the contrary, pesticides will kill natural enemies of stemborer, such as parasites and predators, whereas avoiding pesticide use favors the action of these natural enemies.

Hilling up the plants, which is a common farmer practice in many sweetpotato-growing areas, helps to control the stemborer. If the soil covers the exit holes made by the larvae before pupation, the adults cannot emerge to mate and lay eggs.

5.2.3 Sucking insects

Some insects suck plant juices with their tube-shaped mouth parts. These include aphids, whiteflies, planthoppers, thrips, mites and bugs. Most of these insects are very small and difficult to identify. When they pierce the plant tissues with their mouth parts they can spread virus diseases to the

sweetpotato plants. The virus diseases normally cause more serious effects than the feeding of the insects that transmit the virus. The various groups of sucking insects will be discussed separately in the sections below, as well as some ways how to manage them. But let us first analyze why these insects are becoming an increasing problem in certain areas.

Increased occurrence of small-sized, sucking insects as pests has been observed in intensive sweetpotato growing areas. What causes the explosion of these rapidly multiplying insects? The species discussed here are characterized by very short life cycles and very high numbers of offspring. In some cases reproduction can occur without mating, leading to even faster growth in these female-only populations. Under undisturbed conditions, these species are kept from fulfilling their biological potential for population increase by a great diversity of predators, pathogens and parasites, but when pesticides are used, this natural control is seriously disrupted. Natural enemies are usually more susceptible to pesticides than their hosts or prey. Their population growth rates are lower and they are less numerous.

Farmers often say that their problems with insects like aphids and thrips have begun to occur since the advent of pesticide use on the sweetpotato crop, but they may not know why this happens. Farmers may not be familiar with the idea of insect resistance to pesticides. When we spray pesticides, we never kill all the insects. Those that survive to breed transmit their resistance to their offspring. The more we spray the more quickly we select insects that are difficult to kill with pesticides. The shorter the pest life cycle, the more quickly resistance to pesticides can develop. If a pesticide is used frequently and for long enough, it will eventually fail as a means to control pests.

We can conclude that people can create new pests through pesticide use. In the absence of their natural enemies, pesticide-resistant insects with a high capacity to multiply cannot be controlled unless we recreate environmental conditions that favor the action of natural enemies and minimize the development of pests.

Aphids

Symptoms of aphid damage

Examples of sucking insects

Sweetpotato bug nymphs

Whiteflies

(CIP)

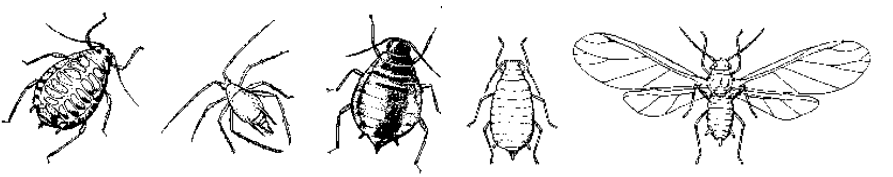
Egg mass of sweetpotato bug

(CIP)

Sweetpotato bug

A. Aphids

Aphids differ in shape and color, measuring about 2-4 mm. Many species, including *Aphis gossypi*, feed on sweetpotato. Aphids exude a sticky honeydew from two small tubes that protrude from their bodies. This honeydew makes the leaves sticky and ants are often attracted to it. Some species of ants protect the aphids and harvest their honeydew; other ants are predators of aphids. Aphids can pick up viruses when they feed on infected plants. Viruses are carried from one plant to another on aphid mouth parts.



Several types and stages of aphids

Aphids can develop from egg to adult in only a week. Newly hatched aphids are called nymphs. Both nymph and adults suck plant juices from leaves and stems. Nymphs are wingless and do not move far. After molting several times,

the nymph becomes an adult. Environmental conditions determine whether adult aphids will develop wings. The winged forms appear when the aphid population is overcrowded; at this point the wings facilitate their dispersal to other plants. An adult female can produce 50 eggs per week. Imagine the increase of aphid numbers in a month, if females survive to reproduce!

Aphids have many natural enemies including ladybird beetles (adults and larvae), lacewings and parasitic wasps and flies, which under undisturbed conditions are very effective in suppressing aphid population development. Aphids, with their short life cycles, often only cause serious problems after pesticide application killed most of these natural enemies, leaving them to multiply rapidly.

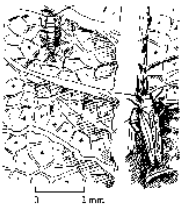
B. Whiteflies

The scientific name of a whitefly species common in sweetpotato is *Bemisia tabaci*. Female whiteflies lay their eggs on the underside of leaves. The greenish-white nymphs are thin, oval and thorny in appearance. The adult is very small and a white layer of wax covers its body. The life cycle of whitefly is completed in 3-4 weeks.

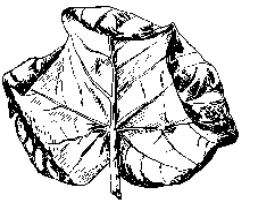
A high population of whitefly in a sweetpotato field can cause the yellowing and death of leaves. Nevertheless, the most dangerous aspect of whitefly infestations is the spread of virus diseases. Only a few whiteflies can infect a whole field very quickly.

C. Planthoppers

Planthoppers often appear in large numbers at night. The winged adults disperse to colonize new crops where they start laying eggs immediately. The nymphs hatching from the eggs molt several times and become successively larger before becoming an adult. Planthopper nymphs and adults suck plant juices from the leaves and stems of sweetpotato. Like aphids, they produce honeydew, making the leaves sticky. A black fungus often develops on the honeydew. Some planthoppers can spread viruses.



Nymph and adult close to the leaf vein

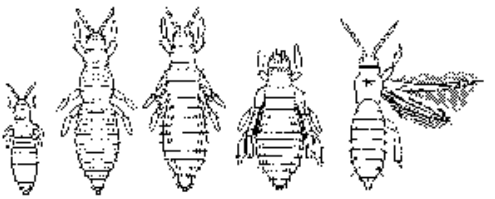


Symptom of planthopper attack

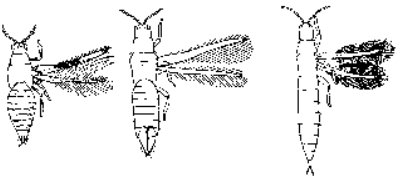
A kind of planthopper that transmits virus

D. Thrips

Thrips are tiny, thin, flat insects of only 1-2 mm in length. Adults are usually black, and may have red or white lines or spots. Generally the nymphs are white, yellow, or greenish. Although the adults have wings that have a feathery appearance, they cannot fly well. Wind helps thrips to disperse over long distances. Generally dry weather favors the growth of the thrips population. However, for optimal proliferation, thrips need high relative humidity. In the rainy season, the population of thrips decreases sharply since many individuals are washed off the plants by raindrops.



Development stages of thrips: nymph, pupa and adult

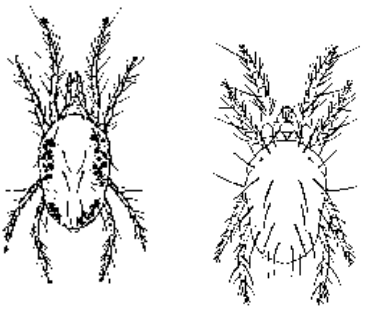


Several kinds of adult thrips

Thrips lay their eggs within the plant tissues. The most active stages are the first and second nymphs. Thrips develop through two or three nymphal stages before pupating in the soil or on the plant.

Thrips damage is characterized by the formation of small silvery spots on the leaves. When the population is high, the small spots unite and the leaves may die.

E. Mites



Adult mites

Mites are eight-legged relatives of the spiders, and therefore strictly speaking not insects. They are less than 1 mm in length and almost invisible to the naked eye. The growth of mites is favored by hot, dry weather. A hard rain can reduce their population sharply since they are easily washed away. Mites are wingless. Some disperse by spinning a silken thread that is blown by the wind and enables the mite to travel on air currents.

F. Bugs

Large numbers of sweetpotato bugs (*Physomerus grossipes*) are often found feeding together on sweetpotato vines. The adults lay groups of eggs on the undersides of leaves or on the stems. The mother bug guards her eggs and the young bugs. Development from egg to adult takes about 85 days.
Bugs have only three stages in their life cycle: egg, nymph and adult. The nymphs are similar in appearance to the adults, except that they have no wings. The adults and nymphs both feed on sweetpotato foliage with their sucking mouth parts, causing wilting and stunting.

G. Natural enemies of sucking insects

There are many kinds of natural enemies that attack small sucking insects and mites. Some are parasitic, and others, such as the ladybird beetle, the lacewing and the larvae of flower flies (syrphids) are predators. Predators may feed on the eggs, nymphs and adult stages. Parasites lay their eggs on or in the bodies of their hosts. The larva of the parasite burrows into the body of its host and develops within. The host insect usually dies by the time the adult parasite emerges. Pictures and drawings of common natural enemies of sucking insects are shown in Section 4.3. Natural enemies provide the most effective mechanism to suppress populations of small sucking insects.

H. Management

The following methods provide some guidelines for controlling small sucking insects and mites:

- Avoid using pesticides! If you have to use them, choose carefully. Use a pesticide that is specific for the pest problem in order to minimize its impact on natural enemies. Do not apply pesticides for control of whiteflies since they are usually resistant to pesticides. Controlling whiteflies as a way to reduce the incidence of virus disease is useless since only a few whiteflies can infect a whole field, whilst we can never kill 100% of the whiteflies present in a field.
- Maintaining plant health can reduce the effect of sucking insects and mites because the plants can compensate for insect attack. Avoid using excessive nitrogen fertilizers. Overfertilization with nitrogen makes plants highly nutritious and more attractive to most sucking insects.
- Use healthy planting material that is free of insects, and of disease symptoms.

If regular field observation is practiced, a farmer will not be taken by surprise by insect attack, although some insect populations can develop rather quickly. Monitoring the field can help us locate infestations that are just beginning. In the early stages, an infestation can be managed by:

- Collecting and destroying the plants or leaves where the invading insects are beginning to multiply.
- Collecting and transferring natural enemies such as ladybird beetles and spiders to the part of the field where the pests insects are concentrated.

5.2.4 Leaffolders

There are several kinds of leaffolders that feed on sweetpotato. In Asia, two of the main species are *Brachmia convolvuli* and *Herpetogramma hopponalis*. The adult is a butterfly that lays its eggs on the leaves of sweetpotato plants. After hatching, the larva encloses itself in a folded leaf by spinning a silk thread to hold the leaf closed. Safe from exposure to pesticides, it feeds by scraping the tissue on the leaf surface, leaving only the skeleton of the leaf. The larva makes a cocoon in the folded leaf. The larval stage is the only one that damages the sweetpotato plant.

Natural enemies include spiders, earwigs, ants, dragonflies, ground beetles and parasitic wasps. Often when we open a folded leave, we will find a natural enemy inside, rather than a leaffolder caterpillar.

Black leaffolder

Larva *Adult*

Green leaffolder

Larva *Adult*

5.2.5 Hornworms

There are several hornworms that attack sweetpotato. The most common one is called *Agrius convolvuli*. The adult stage of the hornworm is a large butterfly that can migrate long distances. The pictures below show the life cycle stages of the hornworm.

Egg *Larva* *Prepupa*

Pupa *Adult* *Adult (uncommon species)*

The butterfly lays its eggs on sweetpotato leaves at night. The newly hatched larva is very small, but grows very quickly. The coloration of the larval stage varies considerably as shown in the figures above. The larval period lasts 3-4 weeks. After reaching its full size (up to 9.5 cm), the larva drops to the soil and burrows underground. It forms a pupal case in the soil. Pupation takes 5-26 days, depending on the temperature.

Hornworm larvae have many natural enemies including parasites (wasps and flies) and pathogens. Diseases caused by viruses are especially important. Nevertheless, the long distance migration capability of the adults means that when an area is newly invaded, the natural enemy numbers may be very low and an explosion of the population of hornworm larvae may occur. This situation can threaten a sweetpotato crop since a large population of larvae can defoliate a whole field very rapidly. If this occurs during the early stages of growth of the crop, or during the time of root formation, yield can be seriously reduced. When the population is still low, handpicking the larvae from the leaves is usually sufficient. Plowing the land between crops exposes the pupa, drastically reducing their chances of survival.

5.2.6 Armyworms

Another kind of sweetpotato foliage feeder is the armyworm. The most important species in Asia are *Spodoptera exigua* and *Spodoptera litura*. The eggs of armyworms are laid in clusters and may be covered with a layer of a felt-like substance. The caterpillars hatch after 3.5 days and take about 2 weeks to reach the pupal stage. The larvae prefer moist sites and may hide in the soil during the day, emerging to feed on plants at night. Initially larvae feed by scraping the leaf surface. As they grow larger, they begin to feed more extensively, leaving only the veins. Pupation occurs in the soil. The development of the common armyworm species from egg to adult takes about 3.5-4 weeks. A *S. exigua* female adult can lay up to 1,000 eggs, whereas *S. litura* can produce as many as 2,000-2,600.

Natural enemies include pathogenic fungi and viruses, predatory bugs, wasps, ground beetles and spiders. More than 40 species of parasitic wasp and flies are known. Several weeds (e.g. amaranthus, water spinach) are hosts for armyworms and should be eliminated when armyworm populations become too high. Caterpillars are susceptible to the biopesticide Bt which at severe infestation could be used for spot application.

Spodoptera exigua

(MS) *Egg mass* *Larva* *(MS)* *Adult*

Spodoptera litura

5.2.7 Tortoiseshell beetles

The tortoiseshell beetles (*Aspidomorpha* spp. and *Cassia* spp.) and their larval stages leave round holes in sweetpotato leaves as they feed. Some tortoiseshells lay eggs in a series of tissue-like layers that form a box-like mass. The larvae are flattened and spiny, and some hold their tails up over their bodies as they walk about. The pupa is less spiny than the larva and is fixed to the leaf. All the life stages are found on both sides of sweetpotato leaves.

The life cycle of the gold tortoiseshell beetle (*Aspidomorpha elevata*) ranges from 3 to 6 weeks, depending on environmental conditions. Several natural enemies including egg and larval parasites and predators have been reported. Control of tortoiseshell beetles is rarely warranted, since the damage on the leaves seldom causes economic root yield loss.

5.3

Types of egg masses

Types of larvae

Types of adults

Damage syn

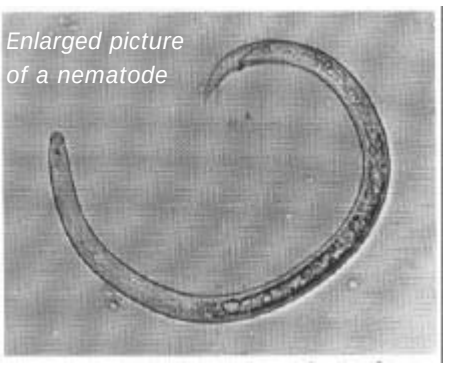
Diseases

5.3.1 Types of diseases

Diseases of plants, like those of humans and animals, may be caused by:

- Nematodes.
- Fungi.
- Bacteria.
- Viruses.

A. Nematodes


Enlarged picture of a nematode

Nematodes are tiny worms that live in the soil and in root tissues. Some species are visible to the human eye with the aid of a magnifying glass, but most can only be seen with a microscope. Their presence is suspected from the symptoms they cause. They cause blister-like swellings or cracks on the edible roots, gall-like swellings on the fibrous roots, and large portions of the root system may die. Nematode egg masses survive in the soil and rotting plant material may harbor the juvenile stages. They can be transported by irrigation water and disseminated through infested planting material.

B. Fungi

Fungi usually cause affected plant parts to rot. Other symptoms include the appearance of spots, powdery areas, or masses of filaments. Powdery growths are composed of fungal spores that can spread to other plants. Fungal spores are like the seeds of green plants—when we observe them, we can be sure that the development of the fungus within the plant has already occurred. Common sweetpotato diseases caused by fungi include scab, root rots and

black rots. Some other fungal diseases infecting the leaves are *Alternaria*, *Cercospora* and *Phyllosticta*. See pictures of symptoms of fungal diseases on the next page.

Symptoms of fungus infections

Scab *Cercospora*

(APS)

Alternaria *Phyllosticta* *(APS)*

(APS) *new symptoms* *old symptoms*

Black rot)

Black rot infestation inside and outside the root

(APS) *(APS)*

C. Bacteria

Bacteria are smaller than nematodes and fungi. They are not visible except under a microscope. Bacteria can cause the formation of wound-like lesions, rotting, and plant death.

D. Viruses

Viruses are different from other organisms because they are much smaller than any other creature. They can only live and multiply inside their hosts (or victims). Once a virus enters a cell in the body of its host, it will take over the

management of the cell's processes, and force the cell to produce more viruses identical to itself. These viruses can then infect more cells. Viruses can attack both animals and plants, but specific types of viruses mostly have specific targets. Each virus causes a specific disease, for example the *influenza* virus causes flu in humans, the *tungro* virus makes rice plants sick, and the *sweetpotato featherly mottle virus (SFMV*) attacks sweetpotato.

The symptoms of virus attack on plants include dwarfing, leaf curling, and the appearance of purple pigment, yellowish spots, yellow veins or mosaic patterns. Heavily virus-infected plants can be detected by their stunted growth and/or yellow leaves of irregular shape. Many viruses are transmitted by aphids or other sucking insects and only a few insects can infect an entire field with virus.

Symptoms of virus infections

Dwarfing *Mottling*

Curling
(SF) *and dwarfing* *(APS)* *(SF)*

" *Yellowing of veins*

(SF) *(SF)* *(SF)*

(APS) *(APS)* *Witches' broom: dwarfing and irregular flowering*

Witches' broom" is a symptom caused by a virus-like organism (a phytoplasma). Plants containing this organism show dwarfing and abnormal development of flowers.

5.3.2 Common sweetpotato diseases

A. Scab

Scab is also called scabies. The causal fungus is called *Elsinoe batatas*. The early symptoms of scab are small brown lesions on the leaf veins and stems. As the scab fungus spreads, the lesions spread and curling and deformation of the foliage occurs. Scab can cause yield losses as high as 50%. Formation of the roots may be affected by the disease.

The resistance level of sweetpotato varieties to scab varies greatly. Some varieties are very susceptible. However, highly resistant varieties also occur, and some show little damage even during the warm, moist conditions that favor the development of the disease. Infected planting material can result in the infection of a whole field, and the disease spreads easily from one field to the next. Planting of infected cuttings is the main way of spreading scab.

B. Root rots

Several fungi and bacteria cause root rots. Once a rotting occurs it cannot be reversed. Infected plants must be destroyed to prevent further spread of the disease. Cuttings should be taken from vine sections that have not been in contact with the soil, since the soil can harbor root rot organisms. Planting material should not be obtained from fields where there are many rotten roots. Since the fungi and bacteria that cause root rots can survive in the soil for a long time, sweetpotato should be planted in rotation with other crops in order to avoid a build-up of disease.

Black rot is a root rot caused by a fungus, but in this case the rotting is dry. Sunken grayish-black lesions form on the surface of the root. Black spine-like structures of the fungus sometimes protrude from the lesions. A smell of alcohol like that of fermenting fruit is often present. In severe infections, yellowing, wilting, stunting and death of affected plants can occur. The use of planting material infected by the black rot fungus perpetuates the disease.

As with wet rots, cuttings taken from plant parts in contact with the soil surface may be infected or harbor fungal spores. The black rot fungus can survive in the soil for 1-2 years. The spread of black rot at harvest time is a particular problem since spores from infected roots are easily transferred to hands, tools, vehicles and other equipment, from which they can spread far and wide. The sweetpotato weevil also spreads black rot. Females can infect roots as they puncture the surface to feed and lay eggs. Weevils can also spread black rot spores to the foliage.

C. Root cracking

Nematodes are only one of the causes of root cracking. Cracks often occur after alternate rainy and dry spells. Roots developing in dry soil tend to have thin skins that crack easily as the root enlarges. Fungi and bacteria easily infect cracked roots.

D. Feathery Mottle virus

Feathery mottle is the most widespread viral disease of sweetpotato. The disease may reduce yields without causing any visible symptoms. When symptoms do appear, they may be difficult to detect or easily confused with other problems such as nutritional disorders. Faint, irregular yellowish spots, yellowing along the central vein of the leaf or the appearance of purplish pigment may be related to infection with Feathery Mottle virus. Many different aphids can transmit the disease.

5.3.3 Where do diseases come from?

Except for nematodes, which have limited mobility, disease-causing organisms cannot actively search for host plants. Diseases are spread by:

- Water.
- Wind.
- Insects.
- Infected planting material.

Most diseases can often survive in the soil for long periods. Nematodes can survive for a long time in the soil until host plants become available. Fungi and bacteria often have a life cycle stage that is specially adapted to survive unfavorable conditions. They are spread by water, wind and insects. Certain insects with sucking mouth parts can spread viruses from infected plants to healthy ones. Diseases are perpetuated when infected plants are used as planting material.

The development of a disease in a crop depends on many factors, including:

- The level of resistance of the sweetpotato variety.
- The general health of the plant, particularly in relation to nutrition, in that too much N often leads to more intense fungal infections.
- The soil type and composition.
- The temperature and the humidity of the environment. Generally, warm, humid weather and soil favors the growth of fungi.

5.3.4 Sweetpotato disease control

Prevention is the best method to control diseases. Once a disease infects the plant, it is difficult or sometimes even impossible to control it, and it is easily spread to healthy plants. Prevention of disease can be accomplished through:

- Field sanitation practices.
- Use of healthy, uninfected planting material.
- Use of resistant varieties, particularly in the rainy season.
- Maintenance of plant health through good management of fertility and water.

A sweetpotato plant with symptoms of virus infection should be immediately destroyed. Viruses are transmitted from infected to healthy plants through insects that suck the plant sap, such as aphids, planthoppers and whiteflies. Therefore, the control of a virus should include the control of the insect that transmits it. In addition, sweetpotato viruses can spread to the next generation when cuttings or roots of infected plants are used as seed. Sweetpotato plants with the symptoms of virus infection should never be used as seed. In China and South Africa, yield increases of more than 30% have occurred as a result of planting virus-free planting material.

5.4 Weeds

Weeds are unwanted plants that may compete with crop plants. We usually think that they have no beneficial effects when they grow on cultivated land, however weeds are not always harmful. Weeds can be divided into three categories:

- Grasses.
- Sedges.
- Broad-leaved plants.

Weeds can cause losses when:

- They compete with the sweetpotato crop for nutrients, light, water and growing space.
- Their removal is costly.
- They provide a refuge for insect pests allowing their survival during periods when there is no crop growing in the field.

Weeds may be beneficial when:

- They provide a source of green manure that supplies nutrients and organic matter improving the soil structure, when applied as fertilizer.
- They form a covering layer over the soil (a mulch). Mulches protect the soil from the light that causes the loss of water and organic matter.
- They provide a source of food (honey and pollen) and act as a refuge for natural enemies.
- They can be harvested to feed livestock.

Whether weeds are harmful or beneficial depends on their type and numbers, and whether they have alternate uses as mulch or green manure or for feeding. Different types of weeds vary in how much water and nutrient they extract from the soil, their shape and growth habits.

Careful weeding can minimize losses and increase the benefit of weeds. Factors to consider when weeding include:

- Timing: Weeding should be accomplished before the sweetpotato vines cover the soil.
- Selective weeding: Eliminate weeds that compete with sweetpotato, leaving plants that harbor natural enemies. Useful weeds can be cut back if they are too vigorous and can be left on the field as mulch.
- Utilization: Try spreading the cut weeds on the field as a mulch or use them as fodder for livestock.

In places where sweetpotato is planted on ridges, farmers often move down the soil from the sides of the ridges at about five weeks after planting, in order to remove weeds, aerate the plant roots and provide a place for side dressing of fertilizer. The weeds are left in the field as a green mulch. When sweetpotato is planted in beds or straight away in the soil, farmers often leave the weeds in the field and they compete with the sweetpotato crop. Selective weeding could increase the yield in this case.