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PEST OF SWEET POTATO

Insects, Mites and Diseases

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and C.E. Sajise

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and
Crisanta E. Sajise

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FOREWORD

Sweet potato (*Ipomoea batatas* (L) Lam.) is one of the major food crops of the world. It plays an important role in peoples' diet in Asia and the Pacific Islands. In the Philippines, sweet potato ranks first surpassing cassava in terms of area, production and consumption; although it has long been considered as a backyard crop generally resistant to pests and thus seemingly ignored by plant pathologists, entomologists and other crop protectionists. With the increasing commercialization of sweet potato, researchers and extensionists alike are now taking a closer look at this once lowly crop.

Pests and diseases are the most important constraints to sweet potato production. These problems are compounded by almost nonexistent pest management practices.

The **Pests of Sweet Potato: Insects, Mites and Diseases** attempts to describe each pest and how its damage can be prevented or controlled. Included in this volume are appropriate photographs and sections on the biology, description or symptom of each pest, nature of damage, and control measures to guide field workers in recognizing pest problems and help them in their war against pests.

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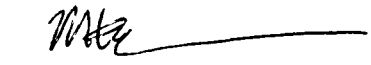

MANUEL K. PALOMAR
Director, PRCRTC

INSECTS AND MITES ATTACKING SWEET POTATO AND THEIR CONTROL

Erlinda A. Vasquez*

In the Philippines, 33 insect and 4 mite species attack sweet potato at different stages of its growth (See Table 1). Most of these pests are plant defoliators.

The arthropod pests of sweet potato can cause direct damage to the tubers by feeding or indirect damage by defoliating or burrowing in vines, both of which reduce yield depending upon the severity of infestation. In addition to feeding, certain insect species such as aphids, leafhoppers and whiteflies transmit most of the virus and mycoplasma-like organisms which cause certain diseases.

These pest species can be classified into two groups: the stem and tuber feeders and the foliage feeders. The first group causes comparatively greater damage to sweet potato than the second, although the latter can threaten sweet potato production during pest outbreaks.

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Table 1. Species of insects and mites attacking sweet potato.

Common Name	Scientific Name
Stem and Tuber Feeders	
Studied:	
Sweet potato weevil	*Cylas formicarius* Fabr.
Sweet potato stemborer	*Omphisa anastomosalis* Guen.
Sweet potato bug	*Physomerus grossipes* Fabr.
Unstudied:	
Brown snout beetle	*Pachyrinchus* sp.
Foliage Feeders	
Studied:	
Leaf miner	*Bedellia somnulentella* Zell.
Black leaf folder	*Brachmia* sp.
Green leaf folder	*Psara hipponalis* Walker
Sweet potato hornworm	*Agrius convulvuli* Linn.
Cutworm	*Spodoptera litura* Fabr.
Brown leaf folder	*Ochyrotica concursa* Wals.
White plume moth	*Aciptilia niveodactyla* Pagenst.
Pink-striped leaf feeder	*Anticrota ornatalis* Dup.
Green tortoise beetle	*Cassida circumdata* Herst.
13-spotted tortoise beetle	*Laccoptera tredecimpunctata* Fabr.
Taro grasshopper	*Gesonula zonocera mundata* Navas
Long-horned grasshopper	*Phaneroptera furcifera* Stal.

Mirid bug	*Helopeltis* sp.
Melon aphid	*Aphis gossypii* Glover
Whitefly	*Bemisia tabaci* Gennadius
Sweet potato spider mite	*Tetranychus marianae* McGregor
Sweet potato false spider mite	*Brevipalpus californicus* Banks

Unstudied:

Tussock moth	*Euchromia horsefieldi* Moore
Semilooper	unidentified
Orange tortoise beetle	*Laccoptera philippinensis* Blanchard
Tortoise shell beetle	*Aspidomorpha miliaris* Fabr.
Small gray snout beetle	unidentified
Slant-faced grasshopper	*Atractomorpha psittacina* Haan
Coreid bug	*Anoplocnemis* sp.
Mirid bug	*Halticus minutus* Reuter
Whitefly	*Aleurodicus dispersus* Russell
Leafhopper	*Bothrogonia ferruginea* Fabr.
Mealybug	unidentified
Flea beetle	unidentified
Broad mite	*Polyphagotarsonemus latus* Banks
Eriophyiid gall-forming mite	unidentified

References: Gapasin, 1981; Jularbal, 1981; Mata, 1984; Corpus-Raros, 1985; and Vasquez, 1988 (personal observation).

STEM AND TUBER FEEDERS

Sweet potato weevil
Cylas formicarius Fabr.
(Coleoptera: Curculionidae)

Biology and description

The eggs are laid singly in holes made by the female in the roots and stems. They cannot be seen easily as they are sealed with brownish gelatinous substance. Hatching of eggs takes place within a week. The larvae start boring into the root or stem depending upon the oviposition site. They feed inside the roots by making tunnels. Feeding lasts for about 2 weeks, during which the larvae undergo 5 instars. Pupation takes place within the tunnel and pupal period lasts for a week. Soon after emergence, the adult stays in the pupal chamber and then cuts its way through the plant tissue. A female adult is capable of laying both fertile and nonfertile eggs. It can lay from 24 to 149 eggs during a period of 54 to 119 days.

The legless larva is whitish with reddish-brown gut. The exarate and sub-ellipsoidal pupa is creamy white and the antlike adult has metallic blue head, forewings (elytra) and abdomen, and reddish-brown legs and thorax (Figure 1a).

Fig. 1a. Larva (top left, 100X), pupa (top right, 130X), and female adult (above, 130X) of sweet potato weevil.

Nature of damage

The adult weevils feed on the tender buds, leaves, roots and tubers while the grubs feed and tunnel into the vines, roots and tubers. The damage in vines is characterized by small feeding and oviposition punctures on the surface and larval tunnels filled with frass in the tissues (Fig. 1b). Damaged tubers have terpene odor and bitter taste making them unfit for human and animal consumption. The damage inflicted by this pest could lead to secondary infection since it provides entrance to pathogens such as bacteria and fungi.

Fig. 1b. Weevil damage on vines (top), and on the external and internal parts of sweet potato tuber (above).

Control measures

Quarantine. Since the weevil does not fly much, it is spread over great distances mostly via infested tubers. An effective quarantine system will reduce the chances of spread.

Cultural. Cultural methods were the earliest control measures recommended for the pest. The possible cultural practices which help reduce weevil damage are as follows:

1. Selection of planting materials

Planting materials are often the primary source of infestation in many situations. Since eggs of the weevil are rarely deposited on the tender portion of the vine, the use of terminal cuttings is recommended.

2. Sanitation

Plant residues often serve as the source of weevil inoculum, thus proper disposal of residues after harvest is essential since the insect may survive in the plant parts and infest the succeeding or neighboring sweet potato crop. Removal of ***Ipomoea*** species which serve as alternate hosts may also help reduce population build-up of weevils.

3. Crop rotation

Crop rotation, wherein sweet potato is planted in sequence with vegetables or staples in the same field, reduces weevil infestation.

4. Hilling up

Soil cracking, which exposes storage roots to weevil infestation, can be prevented by hilling up.

5. Early harvesting

Prompt harvest may help avoid infestation since weevils appear serious if harvesting is delayed.

6. Mulching

Covering the planting area with rice straw or plastic mulch also reduces weevil infestation.

A preplanting mulch of organic materials like Mahwa cake (***Madhyka indica***) or ***Callophyllum*** cake @ 2,000 kg/ha, and leaves of lemongrass ***(Cymbopogon flexosus)***, ***Clerodendron infortunatum*** and ***Chromolaena odorata*** @ 5 t/ha has been found effective in reducing weevil infestation.

Use of resistant cultivars. Resistant varieties should be chosen if available. Deep-rooting varieties with long necks between the tubers and the stems can be used since they generally produce elongated or spindle-shaped tubers which provide physical barrier for the entrance of sweet potato weevil to the tuberous roots.

Sex pheromone. The pheromone (z)-3-dodecen-1-o1-(E)-2-butenoate of the female sweet potato weevil showed remarkable potency in attracting and mass trapping males of ***C. formicarius***.

Chemical control. The following chemicals have been proven effective without restriction for their use:

Carbofuran

Dipping of sweet potato cuttings in a **carbofuran** solution (0.05% a.i.) for 20 minutes before planting can rid the source of weevil in the new planting.

2. Fenthion or fenitrothion

Foliar spraying of **fenthion** or **fenitrothion** at 0.5% one month after planting and thrice at triweekly interval thereafter, or soil drenching using the same chemicals at 0.05% twice, at 50 and 70 days after planting (DAP), can prevent weevil population build-up.

3. Carbofuran and phorate

Carbofuran and **phorate** granules @ 1.5 kg a.i./ha applied once 45 DAP were effective for weevil control. **Phorate** gave the highest cost benefit of 1:18.9.

4. Carbosulfan and endosulfan

Carbosulfan (0.025% a.i.) and **endosulfan** (0.10%) sprayed twice, at 59 and 78 DAP, afforded a benefit/cost value of 24.32 and 22.87, respectively.

Biological control. Parasites, predators, and pathogens have been recorded to attack the weevil at its different development stages (See Table 2). ***Metarhizium anisopliae*** has been identified as a potential microbial control agent of the weevil. Nuclear polyhedrosis virus (NPV) and a bacterium were observed infecting the grubs.

Table 2. Natural enemies of *Cylas formicarius* and their families, orders, country and reference.

Parasitic Insects (Braconidae: Hymenoptera)	
Microbracon cylasovorus Rohwer	Philippines;
Bassus cylasovorus Rohwer	Gonzales (1925)
Bracon cylasovorus Rohwer	Philippines; Eusebio (1983), Esguerra and Gabriel (1969)
Agathis cylasovorus Rohwer	Philippines; Esguerra and Gabriel (1969)
Microbracon mellitor (Say)	U.S.A.;
Microbracon punctatus Mues.	Cockerham (1964)
Metapelma spectabilis Westw.	
Rhaconotus sp.	India; Rajamma
Bracon sp.	and Premkumar (1984)
Predatory insects:	
Euborella sp. (Dermaptera)	Philippines;
Tetemorium sp. (Hymenoptera)	Eusebio (1983)
Drapetis sp. (Empididae: Diptera)	India; Rajamma and Premkumar (1984)
Pheidole megacephala (Formicidae: Hymenoptera)	Casteineras, et al. (1982)
Parasitic nematodes:	
Rhabditis sp. (Rhabditidae)	U.S.A.; Cockerham,
Aphelenchus avenae (Aphelenchidae)	et al. (1954)
Neoaplectana sp. (Neoaplectanidae)	Swain (1943)
Entomopathogenic fungi:	
Fusarium sp. (Moniliales: Tuberculariaceae)	U.S.A.; Cockerham, et al. (1954)
Beauveria globulifera and	U.S.A. (Hawaii);
B. bassiana (Moniliales: Moniliaceae)	Sherman and Tamashiro (1954)
Isaria sp. (Moniliales: Stilbaceae)	U.S.A.; Kemner (1924) as cited by Sutherland (1986)

Source: Villacarlos, L.T. 1989.

Sweet potato stem borer
Omphisa anastomosalis Guen.
(Lepidoptera: Pyralidae)

Biology and description

The eggs are laid singly or in groups of 2 to 3 eggs in crevices on the stem or in a single row of 6 or more eggs along the midrib of the leaf. The larva emerges after an incubation period of 3-8 days. Newly-hatched larva has a reddish tinge on its body and black head. After few days, it turns yellowish white with blackish markings on both the dorsal and lateral sides of the body. Setae are sparse and brown becoming more noticeable as the larva matures. Full-grown larva reaches 30 mm long. There are 5 larval instars with total developmental period of 12-50 days. Pupal period ranges from 3 to 4 days. Pupation takes place in a thin cocoon within the tunnel close to the tubers. The adult is a moth of medium size (15 mm long), with very light brown wings and reddish brown head and body.

Fig. 2. Larva of **O. anastomosalis** *feeding on and tunneling into the stem of sweet potato (1.5X).*

Nature of damage

The larva bores into the main stem and sometimes penetrates the tubers. Larval feeding produces large tunnels causing hollow cavities in the stem (Fig. 2) resulting to wilting and eventual death of infested plants. Attack at early stages of plant growth prevents tuberization since translocation of food and its storage in the roots become severely affected. Further damage occurs when the larva tunnels into the tubers making them nonmarketable.

Control measures

Cultural. Crop hygiene and crop rotation.

Chemical. **Carbaryl** at 0.1% a.i. or **BHC** at 0.1% sprayed at fortnightly intervals is recommended. Biweekly spraying of **deltamethrin** at the rate of 0.025 kg a.i./ha or broadcasting of **carbofuran** at the rate of 2 kg a.i./ha around the stem can give excellent pest control and double the root yield. The latter treatment, however, is not very economical.

Sweet potato bug
Physomerus grossipes Fabr.
(Coleoptera: Curculionidae)

Biology and description

The eggs of this species are laid in groups on the underside of the leaves or on the stem. The mother bug stays with its eggs and young which are gregarious. The incubation period is 15.82 days with 86.83% hatchability. The bug passes through 5 nymphal instars. Total developmental period is 85.45 days for males and 87.49 days for females. The adult bug is brown, about 20 mm long, and with enlarged thighs. Plant species such as ***Ipomoea aquatica, I. triloba*** and ***Basella rubra*** could serve as hosts of the insect.

Nature of damage

The nymphs (Fig. 3) and adults pierce the stem and suck the sap of sweet potato, causing the plants to stunt.

Control measure

It is too minor a pest to require control measures.

Fig. 3. Nymphs of **P. grossipes** *feeding on stem and petiole of sweet potato (1X).*

FOLIAGE FEEDERS

Leaf miner
Bedellia somnulentella (Zell.)
(Lepidoptera:Lyonitidae)

Biology and description

The eggs are laid singly or in groups usually on the lower surface of the leaf near the midrib, veins or at the base of the leaf blade. Incubation period lasts 5-6 days. This insect has 5 larval instars. The larva has a yellowish body with paired pink spots on the dorso-lateral side of the thorax which later disappear and are replaced by red tubercles in all segments (Fig. 4a). During the fifth instar, the larva undergoes a short prepupal period, comes out of the mine and produces numerous silken threads which fix and support the pupae on the nether surface of the leaf (Fig. 4a). The total larval period ranges from 6 to 20 days. Pupation, which lasts 3-6 days, occurs a day after the larva comes out of the mine. The adult is a very small moth (3.5-4.0 mm) with grayish to brown body and light brown scales. A female adult is capable of laying 1 to 67 eggs with an average of 20 eggs per female within a period of 1-2 days of oviposition.

Fig. 4a. Leaf miner larva (25X), pupa (25X), and pupae suspended on silken threads.

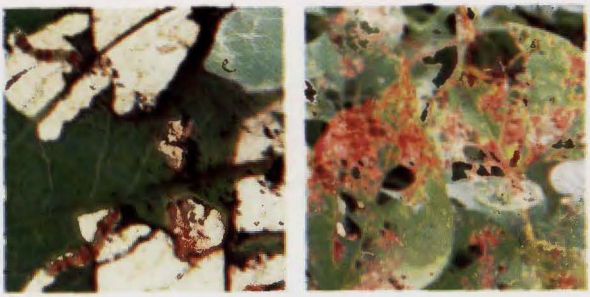

Fig. 4b. Blotch mines on leaves caused by leaf miner; heavily infested leaves.

Nature of damage

The young larva enters the leaf and forms a serpentine mine at first. As the larva matures, it forms blotch mines. The larva feeds inside the mine leaving the epidermis intact. During severe damage, the leaf becomes brown and shrivelled and later shows numerous holes as the mine tissues are destroyed (Fig. 4b). The lower surfaces of the heavily infested leaves become dirty and blackish, and show silken webbings where the insect pupates. A serious outbreak can cut down the effective leaf surface resulting in reduced tuber yield.

Control measures

Biological. Generally, leaf miners are controlled by predators and parasites like ***Apanteles*** sp.

Chemical. The insecticides recommended for leaf miner control are the following: **carbaryl, chlorfenvinphos, diazinon, dimethoate, endosulfan, malathion** and **trichlorphon.**

Use of insect-free planting materials.

Black leaf folder
Brachmia sp.
(Lepidoptera:Gelechiidae)

Green leaf folder
Psara hipponalis Walker
(Lepidoptera:Pyralidae)

Biology and description

Yellowish white oval eggs of the black leaf folder are laid singly on the leaf. Incubation period is about 3-5 days. The insect undergoes 5 larval instars lasting from 2 to 5 days each, with a total larval period of 10.18 days. The larva has prominent black and white markings on the thorax and the abdomen (Fig. 5a). The pupal period is 4-7 days. The adult leaf folder moth is grayish black. A female moth lays an average of 44 eggs during its 5-day adult life.

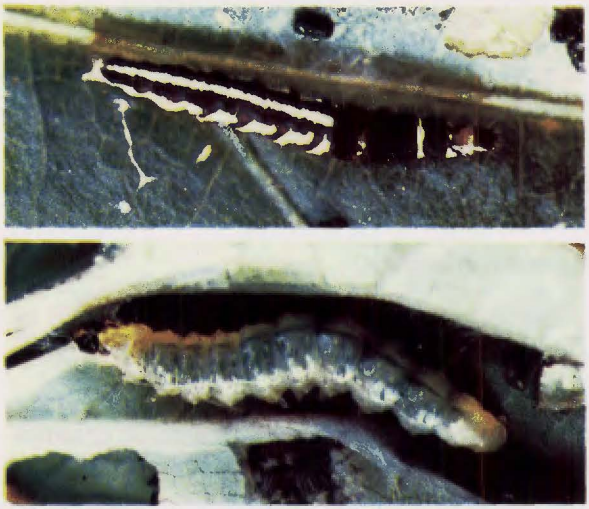

Fig. 5a. Larvae of black (top) and green (above) leaf folders (20X).

Fig. 5b. Leaf folds formed by black (top) and green (above) leaf folders.

Besides sweet potato, the black leaf folder can complete its development only on ***Ipomoea triloba*** and ***I. aquatica.***

The eggs of the green leaf folder are usually laid in groups on the upper surface of the leaf near the midrib. The green shiny oblong eggs are covered by a scale-like gelatinous material. Incubation period takes 3-6 days. The green leaf folder undergoes 5 larval instars which last from 6 to 31 days. The larva is greenish yellow with sparse brown setae and dark brown head and prothoracic plate (Fig. 5a). The pupal

period lasts from 4 to 8 days. The adult is a yellowish brown moth with dark brown markings on its wings. The female adult moth lays an average of 90 eggs during its 3-day life span.

The green leaf folder can complete its development only on ***I. triloba, I. purpurea, I. aquatica, I. pes-caprae*** and ***Mekania macrantha.***

Nature of damage

The black and green leaf folders cause considerable injury to the plants in the field at all stages of plant growth. The larvae of these two species feed inside the folded leaf, leaving the lower epidermis intact. Only one larva is found per leaf fold. The damage caused by these two species can easily be distinguished from each other by the leaf folds they produce. The black leaf folder larva folds the leaf margin only once while the green leaf folder larva folds it twice with the folded area showing some webbings. (Fig. 5b). The holes resulting from feeding of the black leaf folder are smaller than those produced by the green leaf folder. Damage caused by both species results in a lace-like appearance of the leaf while the main leaf veins are left intact.

Control measures

Chemical. Carbaryl, fenitrothion and **trichlorphon** in high and low volume sprays are recommended.

Biological. *Brachymeria* sp. and another hymenopterous parasite attack the green leaf folder while ***Macrocentrus*** sp. and an earwig species attack the black leaf folder.

Use of insect-free planting materials.

Sweet potato hornworm
Agrius convulvuli Linn.
(Lepidoptera: Sphingidae)

Biology and description

Spherical eggs are laid singly on either surface of the leaves. Egg hatching takes place 4 days after oviposition. The larva has a prominent posterior horn. Its color varies from green to brown with distinct patterns (Fig. 6a). There are 5 larval instars with an average of 2 to 5.8 days per stadium. The larva matures within 13 to 25 days and reaches 95 mm in length. Pupation takes place in the soil. The reddish brown pupa is characterized by its prominent proboscis which is curved downward (Fig. 6b). Pupal period is from 5 to 10 days. The adult is a large greyish brown hawkmoth with black lines on the wings and pink markings on the abdomen. The total life cycle ranges from 22 to 39 days.

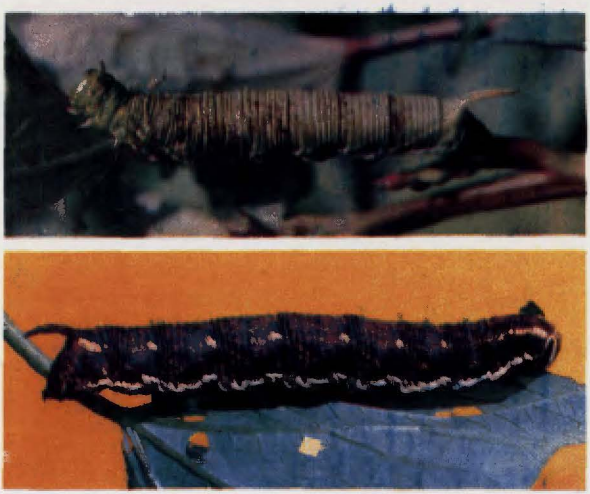

Fig. 6a. Color dimorphism in sweet potato hornworm (top, 0.7X; above, 1.08X).

Nature of damage

The larva is a large voracious caterpillar that is capable of defoliating the plant. It feeds on the leaf blade causing large irregular holes and may eat the entire leaf blade leaving only the petiole.

Control measures

Cultural. Plowing the field to expose the pupae reduces infestation. Handpicking of the larvae may be quite effective in small areas.

Chemical. If insecticide application becomes necessary, a relatively safer and cheaper chemical, like **malathion**, will control this pest since larvae are external feeders and can easily come in contact with the chemical and be poisoned.

Fig. 6b. Pupa of sweet potato hornworm (1.5X).

Common cutworm
Spodoptera litura Fabr.
(Lepidoptera: Noctuidae)

Biology and description

Eggs are laid in mass containing up to 500 eggs which are covered with short buff-colored hairs. Incubation period is 3 days. Newly-hatched larva is greenish and gradually turns brownish black as it matures. A transverse band appears on each side of the body (Fig. 7). Total larval period ranges from 12 to 20 days. The obtect pupa is dark brown in color (Fig. 7). Total life cycle is 27-32 days. The adult is a brownish moth with silvery markings on its forewings.

Nature of damage

The cutworm feeds on young and mature leaves making large holes on the blades. During severe infestation the plant is totally defoliated.

Fig. 7. Larva (4X) and pupa (4X) of sweet potato cutworm.

Control measures

Light trapping. Light is placed over basins of water set in various parts of the field to trap the adults.

Chemical. Several insecticides have been recommended for cutworm control. These include **diazinon**, **malathion**, **acephate**, **mevinphos**, **metamidophos**, **phenthoate** and baits using 10 kg of bran or sawdust, 8-10 liters of water, 1 liter of molasses and 100 g of **trichlorphon**.

Biological. A species of entomogenous fungus, probably ***Nomuraea*** sp. has been observed infecting some larvae in the field.

Brown leaf folder
Ochyrotica concursa Wals.
(Lepidoptera: Pyralidae)

Biology and description

Oblong and brownish yellow eggs are laid singly along the veins of the shoots, especially the very young unopened leaves. The eggs hatch 4 to 5 days after they are laid. This insect undergoes 5 larval instars with a total larval period ranging from 8 to 17 days. The larva has greenish color which acquires brownish tinge as it matures (Fig. 8a). Pupal period is 5 to 6 days. The adult is a dark brown moth (Fig. 8a). The duration from egg-laying to adult emergence is 17 to 28 days.

Fig. 8a. Larva (top, 50X) and adult (above, 10X) of brown leaf folder.

Nature of damage

The brown leaf folder attacks the shoots and prefers young unopened leaves. The larva feeds between the folded leaf blades. The young larva feeds on the upper epidermis leaving the lower epidermis intact so the feeding area appears silvery from a distance. As the larva matures, it eats right through the leaf blade producing large irregular holes on the young unopened shoot. The feeding area turns brown and is littered with blackish excreta (Fig. 8b).

Fig. 8b. Damage of brown leaf folder on sweet potato leaves.

Control measure

Biological. Only one species of hymenopterous parasite is observed attacking pupae in the field.

White plume moth
Aciptilia niveodactyla Pagenstecher
(Lepidoptera: Pterophoridae)

Biology and description

Hemispherical greenish white eggs are laid on either surface of the leaf and hatch 4-5 days after oviposition. Earlier instars are greenish with long white hairs arising from tubercles (Fig. 9a). In later instars, black hairs alternate with white hairs. There are 5 larval instars with a total larval period of 6 to 18 days. The pupal period lasts 3-6 days. The adult is a small moth (7-8 mm) with white body and feather-like wings (Fig. 9b). A female is capable of laying 25 to 129 eggs during an oviposition period of 2 days.

Fig. 9a. Larva of white plume moth (50X).

Nature of damage

The larva feeds on young shoots, preferring the leaves that have not yet opened. On open leaves, it folds together both sides of the blade and feeds inside the fold. The young larva feeds on the upper epidermis only, leaving the lower epidermis intact. The older larva feeds right through the epidermis producing numerous holes, and sometimes eats the entire

leaf blade leaving only the petiole. The damaged leaf does not turn brown unlike that attacked by the brown leaf folder. During severe infestation the plants are heavily defoliated.

Control measure

Biological. ***Apanteles*** sp. attacks larvae of the white plume moth. Parasitism had been recorded in the field to range from 1.4 to 20 percent

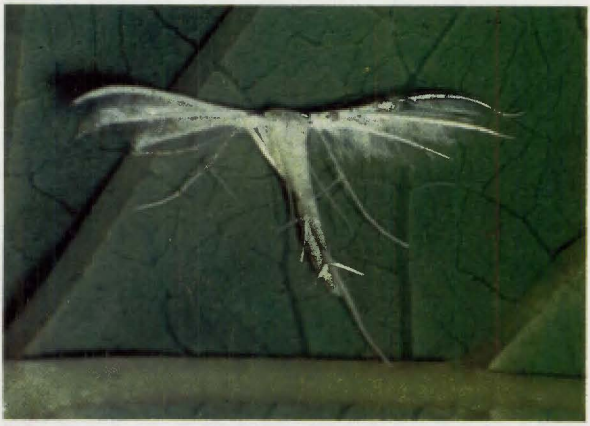

Fig. 9b. Adult of **A. niveodactyla** *(20X).*

Pink-striped leaf feeder
Anticrota ornatalis Dup.
(Lepidoptera: Pyralidae)

Biology and description

Flat disc-shaped eggs are usually laid around the leaf margin or along the veins and are arranged in an overlapping manner. Incubation period lasts from 3 to 6 days. The insect has 5 larval instars with a total larval development period of 7-22 days. Pupal period ranges from 3 to 7 days. A total life cycle of 14 to 29 days has been recorded.

Newly-hatched larva is transparent white and turns yellow as it matures. The pinkish mid-dorsal stripe becomes prominent during the early fourth instar. The stripe appears greenish brown in the third instar. The adult is a small tan moth with wide dark brown band on its wings.

Nature of damage

The larva feeds on the shoots leaving irregular holes on the leaves. A mature larva can eat the entire leaf blade leaving only the petiole.

Control measure

Control for this insect is unnecessary since population in the field is quite low.

Tortoise shell beetles
Aspidomorpha miliaris Fabr.
(Coleoptera: Chrysomelidae)

Orange tortoise beetle
Laccoptera philippinensis Blanchard
(Coleoptera:Chrysomelidae)

Green tortoise beetle
Cassida circumdata Herst.
(Coleoptera:Chrysomelidae)

13-spotted tortoise beetle
Laccoptera tredecimpunctata Fabr.
(Coleoptera:Chrysomelidae)

Biology and description

Information on the biology of the tortoise beetles is sparse. Of the 4 species recorded, only 2 (green and 13-spotted tortoise beetles) had been studied.

The most common species is the green tortoise beetle. Its adult is greenish yellow marked with three irregular black longitudinal bands on the elytra, the middle one along the suture (Fig. 10a).

The pale green egg case containing a single egg is laid on either surface of the leaf. Incubation period is 4-7 days. The larva is very flat and green in color. It has 32 marginal and 2 subanal light green spines and laterally hemmed in with minute spinules and white stigmata. The larva undergoes 5 instars. The oval pupa is light green. Pupation occurs on both surfaces of a leaf, with all the larval skin attached to the pupa. Pupal period ranges from 3 to 7 days. Total life cycle is about 27 days.

The adult of the 13-spotted tortoise beetle is distinguished by its golden brown color with 11 black spots on the elytra and 2 small black spots on the prothorax (Fig. 10a).

The eggs are laid in brown parchment-like membrane of the leaf. The incubation period is 5-6 days. The golden brown to brownish orange larva is flat with fleshy and branching lateral spines. The insect has 5 larval instars with a total larval period of 6-30 days. During each molt, the exuvium becomes attached to a pair of long fleshy subanal spines and appears as a black mass of dirt. The larva attaches itself firmly on the underside of the leaf when about to pupate. Pupal period is 3.7 days. A total life cycle of 14 to 46 days has been recorded. A female beetle lays relatively few eggs, about 1 to 7, during its entire laying period of 2.12 days.

Both the green and 13-spotted tortoise beetles could thrive on alternate hosts belonging to ***Ipomoea*** species.

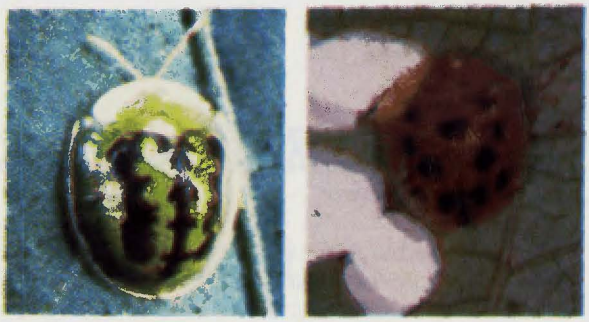

Fig. 10a. Adults of green (30X) and 13-spotted tortoise (10X) beetles.

Nature of damage

The larvae and adults feed on the leaves producing rounded holes on the leaf blades (Fig. 10b). The holes made by ***C. circumdata*** are smaller than those made by the other 3 species. During severe infestation, the larvae and adults can defoliate a whole plant leaving only the stalk and midribs.

Fig. 10b. Sweet potato leaves attacked by tortoise beetles.

Control measures

Cultural. Weeds belonging to the Family Convulvulaceae should be controlled because tortoise beetles can breed on them.

Chemical. Carbaryl at 1 kg a.i./ha and **endosulfan** at 500-700 g a.i./500 liters of water/ha have been found effective. **Malathion** and **MIPC** at manufacturer's recommended rate applied at 7-14 days interval can also effectively control tortoise beetles.

Melon aphid
Aphis gossypii Glover
(Homoptera: Aphididae)

Biology and description

The nymphs of aphids are green to brown and molt four times before reaching the adult stage. Adults are yellowish to green (Fig. 11a) or black, about 1.5 mm long. Females are parthenogenetic and viviparous, each producing 15-20 nymphs a day. ***A. gossypii*** transmits many virus diseases to various crops. Several generations occur a year.

Fig. 11a. Melon aphids feeding on the undersurface of sweet potato leaf (1X).

Nature of damage

Aphids usually attack the growing shoots. They feed on the underside of the leaves and injure the plants by sucking the sap. The leaves curl down at the edges, become wrinkled and discolored (Fig. 11b). During heavy infestation, the vigor of the plant is greatly reduced. Aphid damage also stunts growth of the plant.

Fig. 11b. Damage caused by melon aphid on sweet potato leaves.

Control measures

Biological. Lady beetles (***Chilomenes sexmaculata*** and ***Coelophora inaequalis***), chrysophid predator (***Chrysopha oculata***) and syrphid (***Scymnus*** sp.) prey on melon aphid nymphs and adults.

Chemical. Insecticides like **carbaryl, diazinon, malathion, permethrin** and **decamethrin** are recommended for aphid control.

Whiteflies
Bemesia tabaci Gennadius
(Homoptera: Aleyrodidae)

Aleurodicus dispersus Russell
(Homoptera: Aleyrodidae)

Biology and description

The female of ***B. tabaci*** lays eggs on the underside of the leaves. Only the first larval stage bears legs; later, the larvae (each about 1 mm long) develop into pale yellowish flattened oval and scale-like bodies on the leaves. Oval pupal case (1.16 mm x 0.80 mm) is pale or dark yellow with dorsal pores and markings and various ventral fringes. Adults have 2 pairs of wings, about 1 mm long and slightly covered with white waxy bloom (Fig. 12b). Development of one generation takes 3 to 4 weeks.

The biology of ***Aleurodicus dispersus*** has yet to be studied. What has been reported is only a brief description. Pupa has on its back fine wax threads about 12-15 mm long and 6 pores which secrete wax (Fig. 12a).

Fig. 12a. Pupae of **A. dispersus** *(80X).*

Fig. 12b. Adults of **A. dispersus** *(100X).*

Nature of damage

High whitefly population may cause yellowing and necrosis of infested leaf. A sooty mold often found growing on whitefly excretions, may have adverse effect on photosynthesis.

Control measure

Biological. The nymphs are attacked by two hymenopterous insects, namely, ***Prospaltella clypealis*** Silvestre and ***Prospaltella*** sp.

Sweet potato mirid bug
Helopeltis sp.
(Hemiptera: Miridae)

Halticus minutus Reuter
(Hemiptera: Miridae)

Biology and description

The eggs of this bug are laid singly or in groups on the soft tissues of the host (Fig 13a). Egg incubation lasts 5-6 days with 89.87% hatchability. The bugs pass through 5 nymphal instars, with a total developmental period of 15.18 days for the males and 15.66 days for the females. Adults live for 2-32 days.

Fig. 13a. Egg of sweet potato mirid bug (100X).

The nymphs are orange in color with 2 pin-like projections arising from the middle mesothorax (Fig. 13b). The adults measure about 6 mm long. The male and female can be differentiated by its color; the male has black head, thorax, and wings and white basal end of the pin-like projection of the thorax, while the female has black wings and yellow orange basal end of the pin-like projection (Fig. 13c).

Nature of damage

Adults and nymphs feed on the young shoots of sweet potato. The damage is characterized by water-

soaked lesions, blackening or malformation of the feeding site and finally drying up of the shoots (Fig. 13d). The insects are observed to be abundant during the rainy season.

Fig. 13b. Nymphs of sweet potato mirid bug (50X).

Fig. 13c. Male and female adults of sweet potato mirid bug (10X).

Fig. 13d. Leaf damaged by sweet potato mirid bug.

Control measure

Biological. Species of spider and reduviid bug attack the first and second instars of the pests. Another species of spider preys on both the nymphs and adult while a species of ant feeds on newly-hatched nymphs.

Long-horned grasshopper (katydid)
Phaneroptera furcifera Stal.
(Orthoptera:Tettigonidae)

Slant-faced grasshopper
Atractomorpha psittacina Haan
(Orthoptera:Acrididae)

Taro grasshopper
Gesonula zoriocera mundata Navas
(Orthoptera:Acrididae)

Biology and description

Biological data on these grasshoppers are very few. So far, only the long-horned grasshopper and taro grasshopper had been studied, although they were reared on plant hosts other than sweet potato.

Eggs of ***P. furcifera*** are inserted by females singly or in linear groups into tissues of the host or the woody portion of the twigs. Incubation period is about 20 days. There are 4 nymphal instars lasting from 30 to 41 days. Nymphs are grass-green and measure about 17 mm (male) and 13.76 mm (female) long.

Fig. 14a. Male and female adults of slant-faced grasshopper (1X).

Adult female is about 27 mm long, and foliage-green with brownish red veins on hindwings. Adult life span is about 28 days. The female is capable of laying as many as 149 eggs.

The adult of ***A. psittacina*** is characterized by a pointed conical head. It measures about 30-40 mm. The upper part of the female body is green while that of the male is brownish (Fig. 14a). The hindwings are hyaline with pinkish base.

Fig. 14b. Adults of taro grasshopper (1X).

Using its ovipositor, the female ***G. zonocera mundata*** bores into the petiole of the host plant where it lays its eggs in clusters. It then protects the eggs with reddish brown gummy substance. Nymphs are sometimes semiaquatic as they have been found on water plants like taro, its primary host, and water hyacinth. The adult is about 30 mm long and pale brown or green. It has black stripes running from eyes to tips of wings (Fig. 14b). Knees or hind legs are black. Tibia are bluish and have white black-tipped spines.

Nature of damage

The polyphagous nymphs and adults feed on foliage. They are voracious and sometimes consume the entire leaf.

Control measures

Biological. Under field conditions, eggs of taro grasshopper are parasitized by ***Scelio*** sp. and unidentified chalcids.

Chemical. Pirimiphos methyl and **endosulfan** at manufacturer's recommended rate are effective against taro grasshoppers.

Sweet potato spider mite
Tetranychus marianae McGregor
(Acarina: Tetranychidae)

Biology and description

The life cycle of this species includes four developmental stages, namely: egg, larva, protonymph and deutonymph. The eggs are deposited singly and scattered on the undersurface along or near the midrib or veins of the leaf. Incubation period lasts 3-5 days. The newly-hatched embryo is very small, round, pale yellow and with distinct red eye. It can easily be distinguished for having only three pairs of legs. Upon feeding, its body color turns yellowish green with black dorsolateral marks. Larval period takes about 1-2 days. The protonymph has four pairs of legs and greenish oval body. The deutonymph appears like the protonymph but is bigger.

Protonymphal period ranges from 1 to 2 days while the deutonymphal period, 1 to 3 days. The total developmental period takes about 7-10 days for both

Fig. 15. Leaves attacked by sweet potato spider mites.

sexes. The adult is similar in shape to the deutonymph but bigger and has relatively longer legs. The newly-emerged adult is pale orange but as it grows older, its color becomes carmine red and black markings appear dorsolaterally. The male remains yellowish green like the immatures. Females are capable of parthenogenetic reproduction with unfertilized eggs developing into males exclusively. Mated females are more fecund than immature ones, the former laying an average of 133.7 and the latter 60.8 eggs during their entire life time.

Nature of damage

Adults and nymphs of spider mites suck the sap from the leaves, causing the areas around their feeding punctures to become chlorotic and appear as conspicuous stipplings on the undersurface (Fig. 15). Under heavy infestation, photosynthesis is greatly reduced and the chlorotic areas may coalesce so that the leaves eventually turn yellow and later brown, become scorched, and drop prematurely.

Control measures

Biological. Coccinellid (***Stethorus*** sp.) and staphylinid (***Oligota*** sp.) beetles, unidentified thrips, cecidomyiid maggots and phytoseiids have been observed preying on spider mites.

Chemical. If spraying is necessary, acaricides under various trade names can be used to control sweet potato spider mites.

False spider mite
Brevipalpus californicus Banks
(Acarina: Tetranychidae)

Biology and description

The adult female can lay an average of 4.3 eggs in 20 days. Incubation period is 3 days with 97% hatchability. The mite undergoes 3 molts with an average duration of 2.5 days for both larva and deutonymph and 1.7 days for protonymph. The mean duration of the developmental period (egg hatching to adult emergence) is 6.9 and 6.8 days for the female and male, respectively.

The egg is bright orange, smooth, plain and oblong in shape. Newly-hatched larva is bright red orange and ovoid. It is identified by three pairs of stout legs and orange body. The protonymph has four pairs of legs and the body is ovoid. It is 3 times larger

Fig. 16. Sweet potato leaves attacked by false spider mites.

than the larva and its appendages are more slender, tapering and colorless. A prominent dark reddish area appears on the dorsum while the rest of the body becomes almost colorless as it grows. The deutonymph is similar to protonymph but is larger and more slender. The adult, although bigger, is similar in shape to the deutonymph. The dorsal spot is brighter. The legs and chelicerae are distinct.

Nature of damage

B. californicus is a polyphagous feeder attacking many species other than sweet potato. The mites suck the sap from the petioles and leaves causing the undesurface to become scorched and dotted with whitish feeding punctures (Fig. 16). The entire leaf curls, turns yellowish brown, and drops prematurely to the ground.

Control measures

The control measures described for ***T. marianae*** are also applicable for ***B. californicus.***

DISEASES OF SWEET POTATO AND THEIR CONTROL

Crisanta E. Sajise*

Sweet potato diseases occur both in the field and in storage. Among the field diseases of sweet potato, stem and foliage scab, Cercospora leaf spot and nematode diseases are the major ones. These diseases have been found to cause deformation of plant parts, defoliation, reduced growth rate and partial or total root yield reduction.

During storage, the roots are likewise attacked by a variety of fungi among which ***Botryodiplodia theobromae, Rhizopus stolonifer, Macrophomina phaseolina*** and ***Fusarium oxysporum*** are the major ones.

Although no reliable estimates of losses due to storage diseases are available locally, their presence and probable increase in incidence could become a threat to the development of the sweet potato industry.

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PREHARVEST DISEASES

Stem and foliage scab
***Sphaceloma batatas* (Saw.)**

Symptoms

The pathogen readily infects young stems and laminae and petioles of leaves (Fig. 17a). On the leaf lamina, the fungus prefers to attack the veins resulting in leaf curling and distortion (Fig. 17b). The infection spots are small, oblong and yellowish to reddish brown. On the stems, the spots vary from circular to spindle-shaped, may be flat, depressed or slightly raised, and are brownish and sometimes with water-soaked borders. The spots become rough and scab-like and may join to form larger spots. Disease development is usually enhanced by dry and warm conditions.Temperatures between 25 and 30°C favor fungal growth.

Control measures

- Use of healthy planting materials.
- Practice of field sanitation by burning or burying infected plants and debris.
- Programmed planting.
- Use of resistant varieties.
- Use of **Benomyl** at 1.04 g a.i./liter, **copper oxychloride** at 2.08 g a.i./liter, or **maneb** at 2.08 g a.i./liter every 10 to 14 days.

Fig. 17a. Scabby lesions on petiole and leaf veins.

Fig. 17b. Leaf curling and distortion due to the attack of scab fungus on leaf veins.

Cercospora leaf spot
Cercospora batatae (Zimm.)

Symptoms

The disease is characterized by circular, angular or irregular spot which at first is yellowish brown and with indefinite border. The center of the spot later turns grayish. At times the necrotic area becomes too thin and eventually the infected portion of the leaf is torn leaving a shot hole (Fig. 18).

Fig. 18. Irregular spots on leaves caused by **C. batatae** *infection.*

Control measures

- **Field sanitation.**
- **Cultural.** Rotation with nonhost crops, programmed planting, growing plants at wide spacing, and frequent weedings.
- **Use of resistant varieties.**
- **Chemical.** Spraying every 15 days with **Zineb**, and use of **Benlate** at manufacturer's recommended rate.

Root-knot nematode
Meloidogyne spp.

Reniform nematode
Rotylenchulus reniformis

Depending on the inherent resistance of the host plants, symptoms and damage caused by ***Meloidogyne*** sp. range from slight to severe galling of the roots, surface blemishes, pitting and cracking of tuberous roots, brownish necrotic tissues, scab or pustule-like areas in the roots, and stunting.

Plants attacked by ***R. reniformis*** are generally stunted. The roots exhibit necrotic lesions. Badly damaged roots crack and the tubers become deformed. The cracks which develop early during the enlargement of the root are predominantly of the deep healed-over type.

Fig. 19a. Root-knot galls on sweet potato roots.

Fig. 19b. Swellings on surface of sweet potato storage root caused by root-knot nematode.

Control measures

Chemical.

- Treating the soil before planting with **Nemagon 75 EC** and **Temik 15G.**
- **EDB** applied by chisel injection in row 20 cm deep at a rate of 23.5 liters a.i./ha.
- **Carbofuran** applied as granules 1 - 4 days before planting at a rate of 6.7 kg a.i./ha.

Cultural.

- Planting of disease-resistant varieties.
- Sequential planting of nonhost crops.
- Application of chicken dung was found to control 60 and 61 percent of the populations of ***M. incognita*** and ***R. reniformis***, respectively.

POSTHARVEST DISEASES

Java black rot
Botryodiplodia theobromae (Pat.)

Symptoms

The roots colonized by ***B. theobromae*** are characterized by the presence of many pimple-like or wart-like growths on the surface of the roots which are coal-black in color and almost always in aggregates (Fig. 20).

Fig. 20. Wart-like growth on fleshy storage roots caused by **B. theobromae.**

Rhizopus soft rot
Rhizopus stolonifer (Ehrenberg ex Fr.)

Symptoms

Sweet potato roots infected by ***Rhizopus stolonifer*** tend to be soft and watery, becoming completely rotten within 4 or 5 days after infection is first visible. The fleshy tissue becomes soft and stringy and water exudes readily when skin is broken. The tissues turn brownish in color and a mild odor is noticeable. As the skin is broken, the grayish sporangiophores and mycelium and the dark colored sporangia develop very rapidly, prolonging a coarse whiskery extramatrical growth which is very characteristic of the disease not only on sweet potato but also on other vegetables and fruits which may become infected. The affected tissue sometimes desiccates rapidly and gives the disease the appearance of dry rot. In some cases the tissue may rot in zones adjoining several points of infection on a root and dry out rapidly causing a series of decayed rings.

Surface rot
Fusarium oxysporum (Schlecht.)

Symptoms

F. oxysporum invades the fleshy roots through open wounds, usually of rootlets attached to the fleshy root, and produces circular, depressed, grayish brown lesions on the periderm. These lesions are small at the beginning of storage and gradually enlarge to a surface diameter of 3/4 to 1 inch and to a depth of 1/4 to 1/2 inch. With this enlargement the fleshy roots lose water rapidly apparently due to breakdown of the periderm. As a result, the roots shrink badly, and become unsightly due to the formation of many lesions (Fig. 21).

Fig. 21. Surface rot lesion caused by **F. oxysporum** *on fleshy storage root.*

Charcoal rot
Macrophomina phaseolina (Tassi)

Symptoms

Sweet potato roots invaded by ***Macrophomina phaseolina*** exhibits at least 3 distinct color zones in the flesh: chocolate brown, reddish brown and black. The disease develops slowly and goes almost unnoticed except for a slight darkening of the cortical and epidermal layers. As infection proceeds, the roots become spongy. Finally, with breaks in the periderm, they lose water rapidly and become coal-black, hard and dry (Fig. 22).

Fig. 22. Charcoal rot caused by **M. phaseolina** *on fleshy storage roots.*

Control measures for the postharvest diseases:

Curing

Curing at 28-32°C and 90-95% RH for 10-14 days.

Careful harvesting and handling

The condition of a product entering storage is one of the most important factors governing the success or failure of the storage process. Invasion of the tubers by rotting organisms is greatly facilitated when they have been damaged mechanically by accidental cutting or bruising.

Sanitation

At the end of the storage season, all roots or pieces of roots are removed from outside or inside the storage house, packing shed, storage rooms and containers which are then disinfected with a recommended compound.

Use of resistant varieties

The variability between cultivars in postharvest deterioration and in the existence of some degree of resistance to postharvest diseases has been confirmed. These factors should be borne in mind in the selection and handling of cultivars for storage purposes where, if a choice of cultivar exists, the ones which deteriorate least rapidly and which can be harvested and handled with a minimal degree of damage should be selected.

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