

- Okpala, E. U. *Cultural and biological control of bacterial blight of cassava*. In Proceedings of the First Workshop on Cassava Bacterial Blight in Nigeria. FARTS, Umudike, Nigeria, 1974, 33-36.
- Pereira, A. L. G., and Zagatto, A. G. *Etiology of angular leaf spot of cassava (Manihot utilisima)*. Archives de Instituto Biologico, São Paulo, 34, 1967, 153-160.
- Rosanow, M. *Field experimental check on starch yields of cassava in Indonesia*. 3rd International Symposium on Tropical Root Crops. IITA, Ibadan, Nigeria, Dec. 1973.
- Terry, E. R. *Some epidemiological factors affecting the survival and dissemination of Xanthomonas manihoti*. Proceedings of the First Workshop in Cassava Bacterial Blight in Nigeria. FARTS, Umudike, Nigeria, 1974, 39-41.

World Distribution, Identification, and Control of Cassava Pests

Anthony C. Bellotti and Aart van Schoonhoven¹

Numerous insect and mite pests have been identified as attacking cassava. These pests represent a wide range of insect fauna; more than 100 species have been recorded. Many of these are minor pests and cause little or no economic losses. However recent research has shown that several pests can cause crop losses and must be classified as major pests. These include mites, thrips, stemborers, whiteflies, hornworms, scale insects, and whitegrubs. Many pests, such as mites, whiteflies, scales, whitegrubs, stemborers, ants, termites, are distributed world wide. Others are local pests or limited to one or two continents. Chemical control of cassava pests is uneconomical in many areas where it is a low value crop. Pesticides are expensive and their continual use is impractical for a long season crop such as cassava. Emphasis should be directed toward the use of resistant varieties, biological control, and improved cultural practices. Strict quarantine practices should be enforced to prevent the spread of cassava pests into areas where they are not present.

Insects and mites are limiting factors in cassava production. The recent introduction, and consequent outbreak, of the mite *Mononychellus tanajoa* in West Africa has caused serious crop losses. This is ample evidence for the need for extensive research on cassava pests, knowledge of their geographic distribution and the damage they cause, and the establishment of an effective pest-management program.

CIAT has been able to collect much of the available literature on cassava, and it is now possible for us to get a global view of pest problems. There are numerous pests that attack cassava and they represent a wide range of insect fauna. Many are of minor importance and cause little or no economic losses, while others can cause considerable damage.

Insects Attacking Vegetative Planting Material

Cassava is propagated by vegetative stem cuttings. The planting of insect-free and un-

damaged cuttings is most important.

Infestation of cuttings by white scale *Aonidomytilus albus* can reduce germination up to 50%. Infested cuttings were dipped in insecticide solutions, but they still germinated poorly. We recommend that scale-infested cuttings not be used as propagation material.

The cassava fruitflies *Anastrepha pickeli* and *A. manihoti* cause damage to stems by introducing secondary bacterial rots, which may cause reduction in yield and the loss of stake planting material. Infested stakes are easily distinguishable by the darkened and rotted pith region of the stem. Infected cuttings should not be used as propagating material.

Pregermination and Postgermination Damage to Cuttings and Young Plants

Stem cuttings and young germinating plants are subject to attack by several insects, including whitegrubs (*Leucopholis rorida* and *Phyllophaga* sp. (Coleoptera Family Scarabaeidae, Cerambycidae)). They destroy the bark of planted cuttings which may then rot and die.

¹Centro Internacional de Agricultura Tropical, Apartado Aéreo 67-13, Cali, Colombia.

When young plants (1–3 months) are attacked, the leaves wilt. The larvae feed on the bark of the lower part of the stem, usually below the soil, or tunnel into the cutting. The larvae are white with a darkened head and are 5 cm long. They can usually be located around the cutting or roots of the plant.

Whitegrubs are best controlled with Aldrin (2.5%, 50 kg/ha) and Furadan (3 g/m²) applied below the cutting in the soil. Insecticidal dip treatments have not proved as successful as soil application. A muscardine fungus *Metarrhizium anisopliae* is pathogenic to the grub and there is evidence that this may be an effective control method.

Attacks occur frequently when the cassava crop is rotated after pastures.

Cutworms

Cutworms can injure young plants in three principal ways: (1) The surface cutworms, such as the black cutworm *Agrotis ypsilon* eat off plants just above, at, or a short distance below the surface of the soil leaving the plant lying on the ground. The larvae are greasy gray to brown, with faint lighter stripes; (2) The climbing cutworms such as the southern armyworm *Prodenia eridania* climb the stems and eat buds and foliage and may girdle stems causing plants to wilt and die. The full-grown larvae are dark gray to nearly black and marked with lateral yellow stripes; (3) The subterranean cutworms remain in the soil to feed on roots and underground parts of the stems, causing a loss of planting material. Losses of young plants may reach 50% making it necessary to replant. Cutworm attacks occur sporadically but are more frequent when cassava follows corn in rotation.

Cutworms attacking plants above or at ground level may be controlled effectively with poison baits (10 kg of bran or sawdust, 8–10 l of water, 500 g of sugar or 1-l of molasses and 100 g of Dipterex for ¼ to ½ ha). For underground cutworms soil applications of Aldrin or Furadan around the cuttings are effective.

Termites

Termites will attack cassava in the lowland tropical areas. They feed on planting material and roots of growing plants, and prevent the establishment of cuttings. They are a serious problem in areas with prolonged dry seasons.

Insecticide treatments may give effective control.

Crickets

Crickets damage cassava plants by clipping young shoots after emergence. They can also damage the base of the cassava plant, rendering them more susceptible to lodging by wind.

Insects Attacking Foliage and Buds

Thrips

Several species (*Frankliniella williamsi*, *Corynothrips stenopterus*, and *Caliothrips masculinus*) of thrips, all belonging to the family Thripidae, attack cassava. Thrips are major pests in Central and South America and Africa.

The most important species is *F. williamsi* which damages the terminal buds of the plant. The leaves do not develop normally, leaflets are deformed and show irregular chlorotic yellow spots. Stylet damage to the leaf cells during expansion causes deformation and distortion, with parts of leaf lobes missing. Brown wound tissue appears on the stems and petioles and internodes are shortened. The growing points may die, causing growth of lateral buds which also may be attacked, giving the plants a witches' broom-like appearance. The attack is most frequent during dry periods and plants will recover when the rain starts. Thrips can cause a 15–20% yield loss.

Control is best achieved through the use of resistant varieties which are readily available. Resistance is based on leaf-bud pilosity and nearly 50% of the CIAT germ plasm bank (2300 varieties) are highly resistant.

Mites

Mites, one of the most serious dry season cassava pests, cause serious damage. The green cassava mite *Mononychellus tanajoa*, native to the Americas, causes considerable yield reduction in parts of East Africa. It is spreading to other parts of Africa.

The mite *Tetranychus urticae* is universal but appears to be a significant pest in parts of Asia. *Oligonychus peruvianus* is limited to the Americas and East Africa.

Mites can be found in great numbers on the undersides of leaves during optimum environmental conditions. Usually older plants are more susceptible to attack.

Mononychellus tanajoa is green and develops in the apical buds, feeding on young leaves and stems. Leaves are splashed with

Table 1. World distribution of cassava pests.

Insect	The Americas	Africa	Asia
Thrips	X	X	
Mites	X	X	X
Hornworm	X		
Fruitfly	X		
Shootfly	X		
Whiteflies	X	X	X
Stemborers	X	X	
Whitegrubs	X	X	X
Cutworms	X		
Gall midges	X		
Lacebugs	X		
Grasshoppers		X	
Mealybugs	X	X	
Scales	X	X	X
Leafcutter Ants	X	X	
Crickets	X	X	
Termites	X	X	X

yellow spots, lose their normal green colour and develop deformities. The attacked stems become rough and brown. Stems and leaves die from top to bottom. Severe attack results in death of the growing point causing excessive branching.

Damage from *Tetranychus* first shows as yellow dots along the midrib of the leaves, eventually spreading and turning leaves reddish or rusty. Older, basal leaves are attacked first and under prolonged dry periods spread to the upper leaves, causing defoliation and death of the plants.

The attack of *O. peruvianus* is characterized by white dots along leaf veins and margins on the undersides of leaves. These dots are web-bings under which the adult female places her eggs, and where the larvae and nymphs develop. These locations first appear as yellow and later brown dots on the leaf uppersurface. The basal leaves are more readily attacked.

Yield reductions of 40% have been reported in Africa for *M. tanajoa*. All three species mentioned here infested the CIAT farm, resulting in a 20% yield loss when the mite attack occurred from the 5th to the 7th month of plant growth.

The CIAT germ plasm has a low resistance level to *Tetranychus* and moderate resistance levels to *Mononychellus* and *Oligonychus*.

There are several effective biological control agents for suppressing mite populations.

Control with Monocrotophos (Asodrin),

Galecron (Fundal), and other organophosphates at commercial doses is effective.

Cassava Hornworm

The cassava hornworm *Erinnyis ello* is a most serious cassava pest in the Americas. High populations of hornworm larvae can rapidly defoliate large cassava plantations. Defoliation during the initial months of plant growth can kill plants and cause yield losses. The ash coloured, nocturnal females deposit their large, light green eggs on the upper surface of cassava leaves. The larvae are polymorphic and colour varies: yellow, green, black, dark gray, and tan are common. Fifth instar larvae may reach 10–12 cm in about 12 days, and migrate to the soil where they form a chestnut brown, black-lined pupa. The adult moth emerges in about 2 weeks. Outbreaks generally occur after the beginning of the rainy season, but are erratic and may be absent for years.

A biological control program is an effective means of hornworm control. Egg parasitism by *Trichogramma* sp. can effectively reduce populations. The paper wasp (*Polistes* sp.) is an important larval predator and *Apanteles* sp. (Hymenoptera) is a larval parasite. Effective control with the bacterial disease *Bacillus thuringiensis* has been obtained.

Dipterex is effective against young larvae but the use of pesticides should be avoided because it interrupts the biological control system.

Cassava Shootfly

Shootfly (*Silba pendula*, *Carpolonchacae chalybea*) damage occurs throughout most of the Americas. Loss of yield is not yet known, but artificial shoot removal (up to 100% at periodic intervals) to simulate shootfly attack, did not affect yield.

The dark metallic blue adult shootfly oviposits between the unexpanded leaves in the growing points. The young larvae tunnel in the soft tissue and eventually kill the growing point. Several whitish larvae may be found in the affected growing point accompanied by a white to brown exudate. The mortality of the growing point retards growth of young plants and causes side buds to germinate, which may also be attacked. Younger plants are more susceptible to attack and most outbreaks occur in the beginning of the rainy season. Planting dates can be adjusted so that the younger

growing stage is passed during low shootfly populations. Larvae are difficult to control. Systemic organophosphate such as Basudin (diazinon), Diostop (dimetoate), Azodrin and Bidrin (dicrotophos) at commercial doses are recommended only for large populations.

Whiteflies

Numerous species of whiteflies (*Bemisia tuberculata*, *B. tabaci*, *Aleurotrachelus* sp., *Trialeurodes variabilis* and *Aleurothrixus* sp.) attack cassava. No direct damage due to feeding is known but high populations may cause mottling, yellowing, and drying of the leaves. Whiteflies can be detected by provoking adults into flight or by observing the pupa and nymphs on the undersides of the leaves. A black sooty mold fungus is often found in association with whitefly attack. High populations are usually associated with the rainy season.

The whitefly *Bemisia tabaci* is a vector of the cassava mosaic disease which causes yield losses in Africa and Asia. This disease is not found in the Americas.

Varietal evaluation for resistance to the *Aleurotrachelus* sp., found in high populations in Colombia, shows moderate resistance for varieties CMC-72 and CMC-57.

Control of whiteflies, if needed, may be achieved with Roxion, Diostop, Metasyptox, and Dimecron.

Grasshoppers

Grasshoppers have been identified as a pest on cassava only in Africa. There are two principal species; *Zonocerus elegans*, the elegant grasshopper, and *Z. variegatus*, the variegated grasshopper.

Both species cause damage in the dry season when their alternate hosts are reduced. In Africa heavy defoliation and stripping of the bark have resulted in yield losses up to 60%.

Grasshoppers can be controlled by the insecticides Gamalin 20 and Temitrothion.

Cassava Lacebug

Yield losses due to lacebug (*Vatiga manihotae*) are not known, but considerable foliage damage can occur. The whitish nymphs and gray adults (3 mm) can be found in great numbers on the leaf underside. Damaged leaves show yellow spots which eventually turn to reddish brown, resembling mite damage.

Leafcutter Ants

Several species (*Atta* sp. and *Acromyrmex* sp.) have been reported rapidly defoliating cassava when large numbers of worker ants move into a crop. A semi-circular leaf cut is made and carried off to the nest. During severe attack the buds may also be removed. Attacks frequently occur during the early months of the crop. The effect of this damage on yield is not known.

Insecticides are the most effective means of control. Nests can be destroyed by fumigation with carbonbisulfide, smoke of sulfur or arsenates. Good results will be obtained by applying Aldrin as a powder or in solution in or around the nest. Granular mirex baits applied along the ant trails will be carried into the nest by the ants and will give effective control.

Gallmidges

Several species of gallmidges (*Cecidomyiidae*, *Iatrophobia* sp.) have been reported on cassava. These fragile flies oviposit on the leaf undersurface and the emerging larvae cause abnormal cell growth in the leaf and gall formation. Leaf galls on the uppersurface are yellow-green to red and when opened, show a cylindrical tunnel with the larvae inside. Gallmidges may retard growth of young plants but are considered of little economic importance and generally do not require control. Destruction of affected leaves at weekly intervals is recommended to reduce populations.

Insects Attacking Mature or Green Stems

Approximately 35 species of stemborers have been identified feeding on and damaging stems and branches of the cassava plant. Most stemborers are the larval stage of coleoptera (*Coelosternus* spp., *Lagochirus* sp.), but some lepidopterous and hymenopterous stemborers are also reported. They generally cause sporadic or localized damage.

Larvae vary in size (up to 30 mm long) and shape depending on the species. Larvae are usually white to yellow to tan and tunnel through the aerial parts of the plants. Stems and branches may break or be reduced to sawdust. During dry periods, under heavy infestation, defoliation and death can occur. Frass

and exudate from the stemwood ejected from burrows by larval feeding can be found on infested branches or on the ground. Pesticide control appears impractical since adults are difficult to kill and larvae feed within plant stems. Populations can be reduced by removing infested plant parts and burning.

Cassava Fruitfly

The cassava fruitfly (*Anastrepha pickeli*, *A. manihoti*) has recently been identified as a pest on cassava. It frequently attacks the cassava fruit and causes economic losses.

It attacks the stem about 10–20 cm below the apex, making a small entrance/exit hole. The yellow to tan female inserts the egg in the stem tissue and after hatching the white to yellow larvae bore into and down through the pith region of the stem.

A bacterial pathogen is often found in association with the larvae and this can cause severe rotting of stem tissue. Often a white exudate is found flowing from the larval tunnel. Severe attacks may cause collapse of the growing points, growth retardation, proliferation of lateral buds, and finally death of the plant.

The extent of crop losses due to this secondary rotting is not known but younger plants (2–5 months) are more susceptible to damage.

The use of attractants or poison baits as controls appears promising. A Hymenoptera parasite (*Opius* sp.) has been identified. The insecticide Lebaycid (Fenthion) gives good control of the larvae in the stem.

Scale Insects

Several species of scales (*Aonidomytilus albus*, *Saissetia* spp.) attack cassava stems. Except for localized incidents they do not appear to cause any significant reduction in yield.

In severe attacks leaves may yellow and drop, the plants are stunted, and stems can dehydrate causing plant death. The greatest damage appears to be the loss of planting material. When heavily infested cuttings are planted germination is greatly reduced and roots will be poorly developed and unpalatable. The adult scale of *A. albus* is mussel-shaped and covered with a white waxy secretion. It attacks the branches, especially in the dry season, thus aggravating drought stress.

The most effective means of control is through the use of healthy planting material, and cutting and burning infested plants. Chem-

ical control on growing plants with *Metasystox* (0.1%) and Malathion (0.1%) is effective.

Mealybugs

Mealybug (*Phenococcus gossypii*) damage has recently been reported from Brazil, Colombia, and parts of Africa, but effect on yield is not known.

High populations of the insect give a cottony appearance to the green portion of the stem and on the leaf undersurfaces. Leaves will turn yellow and dry and stems and buds may also be killed.

Conclusion

Insects and mites are a limiting factor in cassava production. There is an obvious need for an effective integrated pest management and disease control program, based on sound principles and utilizing the adaptability of cassava. As well, strict quarantine measures should be adopted to restrict the spread of insects into areas where they are not now present.

Crop Adaptability

- (1) Cassava is a long-season crop; the continual use of pesticides is impractical.
- (2) Few if any insects will actually kill the plant.
- (3) The cassava plant has the ability to recuperate from insect damage.
- (4) The cassava plant can lose foliage without decreasing yield: A high economic threshold.

Basic Principles of an Integrated Control System

- (1) Cassava is ideally suited to a biological control program.
- (2) High levels of pest resistance are not needed and resistance to some pests already exists.
- (3) It is necessary to understand the insect-plant-environment interaction. Rainfall and age of plant appear to be key factors.
- (4) Cultural practices (selection of planting material, crop rotation, etc.) can reduce pest incidence.
- (5) The intelligent use of insecticides.
- (6) The indiscriminate use of pesticides will interrupt biological control programs.

Pest Management Program

Thrips	Varietal resistance	Whiteflies	Varietal resistance
Hornworm	Biological control	Shootflies	Attractants
Mites	Varietal resistance		Cultural practices
	Biological control		Varietal resistance
Fruitflies	Cultural practices	Stemborers	Cultural practices
	Attractants	Mealybugs	Varietal resistance
	Varietal resistance		Biological control
Whitegrubs and cutworms	Microbial control	Scales	Biological control
	Poison baits		
	Cultural practices		
	Soil insecticides		

Population Dynamics of the Green Cassava Mite and its Predator *Oligota*

Z. M. Nyiira¹

The green cassava mite, *Mononychellus tanajoa* (Bondar) (Acarina: Tetranychidae), also known as the cassava leaf mite, is a fairly new pest in Africa. Its potential threat to cassava production in Africa has attracted serious investigations into its biology, ecology, and possible control. Initial infestations of this mite start in sheltered places, along the midribs and veins of cassava leaves.

Denser populations are recorded during dry spells and more are found in the lower half of the leaf. The ratio of active mites, eggs, males, and females in the apical and basal halves of the leaf are discussed. Cassava plants between 3 and 10 months old were more densely infested than the younger and older plants. Some varieties of cassava supported fewer mites than others suggesting a degree of resistance. Reduction in the number of mites was associated more with absence of leaves than weather conditions, although rain and possibly relative humidity had negative effects on population buildup of the mite.

The Staphylinidae *Oligota* was the dominant and widespread predator. It appeared in sufficient numbers and at the same time as the green cassava mite. The population fell sharply when the host population started diminishing.

The results point out the potential of varietal resistance in cassava and biological control as possible effective considerations in integrated control of *M. tanajoa*.

The green cassava mite *Mononychellus tanajoa* is a fairly new pest of cassava in Africa. Its potential threat to cassava production has attracted much attention because cassava is an important staple in Africa, where 36% of the world total is produced.

Although the green cassava mite was recorded as a major cassava pest in Brazil in 1921 (Bondar 1938), its low status did not demand serious investigation until its discovery in 1971 in Uganda (Nyiira 1972). Since then, detailed studies have been done (Bennett and Yaseen 1975; Nyiira 1975a).

The structure of the population (dispersion) of the green cassava mite on cassava in the neotropics was described by Bennett and Yaseen (1975). They discussed the influence of age of the plant, its physiological condition, and environmental factors on levels of infestation and damage.

Nyiira (1972, 1973) showed that heavy infestations and damage to cassava in Uganda occurred during the hot dry spells. This was later accompanied by premature leaf fall and sometimes tip die-off. Major damage was suppressed by the cool rainy season. Similar observations in Brazil were reported by Bondar (1938) and by Da Costa (1973). Such seasonal fluctuations of the mite population were

¹Department of Agriculture, Kawanda Research Station, P.O. Box 7065, Kampala, Uganda.