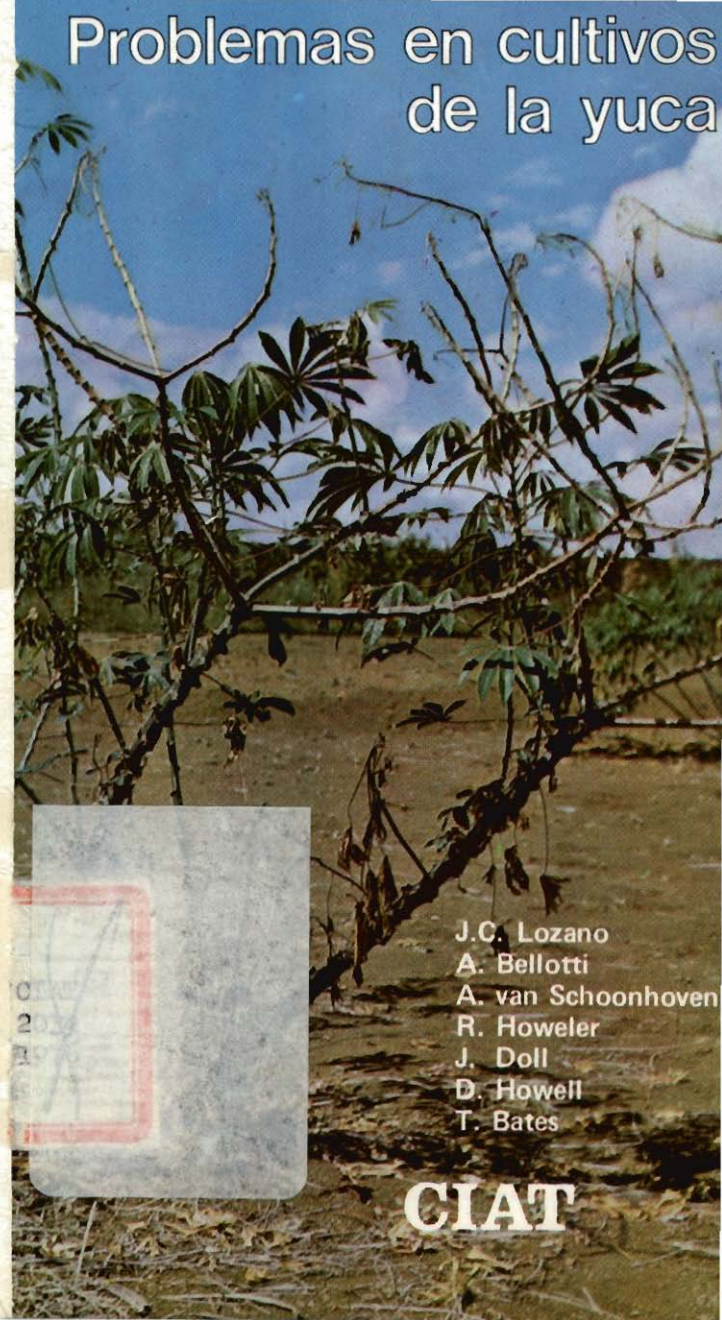
Problemas en cultivos de la yuca



J.C. Lozano
A. Bellotti
A. van Schoonhoven
R. Howeler
J. Doll
D. Howell
T. Bates

CIAT

Series GE-16
July 1976

Field problems in cassava

J.C. Lozano
A. Belloti
A. van Schoonhoven
R. Howeler
J. Doll
D. Howell
T. Bates

Centro Internacional de Agricultura Tropical
Apartado Aéreo 6713, Cali, Colombia

CIAT is a nonprofit organization devoted to the agricultural and economic development of the lowland tropics. The Government of Colombia provides support as host country for CIAT and furnishes a 522-hectare farm near Cali for CIAT's headquarters. Collaborative work with the Instituto Colombiano Agropecuario (ICA) is carried out mainly at its Experimental Centers at Turipaná and Carimagua. CIAT is financed by a number of donors represented in the Consultative Group for International Agricultural Research. During the current year these donors are the United States Agency for International Development (USAID), the Rockefeller Foundation, the Ford Foundation, the W.K. Kellogg Foundation, the Canadian International Development Agency (CIDA), the International Bank for Reconstruction and Development (IBRD) through the International Development Association (IDA), the Interamerican Development Bank (IBD), the United Nations Environment Programme, the Ministry of Overseas Development of the United Kingdom and the governments of Australia, Belgium, the Federal Republic of Germany, the Netherlands and Switzerland. In addition, special project funds are supplied by various of the aforementioned entities plus the International Development Research Centre (IDRC) of Canada. Information and conclusions reported herein do not necessarily reflect the position of any of the aforementioned agencies, foundations or governments.

CONTENTS

FIELD PROBLEMS IN CASSAVA

J. C. Lozano*
A. Bellotti and A. van Schoonhoven*
R. Howeler*
J. Doll*
D. Howell and T. Bates**

INTRODUCTION

The cultivation of cassava (*Manihot esculenta* Crantz) has increased considerably as a result of the increase in the world's population, the scarcity of other sources of nutritional energy, and its high potential production of carbohydrates per surface unit. Nevertheless, although it has been relatively easy to obtain yields of around 50 tons/ha at experimental centers and in some commercial operations, world figures for cassava production average only 10 tons/ha. There are many factors that influence cassava production, the same as in any other crop; but diseases and pests, nutritional deficiencies and plant toxicity, resulting from the misuse of herbicides, affect production considerably.

---

* Plant pathologist, entomologists, soil scientist and weed control specialist, respectively, at the Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia

** Graduate student and professor, respectively, University of Guelph, Ontario, Canada

The information available at present on diseases, insects and problems of a physiological nature is generally quite limited. Descriptions of the symptoms of attack by the different pathogenic agents and physiological problems are even scarcer. Many problems occurring in cassava-growing areas pass unnoticed or are attributed to pathogenic agents that are not found in those areas or to climatic and edaphic conditions that have nothing to do with the cause of the problem. The inadvertent introduction of a pathogen or pest and failure to recognize its potential importance can cause considerable economic losses.

This manual describes some diseases and pests that attack cassava, as well as the symptoms induced by nutritional deficiencies and damage resulting from the misuse of herbicides. In addition, some recommendations for control are given.

James H. Cock	Physiologist, Program Leader
Kazuo Kawano	Plant breeder
J. Carlos Lozano	Plant pathologist
J. César Toro	Agronomist
A. Bellotti	Entomologist
Reinhardt Howeler	Soil scientist

IMPORTANT DISEASES

Cassava is attacked by more than 30 bacterial, fungal, viral, viruslike and mycoplasmal agents. Diseases affecting cassava cause losses in crop establishment, lessen normal plant vigor, reduce photosynthetic capacity, or cause pre- or postharvest root rot. Some pathogens attack only the stalk, which is the normal propagation material, inducing tissue necrosis. They may also invade the vascular system, causing no visible damage but constituting primary sources of infection in the plantations. Other pathogens attack foliar tissues and the tender parts of the stalk, causing spots, blight, defoliation, wilting, dieback and hypertrophies (exaggerated elongation or proliferation of buds and internodes). Others attack only root tissue and the basal, woody part of the stem, causing preharvest root rot. Damage is characterized by a sudden yellowing accompanied by wilting and sudden defoliation. These symptoms may occur at any stage of plant growth, generally during periods of heavy, prolonged rains.

Recently harvested cassava roots may be affected by soft or dry rot shortly after they have been harvested. Although this appears to be a physiological-pathogenic effect, it is frequently correlated with and accelerated by mechanical damage to the roots, which occurs during harvesting.

Recommended agronomic practices for disease control

Although effective, absolute control of all cassava diseases is impossible on a commercial scale, the following general recommendations are suggested in order to keep plantations relatively disease free.

1. Select the soil carefully; it should be light, well drained and not very high in organic matter. Do not plant cassava on soils previously covered by woods or planted to forest and other perennial crops. In these cases, grow a cereal crop (maize, sorghum, etc.) before planting cassava.

2. Use sound agronomic practices: prepare the soil well, install a good drainage system and plant on ridges when rainfall is high (more than 1,200 mm/yr, approximately) or soil is heavy.

3. Use clean "seed" only. Try to produce or select planting material only from disease-free plantations and plants.

4. Handle planting material carefully, avoiding mechanical damage during its preparation and planting. Treat this material with a disinfestant fungicide, such as thiram, chloroneb or PCNB (pentachloronitrobenzene), immersing the cuttings for 3 minutes in a 3 percent suspension of the commercial product in water (approximately 2,000 ppm a.i.). This treatment should prevent damage caused by soil-borne pathogens.

5. Plant cuttings using recommended procedures, leaving an adequate distance between plants according to the variety used. Plant at the beginning of the rainy season to assure good germination and crop establishment. Eliminate weeds, which may act as hosts for pathogens.

6. Do not use machinery or tools that have been used on other plantations —especially where there is bacterial blight— or permit workers from other farms to visit the plantation.

7. Rotate cassava with a cereal (maize or sorghum) for a period of no less than six months if indices of root rot are higher than 5 percent. Improve the drainage.

8. Burn debris from previous cassava crops; do not leave old plant debris after the land has been prepared.

9. Avoid damage to roots during harvesting; pack roots carefully in adequate packing material.

10. Sell or process the harvested product immediately; otherwise, harvest only what is to be sold, processed or used.

Bacterial blight *(Xanthomonas manihotis)*

This is one of the most serious diseases affecting cassava. It is recognized by the presence of water-soaked, angular spots, blight, partial or total wilting of the branches, gum exudate on stems or green branches, dieback, and necrosis of some vascular strands of the stems and roots. These symptoms, which are evident during the rainy season, vary in accordance with the susceptibility of the variety affected and the time that the plant has been infected. The pathogen is generally introduced through the use of cuttings taken from plants from affected plantations. Use clean "seed" only.

Leaf spots

Partial wilting

Dieback

Bacterial stem rot (*Erwinia* sp.)

Shoots of infected plants wilt; the disease is characterized by a pungent, soft stem rot or discoloration of the woody portion of the plant. On the stem surface, there are holes made by insects (*Anastrepha* spp.), which appear to be the vectors that spread the bacteria. These holes are easy to distinguish by the traces of dry latex exudated after the stem has been perforated. Diseased cuttings used for planting do not always germinate; and if they do, plants are stunted with a small number of thick roots. Always use clean "seed."

Partial wilting

Stem cankers

Stem rot

African mosaic (causal agent unknown)

This disease, spread by insects of the genus *Bemisia* (whiteflies), is found in Africa, where it causes considerable losses. A similar disease has also been recorded in India. Its symptoms are characteristic of other mosaics. Young plants have yellowish areas and frequent leaf deformation. The reduction in size of young leaves is also very common (with the presence of yellowish areas) in adult plants. All cuttings from infected plants generate diseased ones; therefore, the introduction of African material should be strictly prohibited since the majority of plantations in Africa are affected by this disease. Use clean "seed" or resistant cultivars.

Infected plant

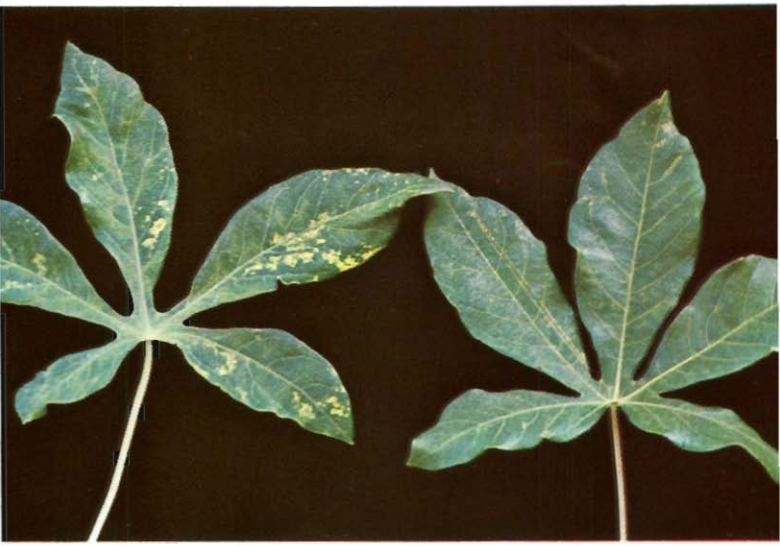
Leaf distortion
and mosaic

Heavily infected leaf

Common mosaic (caused by a virus)

This is an American disease that has also been recorded in Africa (Ivory Coast). The disease is caused by a virus that has been transmitted only by mechanical means and is spread by the use of cuttings from diseased plants. The symptoms are characteristic of all mosaics, consisting primarily in the presence of yellowish areas in the leaf blade and the stunting of diseased plants. In general the yellowish areas are not well defined as in African mosaic; otherwise, the symptoms are quite similar. These symptoms may also be confused with severe attacks of thrips in susceptible cultivars (see corresponding section in chapter on insects). Use disease-free cuttings only; all diseased plants should be removed and burned.

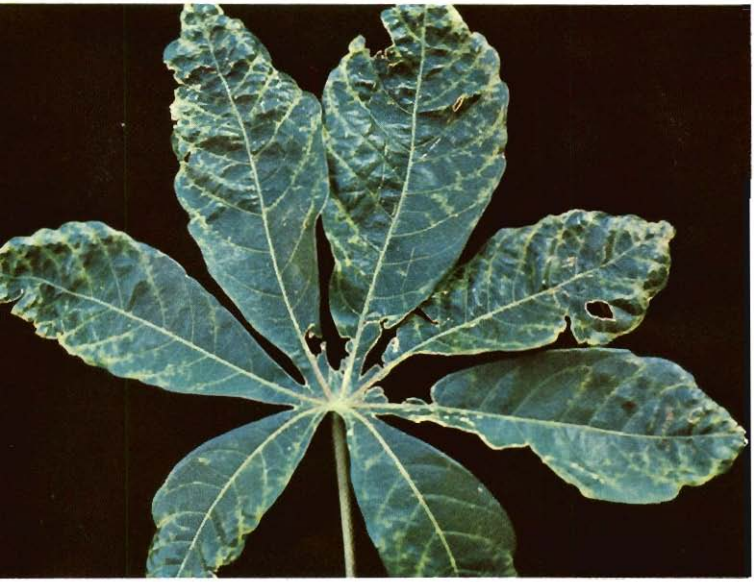
Two symptoms typical of mosaic



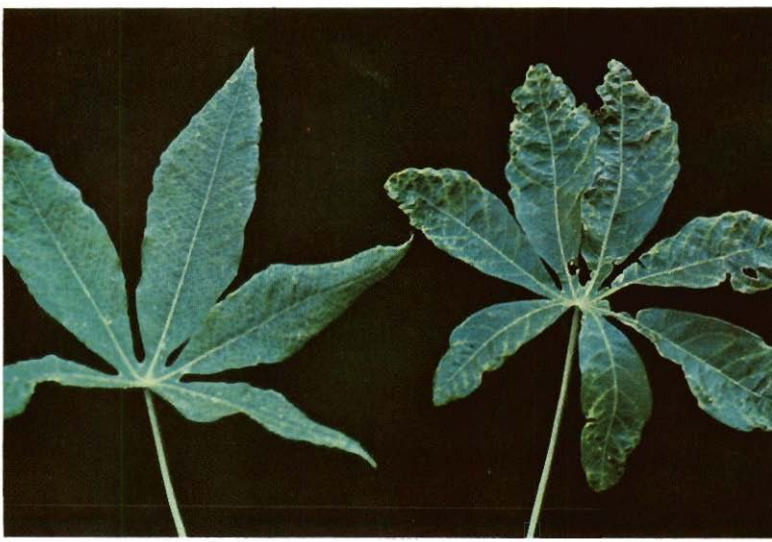
Characteristic distortion and mosaic

Leaf vein mosaic (caused by a virus)

This disease occurs only in limited areas of Brazil and Venezuela. Because of its reduced incidence, its economic importance is limited. The symptoms of the disease are characterized by yellowing of the veins and leaf curling. The disease can be transmitted mechanically or by grafting; moreover, all cuttings taken from infected material produce diseased plants. To eradicate this disease, all plants with suspicious symptoms should be eliminated. Always use disease-free planting material.



Vein yellowing and leaf tip curling

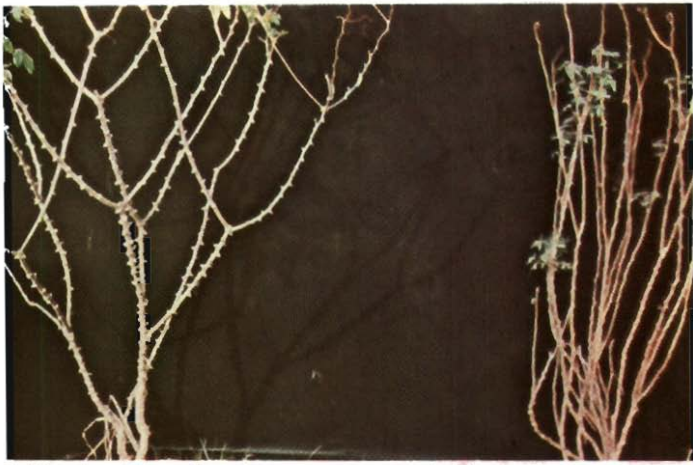


Two symptoms typical of leaf vein mosaic

Witches'-broom (caused by a mycoplasm)

This disease has been recorded in Brazil, Venezuela, Mexico and in the Amazonian region of Peru. Although its incidence is low, the percentage of diseased plants in affected plantations is much higher than in the other diseases caused by the American viruses. There are several types of symptoms, probably due to different races or biotypes of the causal agent. Among them, the most important are (1) plants that show stunting and excessive proliferation of branches; shoots have small leaves and shortened internodes, without showing distortion or chlorosis; (2) proliferation of shoots from the cutting; these are generally weak but grow without showing any other visible symptom of being affected; (3) only a few weak and stunted shoots germinate from the cutting; they never reach normal size. Plants affected by the mycoplasma generally produce up to 80 percent less than healthy plants. As the disease is transmitted mechanically and through the use of cuttings taken from diseased plants, their elimination is indispensable for its control. Always use disease-free material for planting.

Stunting and witches'-broom



Proliferation of shoots from the cutting as compared with normal plant

Stunted and weak shoots

Brown leaf spot *(Cercospora henningsii)*

This is one of the most common diseases in cassava. It almost always occurs in plantations located in areas with high temperatures. When the crop is more than five months old, the disease is more widespread and severe, depending upon the susceptiblity of the cultivar. The disease is characterized by angular, uniformly brown spots on both sides of the leaf; the margins of the spots are well defined and dark. On the undersurface of the leaf, the spots have a grayish olive cast due to the presence of the fruiting bodies of the causal agent. At times, according to the susceptibility of the cultivar, there is an indefinite yellowish halo around the lesions. As the disease advances, the affected leaves become yellow, dry and fall. Susceptible cultivars can be severely defoliated at the end of the rainy season. Use resistant or tolerant cultivars if possible.

Typical brown angular leaf spot

Yellowing induced by brown leaf spot

Blight leaf spot *(Cercospora vicosae)*

This disease appears where brown leaf spot is prevalent; in contrast, this leaf spot is large and without well-defined borders. Each spot may cover one fifth or more of the leaf lobe. The same as brown leaf spot, it is a uniform brown in color but with a grayish center on the underside of the leaf due to the presence of fungal fruiting bodies. The general appearance of this leaf spot disease is similar to that caused by *Phoma* sp. (*Phyllosticta* sp.), nevertheless, lesions caused by *Phoma* sp. have concentric rings on the upper leaf surface. The pathogen can cause heavy defoliation in susceptible cultivars, the severity of the disease is greater when the plants are more than six months old. Plant resistant or tolerant cultivars if possible.

Typical leaf blight

White leaf spot *(Cercospora caribaea)*

This disease is commonly found in humid, cooler cassava-growing areas and causes defoliation in susceptible cultivars. Lesions are small, circular to angular, white or yellowish brown; they are sunken from both sides, reducing the thickness of the normal leaf blade to about one half. The lesions on the under-surface of the leaf often have a diffuse-colored border that looks like an irregular violet-brown line surrounded by a yellowish halo. The center of the spots may have a grayish, velvety appearance during the fructification of the pathogen, which occurs mainly on the underside of the leaf. Plant resistant varieties if available.

White spots on upper leaf surface

White spots on under leaf surface

Concentric-ring leaf spot [*Phoma (Phyllosticta)* sp.]

This disease appears during the rainy season when the temperature is less than 20°C; it causes severe defoliation in susceptible cultivars and occasionally dieback or total death of the plant. The spots are large and brown in color; they do not have well-defined margins and are located near the tips or edges of the lobes or along the midrib or main veins. Initially, the upper surface of the lesions presents concentric rings, formed by the fruiting bodies (pycnidia) of the fungus. Old lesions resemble lesions produced by *C. vicosae* since their concentric rings are washed off by the rain. On the underside, there are no pycnidia so the lesions are dark brown in color. Veins and veinlets become necrosed, forming black threads that radiate from the lesions. The fungus invades the leaf, then the petiole and the green parts of the stem, causing defoliation, dieback or total death of the plant It spreads to the stem, starting from cankers that form towards the base of the petiole of the affected leaf. In cooler areas, always plant resistant or highly tolerant cultivars only.

Superelongation *(Sphaceloma manihoticola)*

This is a disease that has been described only recently; it causes considerable losses in plantations where susceptible cultivars are used. The disease can be recognized by the exaggerated elongation of the stem internodes. The affected stem is thin and weak; diseased plants are much taller and/or weaker than healthy ones. On the green part of the stem, the petioles and the leaves, deformations associated with the formation of cankers can be found. These lens-shaped cankers are found along the midribs or main veins, in the petioles or in the stem. There is occasional dieback and partial or total necrosis of the blade, which results in considerable defoliation. The disease is most severe during the rainy season. As it may be spread by the use of cuttings taken from infected plantations, clean "seed" should always be used. Resistant cultivars should be planted if possible.

Leaf spots and dieback

Concentric rings on upper leaf surface

Cassava ash *(Oidium manihotis)*

This disease occurs during the dry season, being more prevalent on lower leaves. It is characterized by the presence of yellowish leaf spots. Initially, a white mycelium grows on the leaf surface; affected cells turn yellow, forming indefinite pale yellow lesions. Within these lesions, there are areas of necrosed tissue, which form different-sized, pale brown angular spots. Symptoms can be confused with certain types of damage caused by insects and spider mites. The disease is considered to be of minor importance in yield reduction.

Characteristic elongation and leaf distortion

Cankers on petiole and midrib

Cankers on midribs and leaf spots

Anthracnose *(Colletotrichum* or *Glomerella manihotis)*

This disease appears after long periods of rain. It is characterized by the presence of leaf spots found near the edges of young leaf lobes, which are distorted; there is partial or total necrosis of the affected tissue. The pathogen also attacks the green part of the stem, producing cankers and dieback. In the central part of these lesions, pinkish areas, formed by the fructifications of the fungus, can generally be found. Most severe damage is done to cultivations under one month old; attacks after this time can lessen the quality of cuttings obtained from these affected plants. Use clean "seed" and do not plant at the height of the rains.

Yellow leaf spots on upper leaf surface

Rusts (*Uromyces* spp.)

Six species of rust pathogens have been recorded in cassava, localized in different parts of the world. Nevertheless, their incidence and severity are low. It seems that some species of rust occur only in temperate zones where the disease is most severe towards the end of the rainy season; other species are prevalent during the hot, dry season. The disease is characterized by the formation of pustules on the veins, petioles or green stems. These pustules are orange or light to dark brown in color, depending upon the age of the pustule or the type of fungal fructification. Mature pustules show a high degree of parasitism of fungi (*Darluca* spp.). Occasionally the pustules are bordered by a yellowish halo. Generally the pustules induce distortion of the affected parts. The disease is of minor importance.

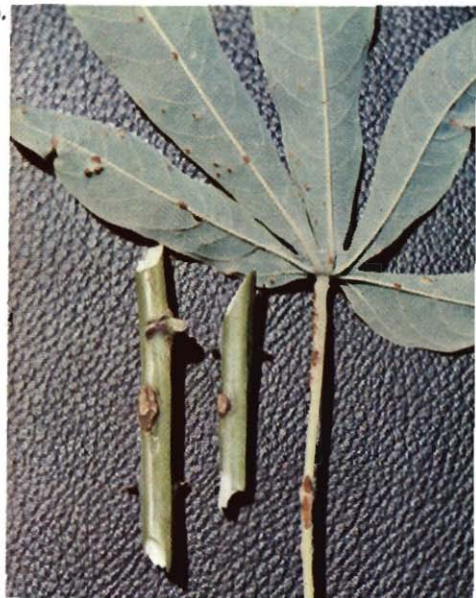
Leaf tip blight

Shoot dieback

Stem cankers

Pustules on stem

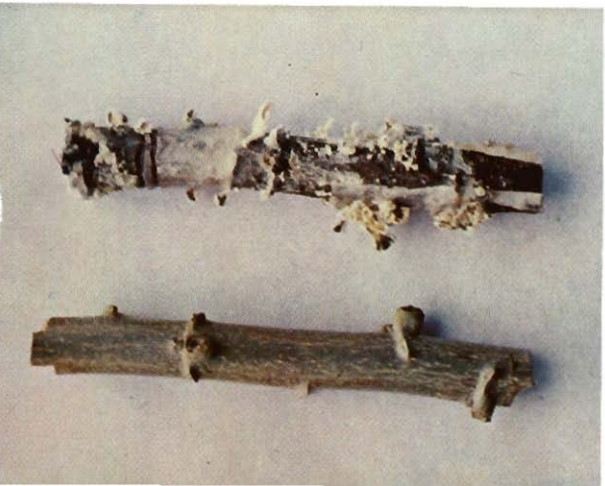
Pustules on stem, petioles and leaf



Stem rot (various pathogens)

The stem, which is normally used for propagation material in cassava, is attacked by pathogens of woody perennials. The affected tissue is generally a different color from healthy tissue, especially around the vascular strands or pith area. At first, the epidermis may show superficial rot; later, fruiting bodies of the pathogen may appear. These bodies vary in form, color, size, etc , according to the species of pathogen. The occurrence of this rot is more noticeable at the end of the rainy season and in cuttings that have been stored under conditions of high relative humidity for periods of more than 15 days. All wounds caused by insects or by laborers leave the plant predisposed to the occurrence of these diseases. Avoid planting "seed" with symptoms of any disease.

Fungal fruiting bodies on stem



Infected propagating material (various pathogens)

Certain pathogens (causal agents of bacterial blight, bacterial stem rot, superelongation, viruses, viruslike organisms and mycoplasma) translocate systemically in the vascular or cortical system and superficially from the stem of diseased plants, without producing any visible symptoms in the tissue they invade. When this material is used for cuttings, the resultant plants develop symptoms characteristic of the diseases that these pathogens cause and constitute a focus for secondary infection. Since the mature (lignified) part of the stem does not generally present any symptoms of infection, the symptoms of these diseases must be looked for towards the upper part of the plant and generally during the rainy season when they are more noticeable. Never use planting material taken from plantations where these diseases have been observed.

Diseased shoots resulting from CBB-infected cutting

Absence of swollen roots in plant from cutting infected with "frog skin" root disease

Elongated shoots resulting from cutting infected with superelongation

Root rot (various pathogens)

Phytophthora drechsleri, Pythium sp., etc.

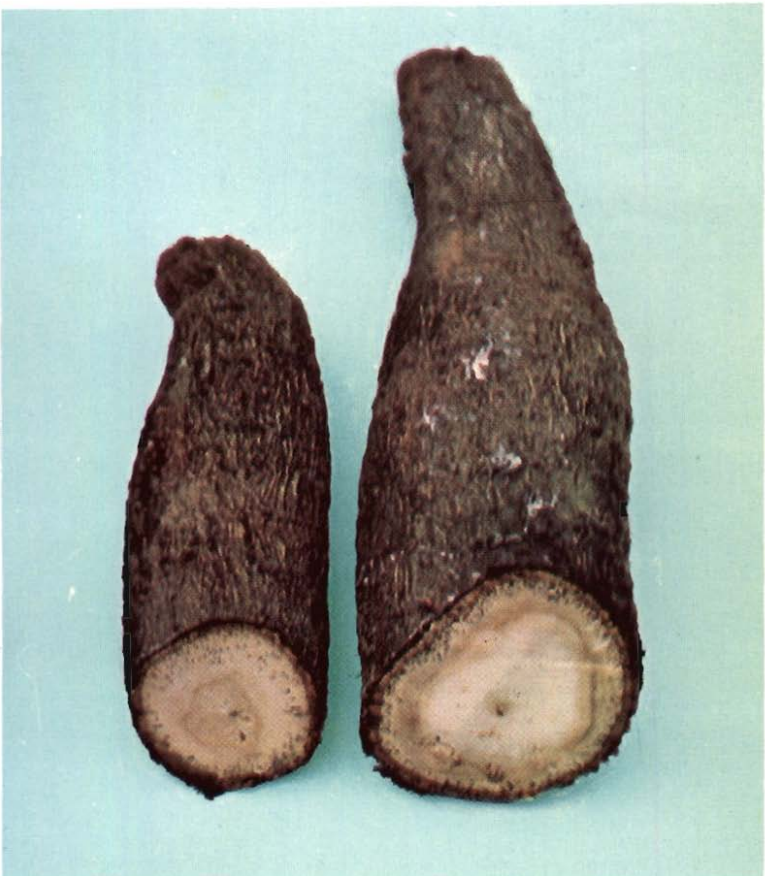
Certain fungi of the soil that cause root rot during the rainy season are widespread in heavy, poorly drained soils with a high organic matter content. *Phytophthora drechsleri* is the most common and important. These pathogens attack young or mature plants, especially when they are near drainage ditches or in poorly drained soils. They cause sudden wilting, severe defoliation and soft root rot. Roots exudate a pungent, watery liquid and decompose completely. Select a suitable soil for cultivating cassava and use good agronomic practices.

Phytopthora root rot

Pythium root rot

Rosellinia necatrix, Armillaria mellea, Fomes lignosus, etc.

Certain species of fungi cause considerable root rot during the rainy season, but only when cassava has been planted immediately after forest clearance or after woody perennial species. Among these pathogens, *Rosellinia necatrix* is the most important. The disease induced by this pathogen is called "black rot" because of the characteristic black color of the infected tissues. Cankerlike root lesions are also formed. To avoid this group of diseases caused by pathogens of woody perennial species, it is necessary to rotate with nonsusceptible crops (cereals) before planting cassava. These diseases are generally found a little before harvest or at harvesting. Infected crops initially present—in zones or patches—yellowing, then wilting, and finally defoliation and dieback. Rotate with cereals and use good cultural practices.



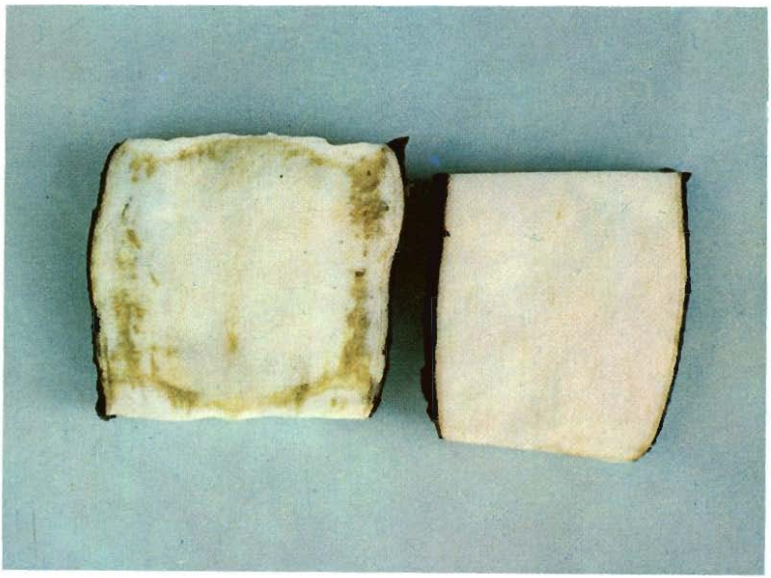
Rosellinia root rot

Postharvest root rot (physiological and/or pathogenic causes)

Cassava roots generally deteriorate a few days after harvesting. This deterioration seems to be related to the cultivar's susceptibility to deterioration and to damage that the roots suffer during harvesting. Roots of some cultivars deteriorate rapidly, whereas those of others remain in good condition for several days. Roots with no mechanical damage remain sound longer, even when the cultivar is susceptible to deterioration. The causes of deterioration have not been determined yet; but it seems that deterioration is a result of physiological and/or pathological effects, taking place during harvesting or immediately afterwards.

Two degrees of postharvest deterioration as compared with the control

Internal postharvest root rot



IMPORTANT PESTS

Cassava is attacked by a large number of mites and insects, some of which cause considerable economic losses. Since cassava is a long-cycle crop, the continued application of insecticides for pest control would be very costly. It should be kept in mind that cassava has the capacity to recover from pest attack when climatic conditions are favorable, especially during the rainy season.

Preventive measures

The best control is to maintain a low incidence of pests. The following measures are recommended to achieve this:

1. Use disease-free planting material.

2. Use cultivars that are resistant or tolerant to pests.

3. Do not plant in soils that are highly infested with insects or postpone planting until the population is as low as possible.

4. Do not destroy natural enemies of pests. When pesticides are applied, pests as well as their parasites and predators are killed, increasing the number of harmful insects. Therefore, selective pesticides should be used -i.e., Thuricide *(Bacillus thuringiensis)* against the casssava hornworm– or nests of paper wasps *(Polistes* sp.) can be placed near the crop to prey on larvae.

5. Apply insecticides only when damage is severe and the plant is in no condition to recover without the aid of this measure. The insecticide should be selective.

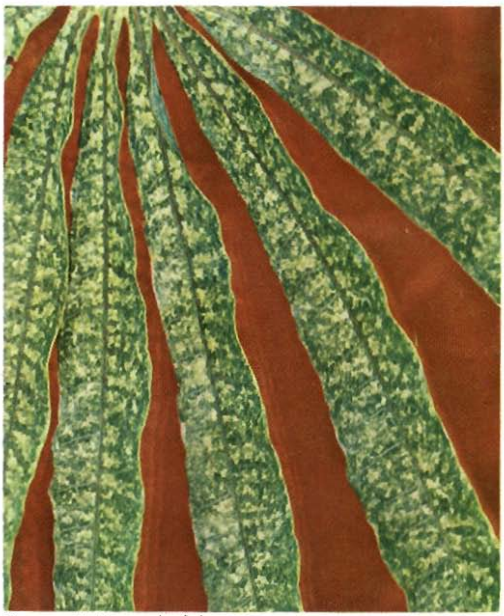
6. Observe quarantine measures to avoid introducing pests to zones where they are not found.

Mites *(Mononychellus tanajoa, Tetranychus urticae, Oligonychus peruvianus)*

Mites are distributed worldwide. Several species attack cassava, frequently during the dry season, causing considerable damage.

M. tanajoa and *M. mcgregori* are green mites that attack the growing point, feeding on young leaves and the green portions of the stem. Infested leaves develop yellow spots, lose their normal green color and become deformed. The shoots turn rough and brown. Infested leaves and stems die progressively, from top to bottom. Severe damage stunts plant growth and induces branching.

Mononychellus sp. damage to growing point



Mononychellus sp. leaf damage

T. urticae attacks mature leaves at the basal part of the plant first, moving to the upper leaves if the dry season is prolonged. Infested leaves have yellow dots along the veins, which become reddish or rust colored as the infestation increases or persists. Severely infested leaves dry and fall, and plants may die.

O. peruvianus normally attacks the lower and intermediate leaves. On the underside of the leaves, there are whitish spots along the center and lateral leaf veins. These spots are webs spun by the female, under which she lays her eggs and the larvae and nymphs develop. On the upper leaf surface, they appear initially as yellowish spots, which turn brown.

Cultivars tolerant to mites have been found. Mites can also be controlled by using methamidophos, dimethoate, or other organophosphorous insecticides at commercial rates of application.

Tetranychus urticae damage

Oligonychus peruvianus damage to leaves

Thrips *(Frankliniella williamsi, Corynothrips stenopterus, Caliothrips masculinus)*

Several species attack cassava, principally in the Americas. The most important is *F. williamsi*, which damages the growing points of the plant. Leaves develop abnormally; young leaves are distorted and deformed, with irregular yellow spots. Brown epidermal wounds are found on the green portion of the stem; internodes are usually shortened. The growing points sometimes die, thereby inducing growth of lateral shoots, which can be attacked with equal severity, giving an appearance of witches'-broom. Outbreaks of thrips are more frequent during dry periods, causing losses of up to 25 percent. Best control is obtained through the use of resistant cultivars. Systemic insecticides such as dimethoate (160 cc a.i./ha) or thiometon (113 cc a.i./ha) give good control.

Thrips damage

Severe thrips damage

The cassava hornworm *(Erinnyis ello)*

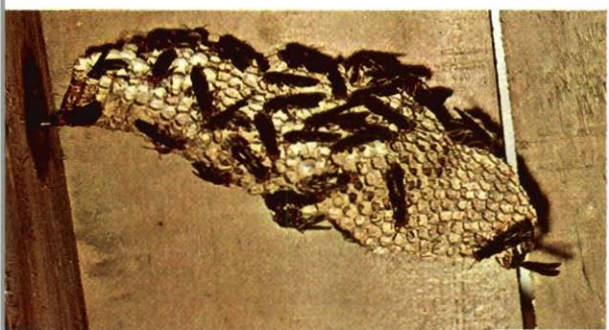
This insect is generally considered as the most important pest of cassava in the Americas. High populations can defoliate large plantations in a short time. When defoliation occurs in the initial phase of crop development, yields are reduced and young plants may die. The ash-colored female is nocturnal; she oviposits her light green eggs freely on the leaf surface. Larvae vary a great deal in color (yellow, green, black, etc.), reaching a size of 10 to 12 cm before migrating to the soil, where they form chestnut brown or black pupae. Greatest incidence generally occurs at the beginning of the rainy season, but outbreaks are sporadic and may be absent for several years. Sound agronomic practices (weed control, good land preparation) reduce populations. Egg parasitism by *Trichogramma* spp. reduces populations, and the paper wasp *(Polistes* sp.) is the most important larval predator. Effective control can also be obtained by spraying bacterial suspensions of *Bacillus thuringiensis.* Chemical control (lead arsenate, trichlorfon) is effective against the larvae but should be avoided since the beneficial insects that exercise biological control are destroyed.

Hornworm eggs

Hornworm larva

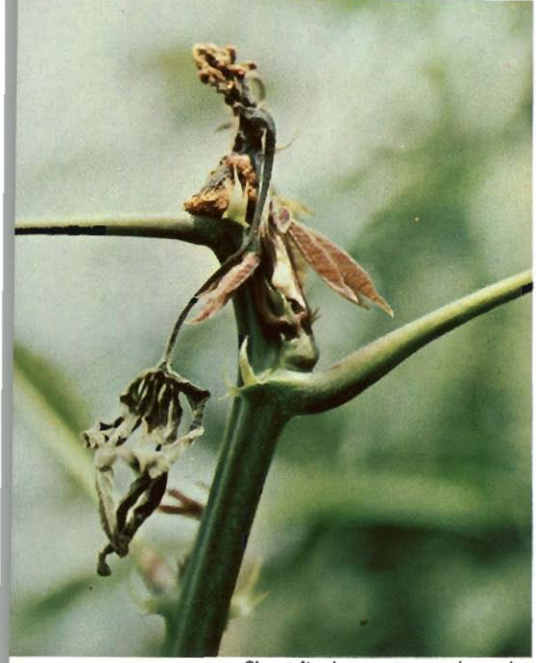
Hornworm adult

Paper wasp (*Polistes* sp.)



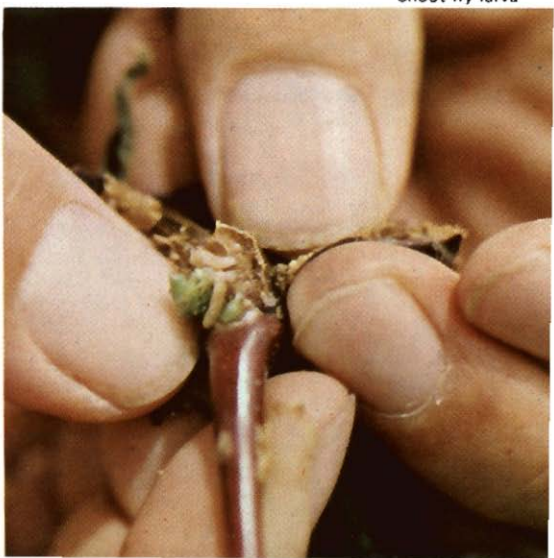
Shoot flies *(Silba pendula, Carpolonchaea chalybea)*

This pest, found only in the Americas, can damage terminal shoots, resulting in a reduction of plant growth. The adult fly is dark, metallic blue in color; eggs are oviposited among unexpanded leaves in the growing points or in small cavities made by the ovipositor in the plant tissue. After hatching, the larvae tunnel in the young plant tissue and eventually kill the growing point. Several whitish larvae may be found in the affected growing point, where there is generally a yellowish or brown exudate. The death of the growing point retards normal growth and induces the formation of new side shoots that may also be attacked. Young plants are more susceptible; damage to older plants probably has no effect on yield. Since heaviest infestations occur at the beginning of the rainy season, planting should be programmed so that initial crop growth takes place when shoot fly populations are low. Larvae are difficult to control, but systemic organophosphorous insecticides, such as diazinon, dimethoate, methamidophos, monocrotophos and dicrotophos, can be used at commercial rates of application.



Shoot fly damage to growing point

Shoot fly larva



Fruit flies *(Anastrepha pickeli, A. manihoti)*

This fly has been frequently reported as attacking the cassava fruit, causing no economic losses; nevertheless, it can also cause severe damage to the stems. The attack on the stem occurs 10 to 20 cm below the growing point, leaving a small entrance or exit hole. The female, which is yellow in color, oviposits in the stem tissue near the tip. Upon hatching, the yellowish white larvae bore their way into the pith region. A bacterial pathogen (see "bacterial stem rot") has been found in association with the larvae; from this association a severe stem rot results. A white latex exudate is often seen flowing from the larval tunnel. Heavy attacks may cause the death of the growing point, thus retarding growth and inducing the formation of lateral shoots. This bacteria-insect association can reduce yields, as well as the quality of the propagation material coming from affected plants. Although methods of control are still in the experimental phase, it can be achieved through the use of resistant cultivars and systemic insecticides such as fenthion.

Fruit fly adult

Fruit fly larva

Severe fruit fly damage

Whiteflies (*Aleurotrachelus* sp., *Aleurothrixus* sp., *Bemisia tabaci, B. tuberculata* and *Trialeurodes variabilis)*

Whiteflies have been recorded in the Americas, Africa and certain parts of Asia. Direct damage due to feeding is not reported; but high populations may cause yellowing and drying of the lower leaves of the plant. Adult whitefly populations can be detected by shaking the growing points of the plants, which disturbs the adults into flight. Pupae and nymphs are found on the undersides of the lower leaves. The presence of a sooty mold is commonly found in association with whitefly attack. High populations usually occur in the rainy season. *Bemisia tabaci* is a vector of the African mosaic disease (see corresponding section of chapter on diseases), which causes heavy yield losses in Africa and Asia. Since this disease does not exist in the Americas, the importance of the whitefly on this continent is minimal. For its control the following insecticides are suggested: dimethoate (250 to 400 cc/ha), demeton or cicrotophos (400 to 600 cc/ha), or phosphamidon (250 to 400 cc/ha).

Whitefly pupae (*Aleurotrachelus* sp.)

Whitefly adult (*Trialeurodes variabilis*)

White grubs (larvae of Coleoptera belonging to the families Scarabaeidae or Cerambycidae)

The grubs, whose adult stage is a beetle, attack the cuttings and roots of the cassava plant. Various species have been recorded in many cassava-growing areas of the world. The presence of these larvae can be detected when the soil is being prepared for planting. Damage is characterized by the destruction of the bark of the cuttings and the presence of tunnels in the woody part. These cuttings may rot and die. When young plants (1 to 3 months) are attacked, they suddenly wilt and die. The larvae also feed on the bark of the basal part of the stem, generally in the zone immediately below the soil. The larvae are white with black heads and reach up to 5 cm in length. They can generally be found around the cutting or roots of the affected plant. The most effective control is obtained using aldrin (1.5 kg a.i./ha) and carbofuran (0.9 g a.i./plant), applied to the soil, right under the cutting.

White grubs attacking cassava roots

White grubs attacking cutting

Cutworms (larvae of *Agrotis ipsilon* and *Prodenia eridania)*

There are several species of cutworms that attack cassava. These can be grouped into the following categories:

Surface cutworms

The black cutworm *(Agrotis ipsilon)*, which feeds on the basal part of the stem near the surface of the soil, leaves the plants lying on the ground. The larvae are greasy gray to brown in color, with faint, lighter stripes.

Climbing cutworms

These cutworms climb the stem, feeding on the buds and foliage; they may also girdle the stem, causing the upper part of the plant to wilt and die. The larvae of the southern armyworm *Prodenia eridania* have been recorded causing this type of damage in many cassava-growing areas. They are dark gray to black in color, with lateral yellow stripes.

Subterranean cutworms

These remain in the soil, feeding on the roots and underground parts of the stem. They cause damage to young plants (killing up to 50 percent), making it necessary to replant. Although the attacks may occur sporadically, they are more frequent when cassava has been planted after maize.

All these larvae can be controlled by using poison baits (10 kg sawdust, 8 to 10 liters water, 500 g sugar or molasses, and 100 g trichlorfon for 1/2 to 1 ha). For underground cutworms, applications of aldrin or carbofuran around the cuttings can be effective.

Cutworms attacking stem

Cutworm damage to cuttings

Stemborers (various species of Coeloptera, Lepidoptera and Hymenoptera)

Many insect species feed on the stems and branches of cassava plants, causing considerable damage. These stemborers are distributed worldwide; but they are particularly important in the Americas, where they cause sporadic or localized damage. Most stemborers are the larval stage of Coleoptera *(Coelosternus* sp. and *Lagochirus* sp.), Lepidoptera (*Phyctaenodes* sp.) and Hymenoptera.

The larvae vary in size and shape, depending on the species; some reach a size of 30 mm in length. The larvae are usually white, yellow or tan in color and can be found tunneling through the aerial part of the plant. The stems and branches may break because of the wind or be reduced to sawdust. During dry periods, affected branches may lose their leaves and dry up; when the infestation is severe, the plants may die. A stemborer attack is very easily detected by the presence of excreta, sawdust and exudate, ejected from burrows made by the insect in the infested branches, and which can be found on the site of infestation or on the ground, just under the plant. Control with pesticides is impractical since it is difficult to kill the larvae inside the stems. Populations can be reduced by removing the infested parts or plants and burning them. Always use disease-free cuttings for planting.

Stemborer damage (pupa present)

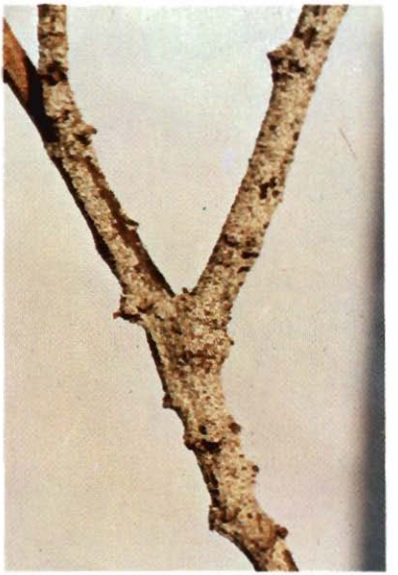
Stemborer damage (larva present)

Larva, pupa and adult of Coleoptera

Scale insects (*Aonidomytilus albus, Saissetia miranda,* etc.)

Several species of scales attack cassava stems; but except for localized incidence, they do not seem to cause significant reductions in yields. They generally attack weak plants. The attack on the stem by *A. albus* can cause leaves to yellow and fall. When damage is severe, the stem is completely covered with scales, plant growth is stunted, the stems may dessicate, causing plant mortality. Some species attack the leaves. Nevertheless, the greatest damage seems to be related to the loss of propagation material: the germination of heavily infected cuttings is greatly reduced; and when they do germinate, the roots are poorly developed and their quality, reduced. Heaviest outbreaks occur during dry periods, becoming worse during prolonged periods of drought. Most effective control is obtained by using disease-free cuttings and by removing and burning infested plants to prevent later dissemination. Chemical control during plant growth can reduce its incidence (oxydemetonmethyl, malathion, at 0.1 percent).

Black scale *(Saissetia miranda)* on cassava



White scale *(Aonidomytilus albus)* on cassava

Lace bugs (*Vatiga manihotae* and *Vatiga* spp.)

Lace bugs have been reported attacking cassava in several South and Central American countries. In Colombia the species *V. manihotae* has been recorded, but losses due to this insect have not been determined yet. Adults are gray in color and are approximately 3 mm long. The whitish nymphs are slightly smaller, both adults and nymphs are found in large quantities on the undersides of leaves. Damaged leaves have small yellow spots that later turn reddish brown, resembling mite damage. Considerable damage can be done to all the foliage of one plant.

Lace bug leaf damage

Lace bug adult and nymphs

Termites *(Coptotermes* spp.*)*

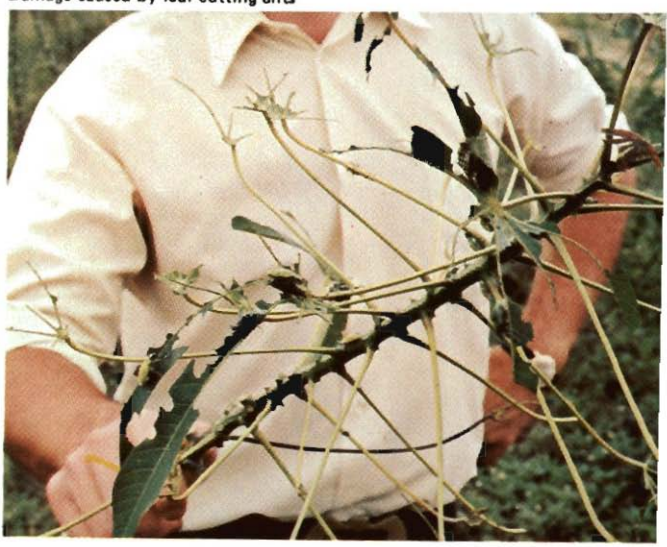
Termites have been found attacking cassava in the tropical lowlands. They feed on propagation material (cuttings), on roots, or on growing plants. In general the establishment of a plantation can be severely affected by termite attack, above all when it occurs during prolonged dry periods. For their control, the use of residual pesticides such as aldrin, dieldrin or chlordane is recommended.

Leaf-cutting ants *(Atta* sp., *Acromyrmex* sp.*)*

Several species of ants can defoliate a plantation rapidly when a large number of worker ants invade it. They cut semicircular pieces of leaves, which they then carry to their nests; in heavy attacks, even the buds are removed. Outbreaks usually occur during the first months of crop growth, but their effect on yield is not yet known. Their nests can usually be seen easily because of the piles of dirt deposited around the entrance holes. Insecticides are the most effective means of control. Ants can be destroyed in the nest by fumigating with carbon disulfide, sulfur smoke or arsenates. Aldrin (in powder), blown into the nest; or heptachlor, dieldrin, BHC and aldrin (in solution), applied in or around the nest, also give good results. Granular mirex, spread along the ant trails leading to the nests, is carried into the nest by the ants, giving effective control also.

Termite damage to cuttings

Damage caused by leaf-cutting ants



Gall midges (Cecidomyiidae)

Several species of flies that induce galls on cassava have been recorded in the Americas. These small flies are generally found on the leaf uppersurface where they lay their eggs. The larvae cause abnormal cell growth, forming galls. The galls, found on the upper leaf surface, are yellowish green to red in color, narrow at the base and often curved. When the galls are opened, a cylindrical tunnel with the larva inside can be seen. Gall midges are generally of little economic importance and therefore do not require control. Nevertheless, there have been cases of retarded growth when there are severe outbreaks in young plants (2 to 3 months). To reduce their incidence, infected leaves should be collected and destroyed at weekly intervals.

Leaf galls

Galls on upper and under leaf surfaces

PROBLEMS OF NUTRITONAL DEFICIENCIES AND TOXICITIES

Although cassava is frequently grown in poor soils, it can show a high response to fertilization. Deficiencies of major elements do not always result in easily noticeable symptoms, rather they are reflected in reduced growth and yields. As a result, many farmers never realize the existence of these deficiencies. Among the major elements, potassium deficiency is the most common, even in soils where other crops do not respond to potassium fertilization. Cassava also seems to be very sensitive to magnesium and sulfur deficiencies.

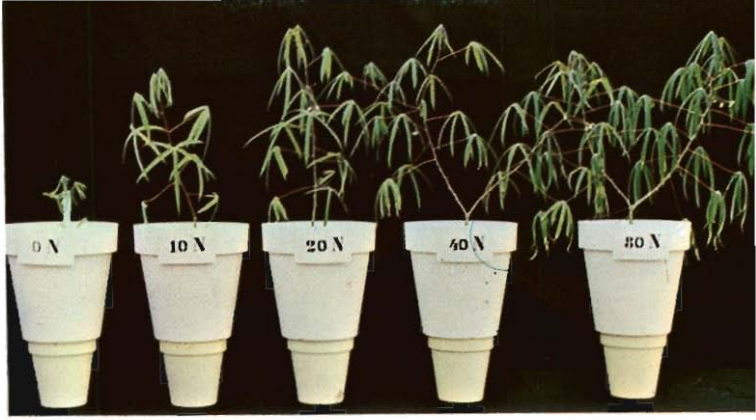
Among the minor elements, zinc deficiency is the most common in alkaline as well as in some acid soils. Cassava may show a negative response to liming in acid soils due to the effect of inducing zinc deficiency. The effect of other minor element deficiencies is less frequent but can be expected in soils with a high pH or in very sandy soils.

Cassava generally adapts well to acid soils, but it is sensitive to salinity or alkalinity. Nevertheless, there are cultivars with a high degree of tolerance to salinity; in this case, the selection of tolerant cultivars is the best solution to this problem.

Nitrogen (N)

Nitrogen deficiency significantly reduces plant growth and production, but there are no clearly distinguishable symptoms. The photograph shows cassava plants growing in sand with different levels (ppm) of N in a nutritive solution. Stunting of plants occurred at low levels of N, but there was no typical yellowing, which is a sign of N deficiency in other crops. The next photograph shows the poor growth of cassava in the absence of N (foreground), as compared with vigorous growth in the presence of N (background).

Nitrogen deficiency in cassava is not as common as in other crops, but it can be found in infertile soils such as oxisols or ultisols. In these soils, the application of N should be moderate (only 50 to 100 kg/ha) since production is lowered if N is applied in excess. Applications should be made at planting and then 2, 3 or 4 months later. Normal N levels in upper leaves are from 5 to 5.5 percent for the leaf blades and 1.5 percent for the petioles.



N response in sand culture

N response in field

Phosphorus (P)

Phosphorus deficiency is characterized mainly by stunting (see photo). Leaves may be slightly darker in color and the purple coloration of the petioles more pronounced; however, the symptoms related to this deficiency are not very clear. Severe deficiency may result in yellowing and necrosis of some leaves. The central photograph shows a plant with typical P deficiency: slender stems, narrow and fewer lobes.

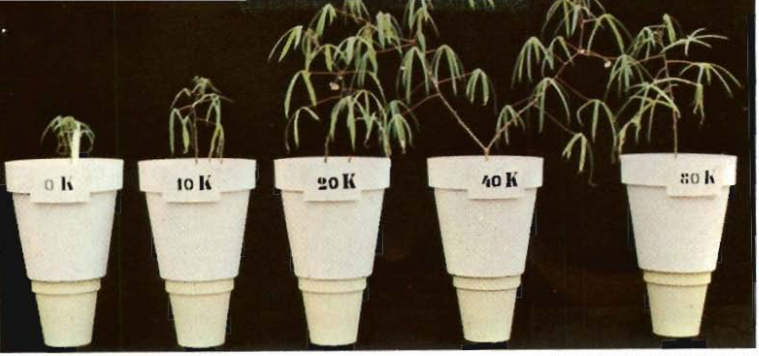
This deficiency is common in oxisols and in volcanic ash soils. It can be corrected by band applications of fertilizer with a high percentage of soluble P, such as triple or simple superphosphate, or by incorporation of less soluble P fertilizers such as basic slag or rock phosphate. Rock phosphate is a good source of P in very acid soils. All P sources should be applied to the soil at the moment of planting. Normal P levels in upper leaves are from 0.25 to 0.50 percent for the leaf blades and 0.12 to 0.15 percent for the petioles.

P response in sand culture

P deficiency

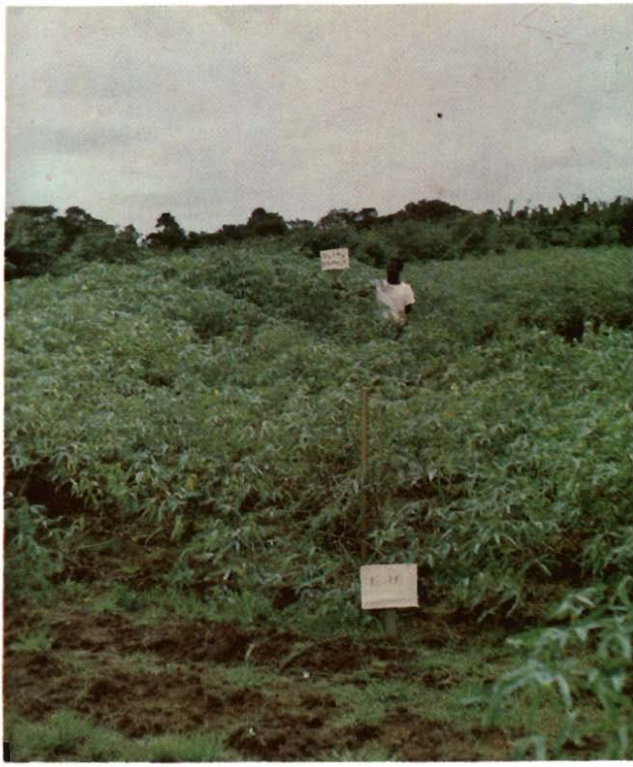
Potassium (K)

Potassium is one of the most important elements affecting production. The deficiency of this element reduces height, without producing definite foliar symptoms (see photo). Plants with a K deficiency generally have narrow and fewer lobes. The lower photograph shows the poor growth of plants due to K deficiency (foreground), as compared with normal growth in the absence of this deficiency (background). Intermediate levels of application (100 to 200 kg K_2O_5/ha) of potassium chloride or sulfate are recommended; the latter source is preferable in sulfur-deficient soils. High applications of K may result in lower yields due to chlorine toxicity (if KCl is used) or to induced magnesium deficiency. Potassium should be band applied at planting and two to three months thereafter. Normal levels of K in the upper leaves are from 1.2 to 1.8 percent for the leaf lobe and from 2 to 3 percent for the petioles.



K response in sand culture

K response in field



Magnesium (Mg)

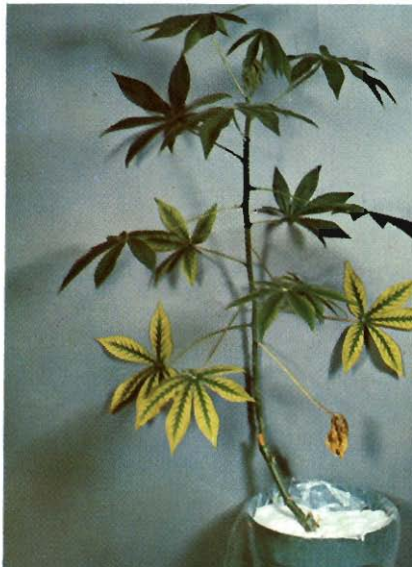
Magnesium deficiency results in growth reduction and intervenal yellowing of the lower leaves. The yellowing begins towards the tip of the leaves or the edges, advancing towards the center. Later the leaves die (see photos).

Cassava is susceptible to Mg deficiencies in soils where other crops may not respond to Mg; high rates of K may also induce deficiency of this element. Magnesium may be applied by incorporating it into the soil as $MgCO_3$ or MgO (20 to 50 kg Mg/ha), or band applications of 10 to 40 kg Mg/ha as $MgSO_4$. Magnesium sulfate is preferable in sulfur-deficient soils.

The levels of Mg in the upper leaves are from 0.25 to 0.3 percent for the leaf blade and from 0.3 to 0.4 percent for the petioles.

Mg deficiency

Mg deficiency



Sulfur (S)

Sulfur deficiency produces a yellowing or a light green coloring of the lower leaves and reduces the height of affected plants (see photo). Cassava seems to be particularly susceptible to S deficiency in highly leached soils, especially those far removed from industrial centers. High applications of K (as KCl) may induce S deficiencies. Sulfur can be applied at a level of 20 kg S/ha as elemental S or in the form of a sulfate, such as potassium or magnesium sulfate or simple superphosphate. Normal S levels in the upper leaves are from 0.3 to 0.4 percent for the leaf blade and 0.15 percent for the petioles. When the relation N/S is more than 16, S deficiency may be expected.

S response in sand culture

Various degrees of S deficiency

Zinc (Zn)

Zinc deficiency produces white or yellow spots on the upper leaves (see top photo) and yellowing and deformation of the youngest, recently formed leaves. Necrotic spots may appear on lower leaves (see lower photo). The color and shape of the spots vary according to the cultivar. Cassava is very susceptible to Zn deficiency, which occurs most frequently in soils with a high pH; but it is also found in soils with a low pH. Liming these soils may reduce yields seriously because of the induction of Zn deficiency. Zn deficiency becomes worse with a high application of P. Zinc should be band applied to the soil at levels of 5 to 10 kg Zn/ha as ZnO or $ZnSO_4$. It may also be applied to leaves with 1 or 2 percent solutions of $ZnSO_4$, or the cuttings may be immersed in 1 or 2 percent suspensions of ZnO.

Normal Zn levels in the upper leaves range from 50 to 60 ppm for leaf blades. Symptoms of Zn deficiency are generally observed when the level of this element is under 20 ppm.

Zn deficiency

Zn deficiency

Zn deficiency

Copper (Cu)

Copper deficiency is not very common in cassava. It produces white spots on the upper leaves (see upper photo), and recently emerged leaves are deformed (lower photo). Symptoms are similar to those presented for Zn deficiency, except that the leaves are less yellow.

Copper deficiency is commonly found in soil with a high organic matter content and also in soils with a high pH. It can be corrected by leaf spray, by applying copper sulfate to the soil, or submerging cuttings in a solution of this compound. Normal Cu levels in the upper leaves are approximately 6 to 12 ppm for the leaf blade.

Cu deficiency

Cu deficiency

Iron (Fe)

Iron deficiency is characterized by the presence of a yellowish orange coloring on the upper leaves (see photos), the yellowing being rather uniform over the entire leaf area. This deficiency is not common in cassava, but it does occur in soils with a high pH, in sandy soils, or in soils with a high organic matter content. Deficiency may be induced by liming or excess applications of Mn. Iron should be applied by leaf aspersion with a 1 to 2 percent solution of $FeSO_4$ or iron chelates. Iron chelates may also be applied to the soil, but they are only effective in relatively high concentrations. Normal Fe levels in leaves range from approximately 100 to 200 ppm.

Fe deficiency

Fe deficiency

Manganese (Mn)

The symptoms of Mn deficiency are similar to those for Fe deficiency: uniform yellowing of all the leaves, beginning at the edges of the leaf blade (see photos).

Manganese deficiency is rare, but it can occur in soils with a high pH or in organic soils. It can be corrected by leaf aspersion of $MnSO_4$ or by band applications of $MnSO_4$ or MnO.

Normal Mn levels in leaves range from 50 to 150 ppm.

Mn deficiency

Mn deficiency

Boron (B)

Boron deficiency is rare and clear symptoms have not been found (see photos). It is most common in alkaline soils and can be corrected by applying borax or other sodium borates (1 to 2 kg B/ha) to the soil or by leaf aspersion of these compounds. Normal B levels in the leaves are approximately 15 to 40 ppm.

B deficiency

Boron toxicity

Boron toxicity is characterized by the presence of white spots or necrosis of the lower leaf edges (see photos), especially in young plants. It is very common when there has been an excessive or nonuniform application of B fertilizers. Plants generally recover.

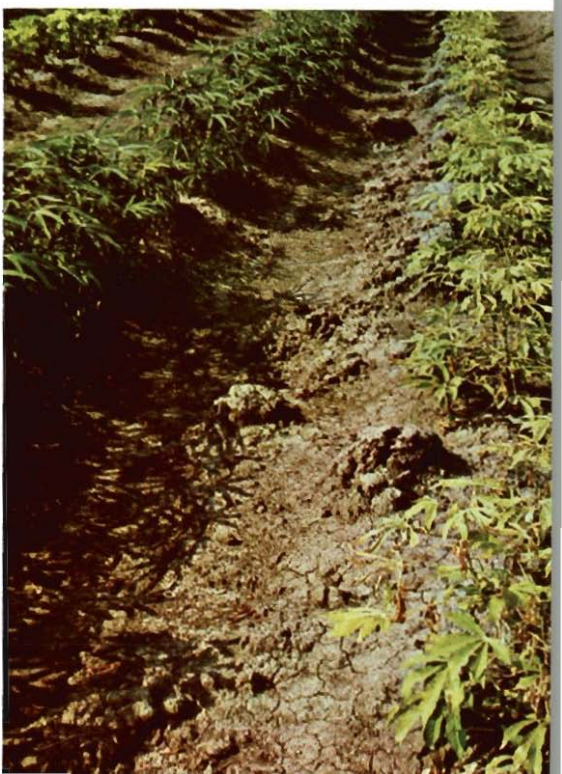
B toxicity

B toxicity

Salinity and/or alkalinity

Symptoms due to these soil problems are characterized by a uniform yellowing of the upper leaves, which proceeds downwards, affecting the whole plant (see upper photo). The leaves die, beginning at the edges, and then fall, later there is dieback of branches. Some cultivars are more affected than others (see lower photo). The problem is most easily solved by selecting tolerant cultivars.

Salt damage



Varietal differences in susceptibility to salt spots

SYMPTOMS OF DAMAGE CAUSED BY HERBICIDES

The use of herbicides in cassava can replace initial weedings that the crop requires to eliminate weed competition during the first weeks of development and thus reach maximum productivity. There are many factors that affect the effectiveness and selectivity of weed-killers in any crop.

In the case of cassava, many preemergence and postemergence products have been found to be selective when they are employed properly; nevertheless, there are cases in which herbicides cause crop damage. The most frequent are as follows:

1. An overdose because of failure to read the label carefully, poor calibration of equipment, or an error in weighing or in calculating the quantity of the product to be added to the sprayer.

2. The utilization of a product or a rate of application not recommended for light soils. The same rate should not be used for all types of soil. When the organic matter content is low and/or the soil tends to be sandy loam or sandy, the rate has to be reduced.

3. The utilization of a sprayer contaminated with other herbicides. The herbicide group that most commonly causes this type of problem is the "hormone" herbicides such as 2,4-D; 2,4,5-T; picloram and dicamba. These products are utilized a great deal in gramineous crops and in pastures. They can cause damage when the same sprayers are used for broad-leafed crops unless the sprayers have been washed well.

4. Volatilization of herbicides. Some "hormone" herbicides are formulated as esters, which range from intermediately to highly volatile. When applied to gramineous crops or in pastures near cassava plantations, the vapors may affect the latter.

5. Drift. If an herbicide that is nonselective to cassava is applied to another crop nearby, the wind may carry the spray, causing damage to the cassava.

6. The leaching of herbicides. Some preemergence herbicides maintain their selectivity due to the fact that they remain in the first few centimeters of the soil and are not in direct contact with the roots; however, should heavy rains occur, they can be leached to the zone of the roots, causing damage. This occurs only in light soils and with relatively soluble products.

7. A poorly directed postemergence application. Cassava does not tolerate much leaf contact with any postemergence herbicide. Therefore, recommendations indicate that the postemergence application should be directed at the weeds, avoiding as much contact with the crop as possible. If this is not done, damage can be caused.

8. The use of contaminated products. Although infrequent, there have been cases where insecticides, fungicides and fertilizers are contaminated with herbicides because they are all stored together in the same warehouse. Besides, when pesticides are not kept in their original packing, they can be confused with other agricultural products.

9. The accumulation of incorporated preemergence herbicides. The construction of beds or ridges for planting will increase the concentration of some incorporated herbicides; as a result, when the cuttings are planted, there will be areas where there is a relative overdose of the product.

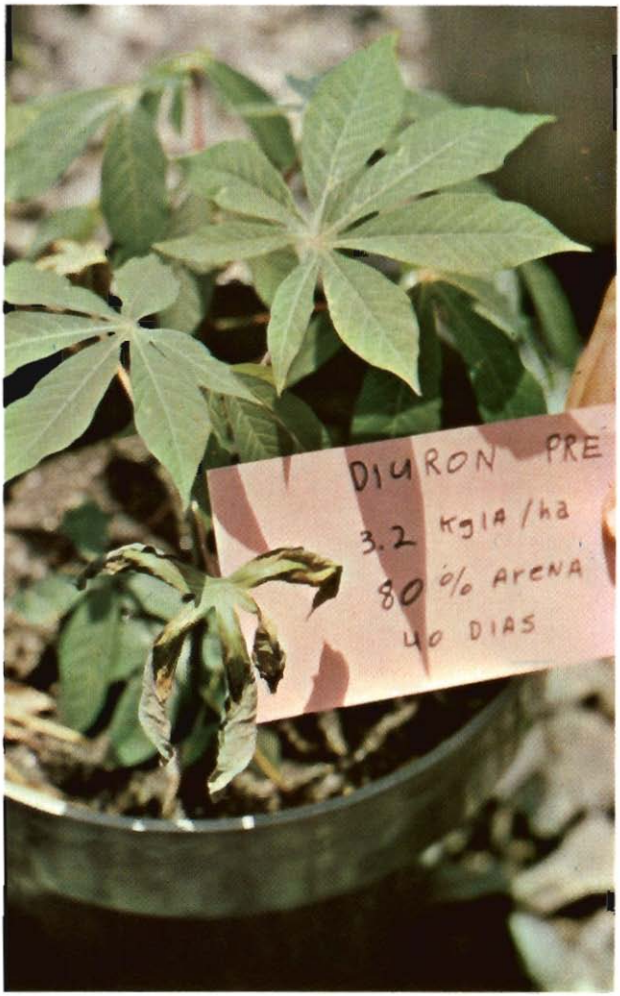
10. The residual effect of herbicides applied to previous crops. Some herbicides have a longer life than the cycle of the

previous crop and the residue is sometimes toxic to cassava; i.e., a strong rate of atrazine in maize or sorghum could persist and cause symptoms of damage when cassava is planted.

There is very little to do that will stimulate crop recovery, the best thing to do is to wait and see if the crop recovers. Cassava will generally recover as long as damage is light. Fertilization is suggested for this purpose. If the damage is due to hormone herbicides or poorly directed postemergence applications, irrigation can be used if the soil is dry; but if the damage is caused by a soil-applied herbicide, it is best not to irrigate since this will only cause more damage.

Diuron (preemergence application)

This herbicide is recommended for weed control in cassava because it is normally selective. It can, however, cause yellowing and/or necrosis of the lower leaves when an overdose is used (two or three times more than the recommended rate) or when it is applied in light soils. The yellowing and necrosis begin at the leaf edges and the veins; normally the crop recovers. The symptoms of linuron and fluometuron would be the same because they belong to the same chemical group.



Marginal necrosis of lower leaves

Diuron (postemergence application)

When diuron is applied after cassava has germinated and the application is poorly directed, it will cause the leaves that have come in contact with the product to necrose and fall prematurely. The product is not systemic; therefore, the damage will be restricted to the sprayed leaves. The plants recover normally.

Necrosis of treated leaves

2,4-D or 2,4,5-T

These products are not recommended for use in cassava. Nevertheless, damage may occur when contaminated sprayers are used or when these products are applied in nearby lots, due to the high volatilization of the ester formulations or when the wind spreads the droplets to the crop. Damage is characterized by irregular growth and distortion of the leaves (see upper photos) and stems, almost always with leaf deformation. The buds and young leaves are the most sensitive to these products (see lower photo).

Leaf deformation

Leaf deformation

Young leaves and growing point affected

Paraquat

This herbicide, recommended in directed postemergence applications, can cause death of the sprayed leaf tissue, resulting in defoliation and blight of the stems in the sprayed area. This symptom is due to the destruction of the cell chloroplast. This damage is caused when the product has been poorly sprayed; nevertheless, the herbicide affects only the tissue that comes in contact with the spray.

Necrosis of all sprayed leaves

Butylate

This product is recommended when there are weeds of the families Cyperaceae or Gramineae; it is normally selective. When an overdose is applied in light soils or when it is incorporated before planting and then beds or ridges are formed, the herbicide is accumulated. This can cause delayed germination of the cuttings and wrinkling or crinkling of the first leaves of the shoots. The plants normally recover.

Stunted growth

Atrazine

This herbicide is frequently used in maize and sorghum. In cases of an overdose, the residue remains in the soil and may cause symptoms of damage in cassava. The lower leaves and intervenal areas become yellow and necrose. When there is a lot of residue, the normal development of the crop is delayed.

Yellowing and necrosis

KEY FOR IDENTIFYING SOME CASSAVA DISEASES

I. Bacterial diseases

A. Angular water-soaked spots; leaf blight; partial or total wilting of green stem tissues; gummy exudate on young stems — Bacterial blight

B. Wilting of growing points; perforations in stems made by insects; internal stem rot — Bacterial stem rot

II. Diseases caused by viral, viruslike, or mycoplasmal causal agents

A. Leaves with yellow patches and distortions

1. Occurring generally in the plantation and the area — African mosaic
2. Localized incidence and in low percentages — Common mosaic

B. Leaves with yellowing in the veins, crinkling and distortion of the tip of each lobe — Leaf vein mosaic

C. Pronounced stunting and proliferation of growing points; normal, but very small leaves; proliferation of shoots from the planted cutting — Witches'-broom (Mycoplasm)

III. Fungal diseases

A. Foliar diseases

1. Spots on the leaf blade

a. Indefinite yellow spots	Cassava ash
b. Brown or white spots	
– Angular brown spots	Brown leaf spot
– Indefinite brown spots	Blight leaf spot
– Indefinite brown spots with concentric rings	Concentric-ring leaf spot
– Indefinite brown spots on edges only; leaf distortion	Anthracnose
– Round or angular white spots	White leaf spot

2. Lesions on the leaf veins and petioles

a. Erupted cankers with brown margins and white centers; leaf distortion	Superelongation
b. Brown or black pustules on either side of the leaf; distortion of leaves and petioles	Rust

B. Diseases of the stem

1. Lesions on the young parts of the stem

a. Erupted cankers of different sizes; elongation of internodes	Superelongation
b. Cankers with blackish margins and pink center	Anthracnose
c. Brown cankers with circular rings	Concentric-ring leaf spot
d. Brown to black cankers; distortion	Rust

2. Lesions on mature (lignified) parts of the stem. Induced by various pathogens of woody crops, generally species of Ascomycetes or Basidiomycetes — Various

C. Diseases of the roots

1. Preharvest root rot

   a. Pungent soft rot — *Phytophthora* sp., *Phythium* sp.

   b. Nonpungent rot — Various

2. Postharvest root rot. Brownish-black streaking of the vascular strands; soft to dry rot — Physiological and/or pathological

KEY FOR IDENTIFYING SOME CASSAVA PESTS

I. Mites

Small, almost microscopic, with 4 pairs of legs, found in large quantities on the undersides of leaves

A. Young leaves attacked; yellow spots and deformation of leaves; death of growing point — *Mononychellus* spp.

B. Initial attack on basal leaves; yellow to reddish leaf spots; drying and falling of leaves — *Tetranychus urticae*

C. Initial attack on basal leaves; presence of yellowish brown spots on the upper surface and white spots on the underside, near the central and lateral leaf veins; spots covered with webs — *Oligonychus peruvianus*

II. Insects

Different sizes with only 3 pairs of legs in adult stage; found in and on all parts of the plant and beneath the soil

A. Insects causing deformation and/or lesions in the leaf area or green part of the plant

1. Growing points attacked, causing deformation and yellow spots on leaves and proliferation of buds — Thrips
2. Presence of yellow to reddish leaf spots; small insect (adult gray, nymph white) found on underside of leaf — Lace bug
3. Yellowing and drying of basal leaves; presence of sooty mold; adult small, white in color, found on shoots; nymphs and pupae on the undersides of lower leaves — Whiteflies
4. Galls formed by abnormal growth on the upper surface of the leaf, yellow to red in color — Gall midge

B. Leaf-cutting and/or leaf-eating insects

1. Defoliation by cutting leaves, except for petioles; large larvae of different colors, almost always with a horn on the posterior extremity — Cassava hornworm
2. Defoliation by cutting semicircular pieces of leaves, sometimes the presence of ants on the plant and/or debris from leaf pieces, and trails in the plantation — Leaf-cutting ants

C. Stem-boring insects

1. Lesions localized on the terminal part of the plant; presence of yellowish brown exudate, death of growing point, presence of white larvae in affected part	Shoot flies
2. Orifices in stem that exudate white latex; sometimes soft rot and presence of yellowish white larvae	Fruit flies
3. Orifices and tunnels in the mature part of the stem; presence of sawdust and excreta coming out of tunnels	Stemborers

D. Stem suckers

Yellowing and weakening of the plant in general; presence of scales on stem	Scale insects

E. Insects attacking cuttings and/or seedlings

1. Wounding and consumption of bark and roots of cuttings and seedlings; no germination, or wilting and dieback of seedlings; white larvae with black heads found around cuttings or roots	White grubs
2. Dieback or seedlings cut at the base, nongermination of cuttings; bark and roots cut and consumed, larvae gray to black in color, almost always found in the ground near the attacked plant	Cutworms
3. Problems in germination; cuttings with tunnels and presence of insects in them; small adult, cream colored	Termites

PHOTOGRAPHS

The authors wish to thank Neil Mac Lellan, photographer of the Rockefeller Foundation, for his collaboration in the photographic work; Dr. A. S. Costa, Instituto Agronômico de Campinas (Brazil), for the photographs corresponding to American viruses and mycoplasma; and Dr. E. Terry, International Institute of Tropical Agriculture (Ibadan, Nigeria), for the photographs corresponding to African mosaic.

Impresiones ltda
Bogotá, D.E. Tel. 44 56 71