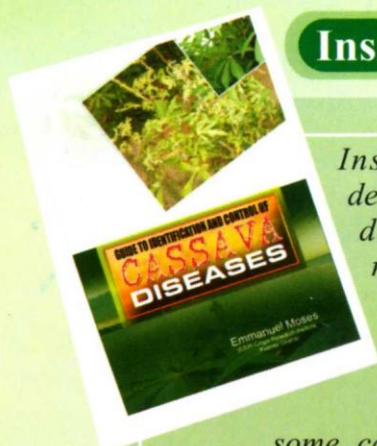




GUIDE TO IDENTIFICATION AND CONTROL OF
CASSAVA
DISEASES

Emmanuel Moses

Inside this Booklet



Inside this booklet is a description of all the major diseases of cassava that reduce yield in most parts of sub-Saharan Africa. Included, however, are some important diseases that may be relatively new in some cassava growing regions of Africa. The descriptions are well supported with pictures of expressed symptoms making disease identification a simple exercise. Integrated methods of disease control specific for each disease have been presented.

This book is intended to serve as a guide for Agricultural Extension Agents and Farmers. Peasant, medium or large scale cassava farmers will all find the contents of this book useful. In addition, students in secondary and tertiary institutions studying Agriculture will benefit from this booklet as a simple crop protection text.

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Guide to Identification and Control of Cassava Diseases

An extension guide for farmers, extension agents and students of tropical agriculture

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Contents

Introduction.....	7
African Cassava Mosaic Disease.....	9
Cassava Bacterial Blight.....	15
Cassava Anthracnose.....	21
Cassava Bud Necrosis.....	25
Brown and White Leaf Spot Diseases.....	28
Root Rot Diseases.....	31

Introduction

Cassava is one of the most important staple food crops in Africa. Three continents, Africa, Asia and Latin America produce large amounts of cassava roots. Over 500 million people in the tropical world particularly Africa depend on cassava as one of their major staple foods. In Asia and Latin America, productions are largely used as raw materials for industries, as animal feed or for export markets. In Africa, the bulk of production is depended on as food by humans. Cassava is one of the most significant food security crops in some parts of sub-saharan Africa and has proved to be the most dependable crop in a number of countries as the last line of defence against famine. In the last decade, cassava is cultivated not just for human consumption in sub-saharan Africa but also to provide raw materials for emerging industries that depend on products from the roots, particularly starch.

The ability of cassava to thrive or do well on poor soils gives it an advantage over yam and the other root and tubers, grains or legumes in Africa. For many years to come cassava will continue to be an important source of carbohydrate to millions of people, particularly the rural and urban poor in Africa. Cassava, therefore, has to be managed more effectively than it is currently experiencing to increase its yield per unit area to ensure that more than enough roots in particular are produced to satisfy domestic, industrial and food security requirements at all times.

Among the factors that affect cassava production, diseases and pests still remain the major constraints that can bring Africa's cassava production to a halt. The recent East African Cassava Mosaic pandemic and the food shortages that resulted from it adds value to the above statement. African cassava mosaic disease is still widespread and causes severe yield losses in production systems that depend on susceptible cultivars. Cassava bacterial blight, anthracnose, bud necrosis, leaf spots and root rot diseases affect yields of cassava in almost all producing countries in Africa. Information on yield losses due to diseases are often based on estimates but observations indicate that losses are significant in most of the cassava growing areas of Ghana.

What is the Importance of Cassava Diseases?

- Diseases cause low yields of edible roots.
- Low yields due to diseases affect incomes of farmers.
- Food security is reduced by diseases.
- Severe outbreaks of diseases such as cassava bacterial blight can result in famine (in whole communities or countries).
- Cassava diseases that affect stems can lead to loss or shortages in the supply of planting materials.
- Loss of leaves through diseases can affect the availability of leafy vegetables.
- Loss of leaves and poor yield of storage roots can affect livestock production in communities that use cassava as animal feed.

Unfortunately, however, cassava farmers in most producing countries in Africa do very little or nothing to control diseases and pests of the crop. An impression that exists among cassava farmers (particularly in Ghana) is that cassava cuttings will give some root yields no matter where they are planted even if no attention is paid to the plants. Also, it is common to meet farmers who regard symptoms of certain diseases of cassava as signs of plant maturity. These incorrect impressions need to be corrected to increase yields of cassava. Farmers must be made aware of diseases and their importance and why it is necessary that diseases must be controlled.

This text is, therefore, written to introduce cassava as a crop with diseases that need to be controlled to increase yields to meet demands for consumption, food security and raw material requirements of industry. Symptoms of diseases have been shown or described to make disease identification an easy exercise. Actions that can be undertaken to control specific diseases have been described. Agriculture extension agents, farmers and students of agriculture will find this small text a very useful guide to controlling diseases of cassava.

AFRICAN CASSAVA MOSAIC DISEASE

Africa cassava mosaic disease (ACMD) is the most important of all cassava diseases known in Africa. Almost all traditional cultivars of cassava cultivated in different countries on the African continent are susceptible to this disease. Yield losses due to cassava mosaic disease range between 20-95% in susceptible cultivars. On a continent that experiences food insecurity, losses of this magnitude in yield of such an important food crop need cannot be accepted. Most traditional farmers who constitute the majority of food producers in Africa do not control mosaic disease. In Ghana for example, yields of cultivars susceptible to mosaic disease are under 10 t/ha in most farming communities compared to yields of 30 t/ha or more that can be achieved with improved varieties resistant to mosaic disease.

Causal Organism and Symptoms of the Disease

Cassava mosaic disease is caused by a virus. The common visible symptom of the disease is the leaf mosaic. Leaves showing this symptom have patches of normal green colour mixed with different proportions of yellow and white depending on the variety. These chlorotic patches indicate reduced amounts of chlorophyll in the leaves, which affects photosynthesis and therefore yields.

In some susceptible varieties, the leaf blades become distorted and are often reduced in size (Figures 1, 2 and 3). Leaf production as a commercial activity can be severely affected when susceptible varieties are depended on.

In highly susceptible cultivars, stunted growth is common, especially in plants that experience early infections. These plants often develop poor stems that are not useful as planting materials. Poor root yield is associated with stunted growth (Figure 4).

Transmission of ACMD

Infected plants are the main sources of the virus responsible for the disease. The white fly *Bemisia tabacci* is the vector in the transmission of the disease from plant to plant through its feeding on cassava leaves. Virus numbers increase in leaves and stems of infected plants. The disease spreads largely through the use of infected stem cuttings as planting materials.

Control

Use of Resistant Varieties

Improved varieties of cassava resistant to mosaic disease are available in production systems of a number of countries. These resistant varieties have been introduced consciously into areas with high disease pressures to improve yields. Significant increases in yield have been achieved through the introduction of improved varieties in some countries including Ghana. Agriculture extension agents must help farmers in their operational areas to access desired disease resistant varieties.

Farmers cultivating cassava on a large scale, to feed starch producing factories for example, need varieties that are not just high yielding but also mosaic disease resistant to maintain stable yields.

Observations indicate that some improved varieties of cassava lose their resistance after a number of years of planting in areas with high mosaic disease pressures. Performance of improved varieties introduced to control diseases therefore needs to be monitored continuously to detect loss of resistance and ensure early replacement with new cultivars.

Most of the traditional varieties of cassava cultivated extensively by farmers in Africa are susceptible to mosaic disease. Peasant farmers in most circumstances prefer their local traditional varieties despite being low yielding and susceptible to mosaic disease because of certain unique cooking qualities. It is necessary that yields and disease resistance attributes of these traditional varieties are improved in the interest of traditional cassava farmers who actually produce the bulk of the cassava consumed on the continent.

Use of Healthy Planting Materials

The spread of the disease as mentioned earlier is largely due to the use of infected cuttings as propagating materials. Mosaic disease can be controlled effectively through the use of healthy or virus free planting materials. Farmers must select stems from plants with no mosaic symptoms to produce cuttings.

If the source of planting materials is from a branching susceptible variety, spread of the disease can be reduced if cuttings for planting are derived from the branches rather than the main stem. Cuttings from the main stem often sprout with the disease. In non-branching varieties it is preferable to avoid using cuttings from the basal portion of stems as planting material. Cuttings from the basal portions of stems give rise to young diseased plants at sprouting.

Plants that develop from healthy cuttings often grow vigorously to escape early infections and give good leaf and root yields. Programmes of planting material multiplication that supply stems to large numbers of farmers must ensure that disease free stems are distributed to prevent large scale spread of diseases especially into new communities.

Roguing

The practice of removing the few diseased plants showing symptoms of the disease from a population of healthy ones and destroying them (roguing) reduces spread of diseases particularly on farms. Regular inspection of plants on a farm is necessary if effective disease control is to be achieved.

Young plants from sprouted cassava stem cuttings showing mosaic symptoms can be replaced with new healthy ones to maintain high planting densities.



Figure 1. Cassava plants showing healthy leaves. Note absence of chlorotic areas.
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Figure 2. Cassava plant showing the typical leaf mosaic symptom. Note the yellow and green patches on leaf blades (chlorotic areas).

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Figure 3. A severely infected plant of a highly susceptible cultivar showing distorted leaves and poorly developed stems.

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Figure 4. Root yields of two plants planted on the same day and harvested twelve months after planting. The smaller plant is showing all the important features of the mosaic disease.

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CASSAVA BACTERIAL BLIGHT DISEASE

Cassava bacterial blight (CBB) can be found in all cassava producing countries and in the opinion of the authors is the most devastating of all known diseases of the crop in Africa.

In susceptible cultivars, CBB can cause 100% yield loss when environmental conditions optimum for disease outbreaks occur. CBB causes death of leaves and stems and as such severe yield losses are often encountered when outbreaks of the disease occur. Severe outbreaks of CBB in epidemic proportions caused famine in Zaire (now Congo DR) and Nigeria in the early 1970s. In severe outbreaks of the disease shortages in the supply of planting materials may result.

Causes and Symptoms of Diseases

The disease is caused by a bacterium (*Xanthomonas campestris* pv. *manihotis*). Distinctive symptoms of the disease include the appearance of water soaked spots or lesions on leaves of infected plants. The spots often start along the veins, margins and tips of leaf blades. As the disease develops, neighboring spots join together to form large brown patches or blights killing the leaf blade as it expands (Figure 5). The leaf dries or wilts and finally falls.

In some susceptible cultivars, creamy or yellowish brown gummy exudates are discharged on leaves or stems but often distinctively on leaf petioles of infected plants (Figure 5).

Petioles of blighted leaves are often horizontally orientated to the main stem axis. In advanced stages of the disease, dieback of stems is common (Figure 6). It is common also to find new shoots developing from dead ends of stems of severely infected plants.

Transmission of CBB

The spread of the disease occurs if the bacterial causal organism is transferred from an infected plant to a new susceptible plant. Often the bacterium gains entry into plants through wounds or openings or scratches on leaves and stems.

Farm tools particularly cutlasses can easily be used to transmit the disease from farm to farm if tools are not cleaned after work in an infected field.

Stems of infected plants are sources of the bacterium that causes the disease. The spread of the disease is largely through the use of cuttings derived from infected stems in starting new farms.

It is common to find grasshoppers on plants showing symptoms of CBB compared to healthy plants in the same area (Figure 7). This observation has been made in several disease documentation surveys. Grasshoppers and other insects that feed on cassava may therefore be involved in the transmission of the disease from plant to plant on the same farm or over long distances.

Control

Resistant Varieties

In CBB endemic areas or localities with reported cases of the disease, farmers must consciously search for and plant CBB resistant varieties if economic yields of cassava are to be sustained.

Rouging of Plants

Farmers cultivating susceptible varieties regularly must inspect their plants and remove those showing symptoms of the disease and destroy them through burning. This practice of search and destroy must seriously follow the first few rains coming after the dry season. It is safe to eat storage roots from CBB infected plants. Early detection and destruction of plants showing symptoms of the disease can prevent or slow down the spread of the disease on a farm.

Fallow

If complete outbreaks on whole farms are observed, it may be necessary to harvest roots immediately and destroy stems and leaves and other plant debris through burning. Infected plant debris may also be ploughed deep into soil. In both situations the land must be allowed to fallow for few years (3 years minimum) before it is planted again to cassava. The bacterium responsible for the disease is unable to survive over a long period outside the host.

Crop Rotation

In communities where land for peasant farming is scarce, fallowing of land may not be a good disease control option. After destruction of infected plant debris as described in the preceding section, cereals, grains or legumes can be planted on the same piece of land. After three seasons the land can be returned to cassava.

Quarantine Measures

In cases of localized outbreaks of CBB it may be necessary for a localized quarantine measure to be implemented that ensures that planting materials from CBB outbreak zones are not moved into other communities. Farmers must be educated to appreciate the importance of such a measure.

Quarantine authorities must monitor movement of planting materials across borders and ensure that uncertified planting materials are quarantined to be sure of their safety. Tissue culture materials from unreliable laboratories or sources must pass quarantine regulations before they are allowed into cropping systems of countries.

Use of Healthy Planting Material

Farmers must consciously harvest stems from healthy plants completely free of any of the described symptoms of the disease. It is generally wise to avoid using planting materials from any farm suspected to be under CBB attack even if symptoms of the disease have not been observed on plants.

Pest Control

Grasshoppers and other insects that can serve as carriers of the bacterium from farm to farm must be controlled using environmentally friendly measures. Controlling grasshopper movement after the early first rains of the wet season can reduce the spread of CBB.

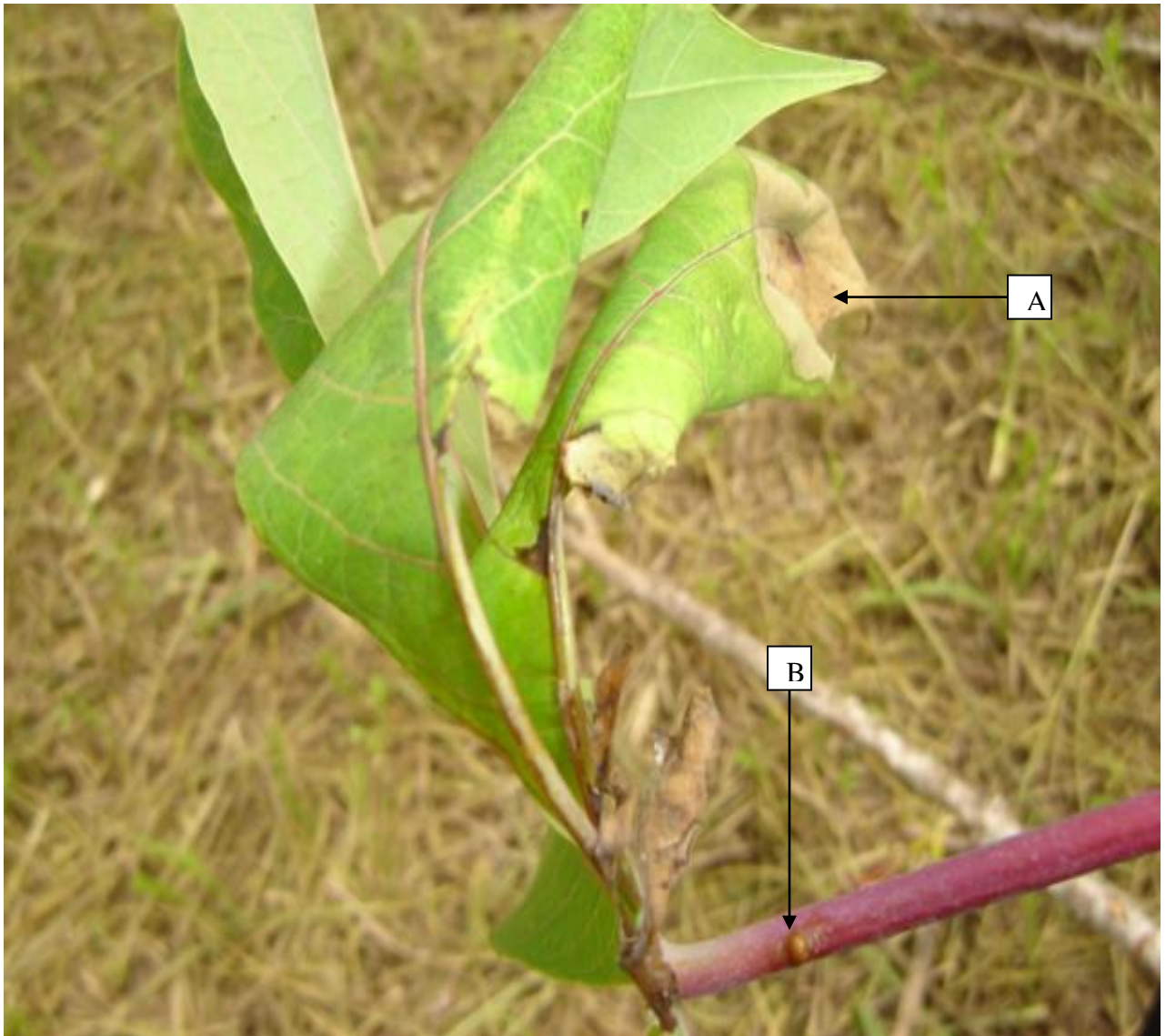


Figure 5. A typical leaf from a CBB infected plant showing two important symptoms of the disease. A- blighted patch; B- a brownish gummy exudate deposited on the reddish leaf petiole.

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Figure 6. A CBB infected plant showing severe dieback. Note the great loss of leaves.
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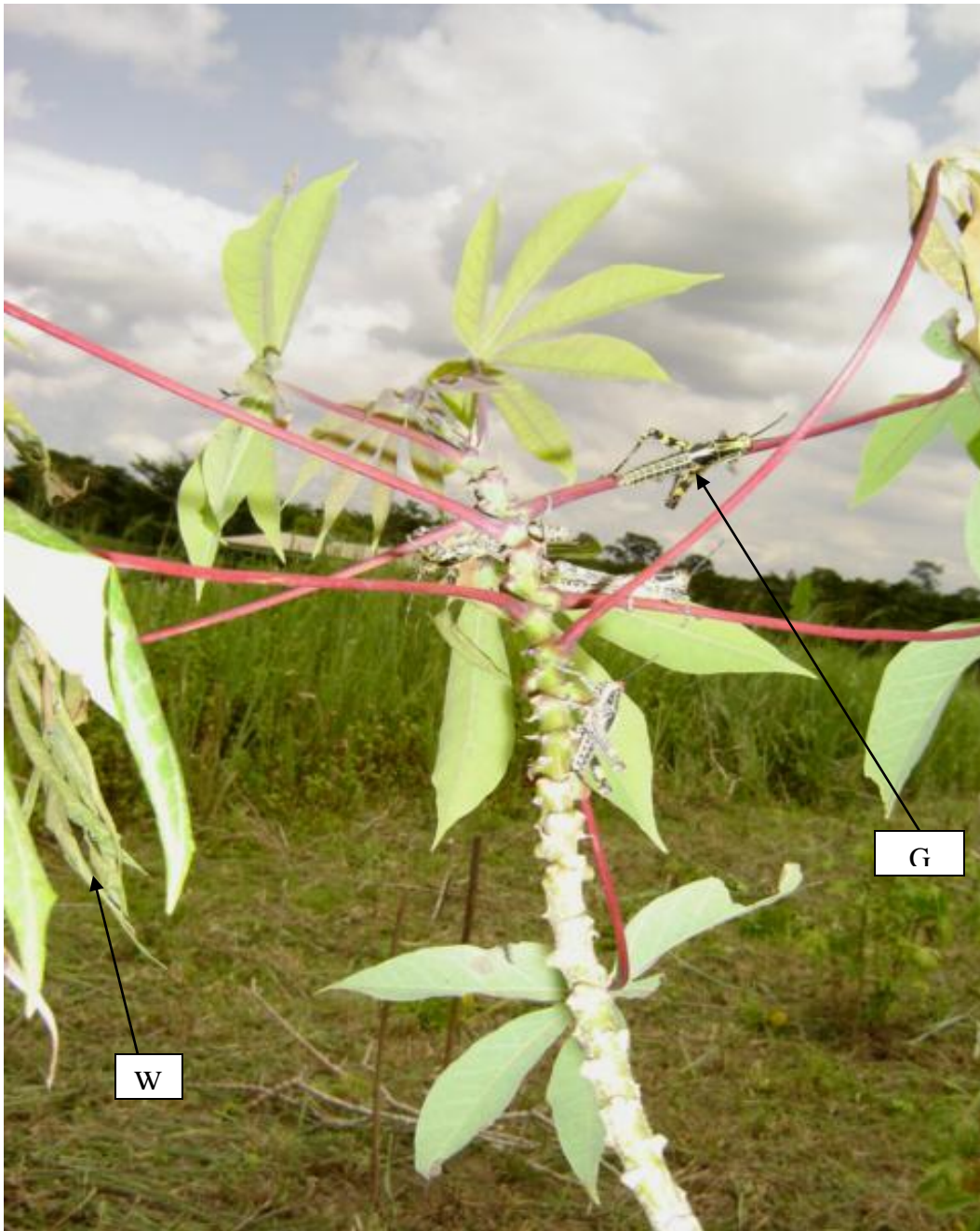


Figure 7. A CBB infected plant showing wilting (arrowed leaf W) and grasshoppers (G). The grasshoppers are believed to be involved in spreading the disease from plant to plant.
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CASSAVA ANTHRACNOSE DISEASE

Cassava anthracnose disease (CAD) is widespread in most of the cassava growing regions of Africa. The disease is caused by a fungus (*Collectothricum gloeosporioides*) that is also capable of causing diseases on other food crops. It is estimated that CAD causes yield losses in the neighbourhood of 30% or more in susceptible cultivars. The disease affects both leaf and stem production. Severe anthracnose attacks can cause death of stems which can affect the availability of planting materials especially in large scale production systems.

Symptoms

The main distinctive symptom of CAD is the appearance of cankers or sore-like lesions on the stem of susceptible varieties (Figures 8 and 9). The cankers may be formed at the nodes bearing petioles or along any part of the stem depending on the variety.

Depending on varieties or existing environmental factors, cankers may be small or large. Young and older parts of stems may bear cankers. Cankers may develop cracks, exposing inner tissues of stems to the external environment. Cracks when present serve as entry points for other disease causing organisms. Development of cankers may result in distortions in the shape of infected stems.

Wilting is observed in infected plants and this is often accompanied by defoliation. Dieback of stems is an important symptom of the disease and in some varieties entire infected stems may die back and break off. The symptoms of the disease often start and develop rapidly in the wet season.



Figure 8. An infected cassava stem showing cankers or lesions (arrowed). Note that the main stem on display has lost its leaves.

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Figure 9. A severely infected stem showing cankers (arrowed) and poorly developing young branches. This type of cankers could potentially produce cracks in the stem.
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Transmission of the Disease

Spores of the disease causing fungus are spread by wind or rain splashes and may gain entry through wounds on stems to establish the disease. Feeding holes made by the sap feeding bug *Pseudotheraptus devastans* may also be the entry holes for the spores of the causal organism.

Planting stem cuttings bearing cankers of the disease is one of the means of spreading the disease into new areas. Shoots that develop from cuttings bearing cankers develop symptoms of the disease early and are likely to suffer higher yield losses.

Control

Resistant Varieties

The most reliable control measure is to use desired anthracnose resistant varieties particularly in localities with high CAD pressures. Cultivation of disease resistant or tolerant varieties is even more important in large scale production systems that require stable high yields to feed industries that depend mainly on cassava as raw material.

Healthy Planting Material

In situations where desired varieties are susceptible to CAD, healthy stems free of cankers and dieback tissues must be selected to provide cuttings for new plantings. Healthy cuttings sprout well and give rise to young vigorous growing plants that are likely to escape early infections. Where canker bearing stems are the only available sources of planting materials, stem cuttings must be dipped in appropriate fungicides recommended by extension agents in their operational areas. Spores and other fungal materials of disease causing fungi can be destroyed by a few minutes of dipping in suitable fungicides.

Farm Sanitation

Stems and leaves from infected plants after harvest must be destroyed by burning to reduce the amount of fungal spores and other infective structures that can cause infections in the next generation of plants.

Host Range of Causal Organism

The fungus that causes cassava anthracnose can also cause diseases on other food crops such as pepper, avocado, banana, pawpaw and yam. Spores therefore can be transferred

from these plants to cause infections in cassava. Plant debris from plants suspected to be harboring the anthracnose causing fungus must be destroyed by burning, particularly during land preparation before cassava is planted.

CASSAVA BUD NECROSIS

Bud necrosis is a fungal disease usually found in cassava growing areas with humid environments. Incidence of the disease is therefore higher in the humid forest zones compared to the drier savanna areas. Observations indicate that poor farm sanitation (weedy fields) in high relative humidity zones promotes high incidence and severity of the disease.

Symptoms

The main symptom of the disease is the appearance of dark or grey patches or necrotic lesions on stem surfaces of susceptible cultivars (Figures 10 and 11). The necrotic areas are made up of fungal tissue of the causal organism. Necrotic areas often cover buds on the stem giving the disease its name (Figure 11).

Transmission

The disease spreads through spores that are carried by wind from plant to plant or from farm to farm. Bud necrosis of cassava, however, largely spreads through the use of infected stem cuttings bearing necrotic lesions in planting.

Control

Healthy Planting Materials

In farming communities where the desired varieties grown are susceptible to the disease, farmers must use cuttings derived from healthy stems completely free from necrotic lesions.

Stem cuttings with infected buds often fail to sprout when planted, resulting in poor plant establishment on farms. In large scale commercial production farms, refilling or replacement of cuttings that fail to sprout increases production cost to farmers.

Good Farm Practices

Incidence and severity of bud necrosis is significantly reduced on farms when good planting distances that allow free movement of air around plants are maintained. The disease is better controlled when weeds are also well managed. These good practices

contribute effectively to disease control when healthy planting materials are always used to start farms.

Plant debris, especially stem pieces bearing necrotic lesions, must be destroyed by burning immediately after harvest to reduce sources of infective fungal spores.

Host Range

The fungus that causes bud necrosis can also live on other crops such as yam, banana and mango. Debris from these plants suspected to be harboring disease-causing organisms must be destroyed by burning, particularly during land preparation.



Figure 10. Cassava plant with bud necrosis lesions on stem. The dark patches are the necrotic areas.

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Figure 11. A susceptible cultivar of cassava with grey necrotic areas on bud (arrowed).
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BROWN AND WHITE LEAF SPOT DISEASES

Brown and white leaf spots are relatively minor diseases of cassava caused by fungi. White leaf spot is less frequently seen in most cassava growing areas in Ghana compared to brown spots. In Ghana, symptoms of brown spots are seen by some farmers as signs of crop maturity.

Symptoms

The key symptom of brown leaf spot disease is the appearance of few to several brown spots on the upper surface of leaves of susceptible varieties (Figure 12). Margins of brown spots are irregular. The middle of brown spots may break given rise to ‘shot holes’.

White leaf spot disease is characterized by the presence of white spots on the upper surface of leaves of infected plants (Figure 13). Symptoms of both diseases may be found on the same leaf (Figure 13).

Control

As mentioned earlier, several farmers regard symptoms of brown leaf spot disease as signs of crop maturity because the spots according to these farmers show up when plants are fully grown. Very little or nothing is therefore done to control the disease.

Observations indicate, however, that in some susceptible cultivars brown spots appear early after planting. In such varieties large areas of the surface of leaves may be covered by brown spots reducing the total surface area available for photosynthesis. Yields will be reduced in situations of this nature. Efforts must therefore be made to control leaf spot diseases.



Figure 12. Leaves showing brown spots.
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Figure 13. Cassava leaf with white leaf spots.

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Infected leaves that drop from plants are sources of spores of leaf spot causing fungi. From infected leaves spores are carried by wind or rain splashes to cause new infections. Weeds can also serve as sources from which leaf spot fungi may spread. Good weed control practices can, therefore, reduce the spread of leaf spot diseases.

ROOT ROT DISEASES

Root rot diseases are very important because rotten storage roots of cassava are unwholesome for consumption. Severe outbreaks of root rot diseases on a large scale may result in food shortages or even threaten food security in communities that depend very much on cassava as a major staple food. Root rot diseases may lead to death of entire plants - a situation that can affect the availability of planting materials and leafy vegetables. Root rot diseases can also affect the supply of storage roots to large scale processing factories that depend on cassava as the only raw material.

Causes and Symptoms of Root Rot Diseases

Peasant farmers that cultivate cassava are often quick in attributing root rots to waterlogging and periodic flooding of land planted to cassava. It is true that waterlogged soils are not good for cassava production because they promote rots. There are however other causes of cassava root rot that may be due to pathogenic microorganisms (fungi and bacteria) and some parasitic mushrooms. In most parts of Ghana root rot diseases are caused by microorganisms.

In the last fifteen years, however, a parasitic mushroom (*Polyporus sulphureus*) (Figure 14), originally suspected to be pathogenic on woody plants, has been found attacking cassava plants and causing severe root rots (Figures 15 and 16) in Ghana. This parasitic mushroom is capable of causing 100% yield loss on farms where susceptible cultivars are planted.

Another parasitic fungus that produces small whitish fruiting bodies at the distal end of attacked cassava plants (Figure 17 and 18) was discovered in Ashanti region of Ghana in the last three years. The fruiting bodies of this parasitic fungus appear late in disease development and storage roots of attacked plants may be completely rotten by the time the whitish fruiting bodies become visible on stems. The bases of attacked stems become weak, and lodging is very common in fields attacked by this parasitic fungus. An interesting feature of this rot disease is that certain flies use the rotten roots as breeding grounds for their larvae. A characteristic foul smell is associated with this root rot disease. Yield losses as high as 45% have been recorded in fields of susceptible cultivars.

Certain rot causing organisms actively attack storage roots when they overstay in the soil or when harvesting is delayed. A number of fungal species including *Botryodiplodia theobromae* cause rots of this kind in several soil types. An example of this rot is shown in Figure 19 where the roots on display were harvested 24 months after planting.

General symptoms of root rot diseases include wilting of leaves, which in most cases is accompanied by defoliation. Other symptoms include swollen roots with colored inner

tissues (Figure 19). Rotten roots may be soft and produce an offensive odour (this is often associated with rots caused by bacteria). Shoot or stem dieback is a feature of plants with underground rotten roots. Root rot diseases may lead finally to death of infected plants.

Methods of Spread of Root Rot Diseases

Root rot diseases caused by some microorganisms require water to spread. Reproductive or infective units of certain rot causing fungi have to swim to reach a new host to initiate a new attack.

Plant debris, especially rotten roots (Figures 16), left on fields after harvest are sources of spores or other infective structures that can cause new infections.

Root rot diseases can spread through the use of farm tools such as cutlasses and hoes contaminated with spores of fungal organisms or bacteria cells.



Figure 14. Bright yellow fruiting bodies of the parasitic mushroom *Polyporus sulphureus* that causes severe root rot of cassava.

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Figure 15. The parasitic mushroom *Polyporus sulphureus* (arrowed) growing on a young cassava plant.

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Figure 16. Rotten root of cassava (R) caused by the parasitic mushroom *Polyporus sulphureus* (M) (the fungus leaves a yellow pigment in the rotten storage roots).
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Figure 17. Whitish fruiting bodies of a newly discovered root rot causing fungus growing at the base of a susceptible cassava plant.

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Figure 18. A dislodged infected stem from Figure 17 showing the whitish fruiting bodies of the rot causing fungus.

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Figure 19. Rotten root of cassava harvested 24 months after planting. Note the inner colored rotten tissue.

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Control of Root Rot Diseases

Site and Land Selection

One important characteristic of land suitable for cassava cultivation is that it should not be subject to flooding. Waterlogged soils also promote root rot diseases and must be avoided at all times. Farming close to rivers and streams must be avoided as these areas are likely to be flooded at some time in the year. A sandy loamy soil that is well drained is a good soil type for cassava.

It is advisable not to cultivate cassava on land that has a history of root rots and other major diseases. Any land showing the presence of any of the root rot causing mushrooms described above should not be planted to cassava. If the only land available for cassava cultivation has a history of root rots, then good disease management practices must be maintained if good yields are expected.

Land suitable for cassava production must be fertile enough to give a healthy crop of plants. Healthy plants are not easily attacked by diseases. Fertility of poor soils can be improved through the addition of organic fertilizers such as poultry manure if inorganic fertilizers prove too expensive.

Disease Resistant or Tolerant Varieties

Farmers are always advised to plant disease resistant or tolerant varieties if they are available. In localities with a long history of root rot diseases, farmers must consult their Agricultural Extension agents for advice on the best varieties to cultivate to minimize losses in yields. Results of work in *Polyporus* endemic areas in Ghana indicate that some varieties tested give yields two times higher than the susceptible local cultivars.

Quarantine Measures

Cassava stems from fields with visible signs of root rot diseases must not be used as planting materials, even if they look healthy. Stems from such fields are likely to carry spores of root rot fungi.

Localized or national quarantine measures to check movement of planting materials from root rot endemic areas into new localities may be necessary to check the spread of root rot diseases.

Good Farm Sanitation

Destruction of plant debris including rotten roots (Figure 19) and stems bearing fruiting bodies (Figure 20) immediately after harvest is a good measure that destroys spores of pathogenic fungi. The leathery fruiting body in Figure 20 after harvest can persist for over a year and is a good source of spores for new attacks in the subsequent season's crops. Disease severity on farms can be reduced through destruction of debris that carry spores into the next planting season

Fruiting bodies of parasitic mushrooms such as *Polyporus sulphureus* start their development on cassava plants after the first few rains following the dry season. Regular harvesting and destruction of young fruiting bodies shortly after they appear and destroying them through burning reduces severity of rots on farms. Harvesting and destroying the fruiting bodies soon after they appear prevent them from producing spores required for the spread of the disease.



Figure 20. Rotten cassava roots left on a harvested field. This is a good source of spores and other infective structures of pathogens for new infections in the next season's crop of cassava..

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Early Harvesting

Some root rot causing organisms actively invade and degrade storage roots when they are well developed and harvesting is delayed. Early harvesting therefore prevents or reduces incidence of rots in some varieties of cassava.



Figure 21. Stems of cassava with an attached old leathery fruiting body of the root rot fungus *Polyporus sulphureus* (arrowed).

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Crop Rotation

Most root rot causing pathogens are soilborne and therefore continuous cultivation of susceptible varieties on the same piece of land may lead to a build-up of pathogen populations on a farm. Incidence and severity of diseases on the same field therefore increases year after year.

Rotating cassava with cereals or grains every three years can help reduce the effects of root rot diseases on a farm. It is advisable not to plant cassava continuously for three years or more on the same piece of land especially in localities with high disease pressures. The absence of host plants from a field for a reasonable period of time deprives pathogens of their nutrient supply and this often leads into a decline in pathogen populations.

Fallow

Fallowing of land after five or more years of continuous cassava cultivation for a period of three to five years is a good measure that can reduce incidence and severity of cassava diseases. When practised properly, fallowing can help eliminate a disease completely.

from a locality or reduce its incidence significantly. In localities where pressure on available land is high, crop rotation may be the better of the two options.

Clean Farm Tools

Farm tools such as cutlasses, hoes and ploughs used on fields with a root rot history must be cleaned immediately after use before being used on a second farm. This reduces the spread of diseases from farm to farm.

Avoid Planting Cassava as the First Crop after Clearing Woodlands or Forests

Certain parasitic mushrooms can grow on woody trees or cassava depending on which one is available or preferred. It is therefore not advisable to cultivate cassava as the first crop just after clearing forests or woodlands. In the absence of woody trees, introduced cassava plants will be attacked. Woody stumps left on farms after clearing woodlands may serve as secondary hosts or reservoirs to fungal pathogens that attack cassava. It is therefore a good practice to remove stumps from cleared fields.

Host Range

Pathogenic organisms causing root rot diseases of cassava, particularly fungi, may have more than one host. This implies that a single pathogen can cause diseases in more than one species of plant. Some root rot fungi of cassava can attack soybean and sunflower. The *Polyporus* root rot mushroom can attack a number of crops including yam and citrus. Care should therefore be taken in the selection of crops for rotation or intercropping with cassava.