OUTBREAKS OF CASSAVA DISEASES AND LOSSES INDUCED

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ABSTRACT

Cassava (*Manihot esculenta* Crantz) is affected by more than 40 diseases induced by viruses, bacteria, fungi and phytomonas. Even though a 100% disease loss is rare in most cassava production systems, disease outbreaks occur and pathological problems of cassava are in many cases responsible for the reduced yields. The most important pathological problems of cassava are those that affect the sanitary quality of stems (commercial source of planting material), soil-borne pathogens capable of inducing root rots and microbial root inhabitants that induce post-harvest deterioration via root injuries at harvest. Based on world average losses, root rot pathogens causing both pre- and/or post-harvest deterioration are the most important.

Introduction

Cassava, *Manihot esculenta* Crantz (Euphorbiaceae), is a starchy root crop that is among the most important tropical foods. World production is estimated to be 120 million tons annually. Because the roots contain 65% of water, annual production of dry matter amounts to 42 million tons, or a calorie equivalent of 40–50 million tons of grain. About 80% of cassava produced is used for human consumption and constitutes the principal carbohydrate source for more than 500 million people in many developing countries. In countries of tropical Africa, for example, cassava provides an average of 230 calories/person/day; in Zaire, the average daily intake exceeds 1,000 calories/day. The remaining 20% of the production is used for animal feed and industrial purposes (Cock, 1985).

Cassava is grown between 30° North and South latitude under very broad climatic and edaphic conditions. The plant is completely domesticated and shows a high degree of local adaptation. Cassava is a perennial plant and is multiplied by cuttings from the woody stem. The large, swollen, true roots, resembling sweet potatoes, may be harvested seven months after planting in warm areas. However where the temperatures are low, harvest may be delayed for 18 months or longer. The world average yield is 9 t/ha, but yields of only 4–7 t ha are common in many areas. Under favorable, semi-commercial conditions, yields of 40 t/ha can be obtained (Cock, 1985).

Many cultivation systems have been developed, including mixed-cropping, that generally maintain stable, although low yields. Recent economic difficulties in most developing countries, have stimulated policy makers to reevaluate the potential of native crops as substitutes for foreign food imports (Horton *et al.*, 1984). Partly as a result of this, cassava cultivation has been expanding rapidly, with concurrent increases in international exchange of planting material over the past 20 years. New areas with large monocrop cassava plantations are being established, and with this change, pathological and entomological problems are flourishing and causing heavy losses in many countries.

Importance of diseases on cassava

Cassava has been considered to be a species tolerant to adverse edaphic and climatic conditions as well as to the attack of pathogens and pests. This is correct when comparing production stability of native cassava clones with that of other crop species in a given region. A total crop failure is rare. Similarly, cassava produces satisfactory yields in areas where other crop species often fail (Cock, 1985; R. Moreno, CIAT, unpublished). However, when yields obtained by traditional cassava growers, or average yields in regions, countries or even continents, are compared with those obtained

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in experimental centers or by progressive cassava growers, differences are striking. A high percentage of this is due to the stress exerted by pathogens on the crop, even though other abiotic stresses also reduce yields simultaneously and severely.

Severe outbreaks of cassava diseases have been reported during the 1970s and 1980s. The cassava bacterial blight (CBB) epidemic in Central Africa induced losses of around 80% (Persley, 1976) and in Zaire, where the plant leaves are an important source of protein for human food, the CBB-epiphytotic from 1970 to 1975 resulted in starvation (R. Zeigler, personal communication; Persley, 1976). In 1974 an epiphytotic, caused by a complex of pathogens reduced yields by approximately 50% in large plantations of Minas Gerais, Brazil as a result of the introduction of cuttings from infested plantations located several hundred miles away. Yields of cassava plantations along the Amazon River have decreased by more than 30% due to a root rot induced by *Phytophthora drechsleri*. More than 70% of the plantations in the states of the Amazonas and Para are affected. The price of fresh cassava roots and farinha (a processed cassava flour used as food in Brazil) increased 5 to 10 fold during 1988.

Several years of research in locations with diverse ecological conditions have demonstrated that cassava diseases are not universal. Pathogen distribution and incidence are limited by specific climatic and/or edaphic factors that restrict them to ecological zones (Table 1) (Lozano *et al.*, 1984). Susceptible clones may not survive in areas of high disease pressure; however the performance and yield of the same clones may be very good in other locations (with different edapho-climatic characteristics) where these diseases are not present (Table 2) (Lozano *et al.*, 1978). Disease constitutes an important factor that determines the stability of a clone in a given region (Lozano *et al.*, 1984).

Table 1 Damage induced by cassava diseases identified and evaluated in four ecosystems (edapho-climatic zones, ecz; see Lozano *et al.*, 1984, for more complete description) in Colombia during 1979 through 1982

Diseases	ECZ number and description			
	I Low rainfall lowland tropics	II Acid soil savanas, high rainfall	IV Mid-altitude tropics	V Highland tropics
Frog skin	–[a]	–	++	–
Cassava common mosaic	++	–	++	++
Bacterial blight	++	+++	–	–
Bacterial stem rot	–	–	++	–
Cassava ash	+	–	++	++
Brown leaf spot	++	++	++	–
Brown leaf blight	++	–	++	–
White leaf spot	++	–	+	++
Concentric ring-leaf spot	–	–	–	+++
Anthracnose	+	+++	+	+++
Superelongation	+	+++	+	–
Choanephora leaf blight	++	++	–	–
Root rots	+	+	+++	+
Diplodia stem and root rot	+++	–	++	–

[a] +++=Severe damage (yields were reduced at significant levels during the years of evaluation); ++=Moderate damage (yields were reduced at significant levels during one or two years of evaluation); +=Light damage (yields were not reduced); –=Not observed (CIAT, 1981; Lozano, unpublished).

Table 2 Fresh root yield (t/ha) of different clones with different reactions to negative production factors (NPFs) existing in Popayan, Darien and CIAT ecosystems

Clone	Popayan	Darien	CIAT
CMC 92	22.3[a]	26.6	8.2
Morada	16.5	18.3	
M Col 80	13.7	15.3	
M Col 235	14.5	11.5	
M Col 230	11.3	10.3	
M Col 307	6.5	6.7	
CMC 39	8.6	8.8	13.0
M Col 22	0.3	0.0	39.4
M Mex 59	0.9	2.4	33.1
CMC 40	3.8	5.3	42.2
CMC 84	1.0	4.0	40.3
CMC 76	0.5	1.4	36.0
M Col 113	5.0	2.5	26.8
CMC 9	0.5	0.1	31.7
M Mex 23	1.0	1.0	34.3

[a] Data taken during 1974-1975 by the Agronomy and Pathology sections of the Cassava Production Program at CIAT (Lozano, Byrne and Bellotti, 1980)

Yield losses due to diseases of cassava

Diseases of cassava can be arranged in four groups based on their effect on fresh root yield or root deterioration.

1 Wind-blown pathogens

These agents are disseminated by the wind, and occur most readily during rainy periods. Leaf blight (*Cercospora vicosae*), brown leaf spot (*Cercosporidium henningsii*), superelongation (*Elsinoe brasiliensis*) and Phoma leaf spot (*Phoma manihotis*) are the most serious diseases of cassava belonging to this group. Losses have been evaluated by comparing yield (tons of fresh roots and/or starch/ha) of untreated controls with fungicide-treated plots of clones with various degrees of resistance to these diseases (Teri *et al.*, 1977; Zeigler *et al.*, 1984, CIAT, 1974). Yield losses induced by these diseases are mostly due to the effect of defoliation and, in the case of superelongation and phoma leaf spot, to dieback (Zeigler *et al.*, 1984; CIAT, 1974); losses range from 18.8 to 92%, or from 9.5 to 12.5% of starch content (Table 3).

2 Stem-borne pathogens

Pathogens of this group systematically infect stems, decreasing the sanitary quality of the planting material. Dissemination to other locations is mostly via infected vegetative planting material. Invasion of stem tissue is relatively slow, particularly for pathogenic fungi and bacteria invading lignified stems of intermediate resistant or resistant clones (Lozano, 1986). The most important diseases of this group are: cassava bacterial blight (*Xanthomonas campestris* pv. *manihotis*), viruses, diplodia (*D. manihotis*) and fusarium (*Fusarium* spp.) stem and root rots.

Losses induced by pathogens in this group are related to the degree of cutting infection and the percentage of infected cuttings planted in a given plantation. The degree of cutting infection increases by successive planting of cuttings from affected plants. The percentage of infected cuttings planted is related to the number of infected mother plants at the time of cutting preparation. Mechanical transmission of some viruses and bacteria may increase if contaminated tools are not

Table 3 Yield losses induced by cassava diseases on susceptible clones planted in locations where edapho-climatic conditions favored disease incidence

Disease group according to pathogen dissemination	Yield reduction (%) Fresh roots	Starch content	Reference
Wind-blown pathogens:			
Leaf blight	26.9	9.5	Teri *et al.*, 1977
Brown leaf spot	18.8	12.5	Teri *et al.*, 1977
Phoma leaf spot	92.0	-	CIAT, 1975
Superelongation	80.0	-	Zeigler *et al.*, 1984
Stem-borne pathogens:			
CBB	49.8 to 70.0	0.0	CIAT, 1974; Otim-Nape, 1985
Cassava bacterial stem rot	33.1	-	Lozano and Bellotti, 1978
Common mosaic virus	10.0-20.0	-	Costa *et al.*, 1970
The frog skin	80.5	-	CIAT, 1981
The Caribbean mosaic virus	69.5	-	Lozano *et al.*, 1984
African mosaic virus	78.0-86.0	-	Bock, 1984
Diplodia and stem root rot	30.3	-	CIAT, 186
Fusarium stem and root rot	20.0-100.0	-	Lozano, unpublished
Soil-borne pathogens:			
Fusarium root rot	69.9	-	Lozano, 1988
Phytophthora root rot	69.9	-	Lozano, 1988
Rosellinia root rot	41.0	-	CIAT, 1973
Small pox disease	62.3	-	Castano *et al.*, 1975
Post-harvest root rots	100.00	-	Wheatley *et al.*, 1984

disinfested.

Losses induced by this group of diseases can be large (Table 3), particularly if a high percentage of severely affected cuttings is planted during a period of favorable climatic conditions for diseases. This results in epiphytotics, such as those reported for CBB in Africa and several regions of the Americas (Lozano, 1986).

3 Soil-borne pathogens

The continuous planting of cassava or other crop species increases the inoculum potential of soil-borne pathogens following introduction via infected planting material, plant debris, machinery, water, etc. They generally affect plants by inducing sudden wilting. Damage can be much more evident at harvesting when roots appear rotted. The degree of root infection depends on the soil infestation at planting which is generally several times higher than the incidence of root rot in the preceding harvest. Soil infestation increases during soil preparation, due to mechanical distribution of infected plant debris (especially by tractors) before planting. If non-lignified cuttings less than 10 cm in length are planted, a high percentage of plants will die before harvest or root rot severity is higher. Losses are generally evaluated by comparing amended plots where soil-borne pathogens are controlled through crop rotation, drainage, planting on ridges, etc. with unamended controls. Losses can reach 100% in some affected regions (Table 3), causing a considerable increase in the price of fresh cassava or by-products.

4 Post-harvest root rot

The usually great difference in the price of fresh cassava roots between producers and retailers is due to the high susceptibility of roots to both microbial and physiological deterioration after harvest (Wheatley *et al.*, 1984). If roots are injured at harvesting, microorganisms belonging to various genera of fungi and bacteria penetrate and invade root tissues inducing rots a few hours after establishment. Affected roots are not edible; losses due to this are frequently high and generally represent more than 10% of all cassava roots produced around the world.

Due to the high percentage of starch in cassava roots (around 70%) many fungal and bacterial species, both saprophytes or pathogenic, are able to induce root rots after harvesting. The severity of deterioration is related to the damage induced at harvest and the length of time roots are stored before consumption or processing. Roots produced in soils highly infested with pathogen or in soils with a high organic matter content may deteriorate more than those produced in pathogen-free or low organic matter soils. A simple record of percentage of rotted tissue/root after a given period of storage is used for the evaluation of post-harvest deterioration (Wheatley *et al.*, 1984).

Yield loss due to cassava bacterial blight

Losses induced by CBB vary throughout the world although they may be very high. Losses can reach 30% when cuttings taken from an infected plantation are planted in a clean plot (Lozano, 1986). If environmental conditions are favorable and no control measures adopted, losses can reach 80% within three successive cropping cycles by using planting material from the previous crop (CIAT, 1975; Lozano and Sequeira, 1974). Generally, losses due to CBB, for susceptible clones, are correlated with the number of infected cuttings (Table 4). The sprouting of buds from CBB-infected cuttings is low. Shoots that do emerge are foci of infection, increasing the incidence and severity of the disease. Rain splash and high relative humidity favor bacterial establishment and invasion. The fresh root yield and number of marketable roots decrease, but the starch and dry matter contents of the roots are not affected (Otim-Nape, 1985). When weak pathogens such as *Colletotrichum* spp. and *Choanephora cucurbitarum* invade CBB-infected tissues, the disease severity is higher due to the synergetic effect of the pathogens (Łozano, 1986). In an area where cassava anthracnose was present, losses exceeded 90% during the first cycle (Lozano, unpublished).

The evaluation of root yield losses due to CBB has been calculated based on plots planted with cuttings from affected plants or with CBB-free cuttings artificially dip-inoculated with a bacterial suspension (1×10^8 cfu/ml). For the calculation of losses due to CBB, anthracnose, and their synergetic effect, a strain of *Pseudomonas putida* was used to control *X. campestris* pv. *manihotis* and benomyl (Benlate, 2g/1) applied to control *Colletotrichum* spp. Around 7 spray applications of each were used to obtain a satisfactory control of each pathogen.

Table 4 Yield reduction due to the use of cassava bacterial blight (CBB)-infected cuttings for planting a susceptible clone in a CBB-favorable location

% of CBB-infected cuttings planted	Yield (t/ha)	Yield reduction (%)
0	28.9[a]	-
25	20.4	29.4
50	15.8	45.3
75	17.9	38.1
100	8.1	72.0

[a] Average data taken from six replicates of 30 plants/plot one year after planting.

General conclusions

Several diseases of cassava are able to induce severe losses in areas where climatic and edaphic conditions favor spread. The severity of most diseases of cassava on susceptible clones is related to the sanitary quality of the planting material used for planting and the cultural practices applied to reduce the inoculum potential of cassava pathogens during the long growing cycles. Post-harvest losses in cassava are so important that they have a profound impact on consumer preference.

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