

Cassava Diseases and Their Control

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For the purposes of control, cassava pathogens are classified as (a) those that attack vegetative propagating material, (b) those that attack foliage and green stem portions, and (c) root rot pathogens that can induce preharvest and postharvest deterioration. Control measures for each of these categories are discussed and recommendations are made. These measures, however, should be applied as part of an integrated system for any cassava cultivation program.

Until recently cassava was considered to be resistant to diseases and pests; it is now accepted that diseases can cause severe losses and that they are economically important. Cassava is affected by more than 30 fungal, bacterial, viral, or viruslike and mycoplasmal agents (Lozano and Booth 1974). These diseases can affect plant establishment and vigour, inhibit photosynthetic efficiency, or cause preharvest or postharvest deterioration. Some causal agents are distributed worldwide, appearing endemically in almost all cassava plantations (leaf spots induced by *Cercospora* spp. and *Oidium* spp.) (Lozano 1976; Terry 1975a). Others are limited to geographical areas or continents (the causal agents of cassava bacterial blight, American viruses, and mycoplasmal diseases) (Lozano 1972, 1975), possibly because their dissemination occurs mainly through the use of infected planting material for propagation.

African mosaic disease and brown streak virus are limited to Africa (Lozano 1972; Terry 1975a), Asian mosaic disease to Asia, and superelongation disease to America (Lozano and Booth 1974; Lozano 1972). Apparently the causal agents of African and Asian mosaic diseases are not present in America, although the vector (*Bemisia* spp.) was recently identified on this continent (Bellotti personal communication). Other widely distributed pathogens attack cassava only during the cool and rainy periods of the year or in areas located at high elevations (more than 1200 m), where

temperatures are below 22 °C (*Phoma* sp. and *Cercospora caribaea*) (Lozano and Booth 1974; CIAT 1974, 1975). There are other pathogens whose incidence is limited by environmental conditions, possibly because they require high relative humidity (nearly to the saturation point) for germination and establishment (CIAT 1974).

Pathogens of Vegetative Material

Cassava is vegetatively propagated by planting pieces of stem cuttings; consequently, cassava pathogens can be disseminated easily by the movement of planting material from infected to uninfected areas. These pathogens can cause considerable damage during the establishment of the crop or at any time during its growth cycle, including: (1) reduction in germination, (2) damping off, (3) decrease of normal plant vigour, and (4) reduction of the potential number of swollen roots due to initial root damage.

These pathogens are mainly fungi, which attack epidermal, cortical, and woody stem tissues (*Sphaceloma manihoticola*, *Gloeosporium* sp.); facultative saprophites or parasites (*Rosellinia necatrix*, *Fusarium* spp., *Armillaria mellea*, *Sclerotinia* sp., *Sclerotium rolfsii*, *Penicillium* spp., *Aspergillus* spp., etc.). These fungi are frequently found in the soil (Lozano and Booth 1974). Other pathogens include (1) bacteria (*Xanthomonas manihotis*, Lozano 1975; or *Erwinia* sp., Lozano et al. 1976; CIAT 1976), (2) mycoplasma, and (3) viruses or viruslike diseases (Lozano 1972; Terry 1975a). These are generally vascular pathogens located inside pieces of stem used for propagation.

The occurrence of these pathogens in a plan-

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tation may be due to the use of planting material taken from infected plantations (Lozano 1972, 1975), the use of infested machinery or tools during the preparation of land and while planting stem pieces, or infested soils.

Control Measures

Taking the foregoing factors into consideration, the incidence of these pathogens in a country, region, or plantation can be prevented by following these recommendations:

(1) A careful selection of all planting material must be initiated by choosing the appropriate area and field for the collection of propagating material. Once in the field, plants and plant sections used for propagation should also be carefully selected. Generally, it is not advisable to take planting material from Africa or Asia to America due to the presence of mosaic disease in the former. Cuttings should not be taken from areas where CBB or superelongation disease is present. The use of cuttings from plantations infected with the common mosaic or vein mosaic virus and mycoplasmal diseases must also be avoided (IDRC 1975; Lozano 1976; Terry 1975a). Cuttings should always be selected from vigorous, apparently healthy plants. The elimination of any stem section with suspicious signs of disease is extremely important in the control of these diseases.

(2) Avoid damage to vegetative propagating material. Germination and establishment can also be improved by the careful handling of cuttings during preparation, packing, shipping, and planting, which prevents injury to both the stem and bud tissues. Some vascular pathogens of cassava are disseminated by the use of infected tools. When handling propagative material, all tools and machinery should be disinfected prior to each use with a 5% solution of commercial formaldehyde.

Fungicide "seed" treatment of cuttings may be valuable. Germination and establishment can be increased by more than 10% by dipping cassava cuttings into a 5% solution of Demosan (1,4 dichloro-2,5-dimethoxybenzene), Arasan (tetramethylthiuram disulfide), Agalol (methoxyethylmercury chloride) or Brascicol 75 (pentachloronitrobenzene) for 3–5 min before planting (CIAT 1974).

(3) Selection and preparation of land are also important factors for successful cassava cultivation. Heavy soils, with a high organic matter content, are difficult to drain and may

remain flooded for several hours after a heavy rainfall. These soils may also contain high populations of organisms that can attack the recently planted cuttings. Land that has been previously used for forest (woody trees, bushes, coffee, etc.) or perennial crops (plantain, sugar cane, etc.) may also contain high populations of root rot pathogens (e.g. *Rosellinia necatrix*, *Armillaria mellea*, *Fusarium* spp., *Sclerotium rolfsii*, *Rhizoctonia* sp., *Pythium* spp., *Fomes lignosus*, *Phytophthora drechsleri*, etc.), which normally attack cassava roots and woody stems (Lozano and Booth 1974).

Adequate cultural practices to ensure good soil preparation and drainage should always be followed. Planting on ridges may also be effective in preventing diseases. Soil must be well plowed and drained. In regions where rainfall is high (more than 1200 mm), planting should be done on ridges to improve drainage and reduce root damage.

Good quality cuttings, about 20 cm long, should be planted so that half the cutting is covered by soil. Water should be applied soon after planting.

Foliar and Green Stem Pathogens

Several fungi (*Cercospora* spp., *Phoma* sp., *Oidium* sp., *Colletotrichum gloesporioides*, *Uromyces* spp., etc.), bacteria (*Xanthomonas manihotis* and *Erwinia* sp.), mycoplasma, and viruses or viruslike causal agents attack the leaves and green stem portions of the plant, or show the most characteristic symptoms in these areas. Damage induced by these agents can lead to a reduction of photosynthesis, thereby decreasing the production and storage of carbohydrates. Reduction in photosynthesis can result from: (1) leaf spotting (chlorotic or necrotic areas) induced by certain fungi, viruses, viruslike causal agents, and bacteria; (2) blight and dieback induced by certain bacteria and fungi; (3) distortion and leaf stunting induced by certain mycoplasma, viruses, and viruslike agents; (4) bud proliferation induced by mycoplasma; and (5) hypertrophy caused by certain variants of mycoplasma (Costa and Kitajima 1972) and the superelongation causal agent (Lozano and Booth 1974; Krausz et al. 1976).

Several pathogens included in this group are endemic in major cassava-growing areas (Lozano and Booth 1974; Terry 1975a). Disease severity appears to be related to susceptibility

of the cultivar and climatic conditions in each area.

Some other causal agents that can be disseminated mechanically or by using diseased planting material are viruses and mycoplasma, found scattered in certain regions of America but whose incidence is low. Cassava bacterial blight, superelongation disease, and African mosaic disease are also disseminated by infected planting material (Lozano 1975; Krausz et al. 1976; CIAT 1976; Lozano 1972). However, since their specific means of dissemination are highly effective, they may suddenly spread in a given region, country, or continent, causing serious epiphytotic a relatively short time after their introduction (Lozano and Sequeira 1974; Terry 1975b).

Control Measures

The control measures suggested for the diseases induced by the aforementioned group of causal agents are:

(1) *Varietal resistance*. Even though there are no resistant commercial cultivars for many cassava diseases, good sources of resistance have been identified and promising hybrids are now being multiplied by IITA and CIAT (IITA 1973, 1974; CIAT 1974, 1975). Resistant genotypes for CBB, *Cercospora* leaf spots, superelongation disease, and *Phoma* leaf spot have been tested during several growing cycles. Good-yielding commercial lines, resistant to the major cassava diseases, should be available in the near future.

(2) *Disease-free planting material*. This is the best control measure to prevent the introduction of causal agents that attack vascular and cortical tissues. These causal agents include viruses or viruslike diseases (common mosaic virus, vein mosaic virus, and African mosaic disease), mycoplasma (witches' broom disease), bacteria (*X. manihotis* and *Erwinia* sp.), and epidermal and cortical fungi (*Sphaeloma manihoticola*, etc.). Methods for producing CBB-free planting material have been developed at CIAT (Lozano and Wholey 1974; Takatzu and Lozano 1975; Cock et al. 1976). The culture of meristematic tissues has also been reported (Kartha and Gamborg 1975). Both techniques are useful tools for producing disease-free planting material. They could be used to supply basic stock for the rapid multiplication method recently reported by Cock et al. (1976).

(3) *Roguing*. Pathogens reported to be dis-

seminated mechanically from diseased to healthy plants (Costa and Kitajima 1972; Lozano 1972) can be eliminated by roguing. The common mosaic virus, the vein mosaic virus, and the witches' broom mycoplasma diseases are also included in this group. Rogued plants must be destroyed by fire. We also suggest that tool surfaces be sterilized.

(4) *Cultural practices*. Within a few days after planting, the cassava foliar system provides a microclimate with lower temperatures, high relative humidity, and low air circulation between the ground surface and the top of the plants. The formation of this microclimate depends upon the variety planted (varieties with low or high leaf area index), as well as on the plant population. These conditions may favour the incidence and severity of fungal and bacterial foliar diseases such as *Cercospora* leaf spots, *Phoma* leaf blight, cassava bacterial blight, etc. Their incidence and severity may be reduced by selecting varieties with low leaf area index. Plant population and foliar index should be just high enough to supply satisfactory weed control and good yield. A leaf area index of about 3 appears to be optimal for root yield (Cock personal communication; CIAT 1975, 1976). Appropriate planting time may also reduce the incidence of these diseases; planting at the beginning of the rainy season ensures good establishment. The canopy will close across the rows during the dry season, approximately 4 months after planting. Because of the dry environment, a favourable microclimate for these pathogens will not be formed.

Root Rot Pathogens

Cassava roots often deteriorate before or after harvesting. Preharvest root rot is the result of attack by soil-borne pathogens. Post-harvest root rot appears to be a combination of physiological-pathological factors, generally accelerated by mechanical injury to the roots during the harvesting operations (Booth 1975).

Preharvest Root Rot

The appearance of preharvest root rot problems in a cassava plantation is generally a result of using poor-quality, diseased cuttings. Inadequate preparation of the land can also result in preharvest root rot. Therefore, the aforementioned recommendations for selection and treatment of cuttings before planting and

the cultural practices suggested for land selection, preparation, and maintenance should be strictly observed to prevent or reduce root rot incidence. If root rots increase to levels higher than 3%, which is considered to be economically important, crop rotation with cereals (maize, sorghum, etc.) or crop fallowing for a 6-month period is also recommended. These practices should decrease the inoculum potential of root rot pathogens; however, effective control of these diseases through the use of crop rotation or crop fallowing has not been demonstrated. It is possible that longer periods of rotation or crop fallowing are needed in order to decrease the incidence of pathogens that produce resting structures, such as sclerotia, chlamydospores, rhizomorphs, etc. It has also been observed that some cultivars are more susceptible to root rot diseases than others. The development of resistant cultivars could be considered for the control of these diseases.

Postharvest Root Rot

Cassava roots cannot be kept in a fresh state for more than a few days after harvest if certain precautions are not taken. This presents serious problems in the marketing and utilization of the crop and results in heavy losses. Two types of deterioration have been reported (CIAT 1974, 1975; Booth 1973): physiological or pathogenic, or a combination of the two.

Several control measures to reduce postharvest deterioration have been suggested:

(1) Leave the roots in the ground until needed. Once harvested, the roots should be used immediately or dried for longer storage life. This necessitates a scheduled program of planting and processing.

(2) The rate of primary deterioration varies among cultivars (Montaldo 1973; Booth, Noon, and Kawano, personal communication), so those which display the slowest rate of deterioration should be used.

(3) One of the most important factors in the success of cassava storage is the condition of the product to be stored (Booth 1975). Care should be taken during harvesting and handling to minimize damage, and only the least damaged roots should be stored.

(4) Deterioration can be delayed by the use of various surface sterilants and fungicides (Booth 1975), refrigeration and waxing (Singh and Mathur 1953; IIT, 1973). However, the

high cost and low efficiency of these techniques severely limit their use.

(5) Small quantities of roots can be preserved for several days by using simple techniques such as reburial, or coating in mud and placing under water. Burying the roots in a trench or covering them with soil or a mixture of straw and soil gives good results (Ingram and Humphries 1972). Booth (1975) was able to store roots for up to 3 months in field clamps similar to those used for storing potatoes in Europe. He also reported that cassava could be stored in boxes with moist sawdust at room temperature. As a result of this research, it was concluded that cassava roots, like many other root and tuber crops, can be cured, requiring only high relative humidities at temperatures between 25 and 40 °C.

Conclusions

There are very few economically feasible chemical control measures for cassava diseases. The most practical control methods are to: (1) plant disease-resistant cultivars; (2) use adequate cultural practices; and (3) plant disease-free material treated with fungicide. At present cassava improvement programs are concerned with long-term research to produce and release high-yielding multiple-disease-resistant cultivars. This will take some time; however, the foregoing recommendations should provide effective short-term control, which should minimize the incidence and spread of cassava diseases.

Booth, R. H. *The storage of fresh cassava roots*. In Proc. International Symposium on Tropical Root and Tuber Crops. Ibadan, Nigeria, 1973 (in press).

Cassava storage. CIAT, Cali, Colombia, Bulletin EE-16, 1975, 18 p.

CIAT *Annual Report 1973*. CIAT, Cali, Colombia, 1974, 260 p.

Annual Report 1974. CIAT, Cali, Colombia, 1975, 253 p.

Sistemas de producción de yuca. In Informe Anual CIAT 1975, CIAT, Cali, Colombia, 1976, 63 p.

Cock, J. H., Wholey, D. W., and Lozano, J. C. *A rapid propagation system for cassava*. CIAT, Cali, Colombia, Bulletin EE-20, 1976, 11 p.

Costa, A. S., and Kitajima, E. W. *Studies on virus and mycoplasma diseases of the cassava plant in Brazil*. In Proceedings IDRC/IITA Cassava Mosaic Workshop, International Institute of Tropical Agriculture, Ibadan, Nigeria, 1972, 48 p.

- IDRC *The international exchange and testing of cassava germ plasm. Proceedings of an interdisciplinary workshop held at CIAT, Palmira, Colombia, 4-6 February 1975.* International Development Research Centre, IDRC-049e, 1975, 74 p.
- IIT *La yuca parafinada.* Revista del IIT (Colombia), 78, 1973, 131-148.
- IITA *Root and tuber improvement program.* In Annual Report 1973. IITA, Ibadan, Nigeria, 1974, 39 p.
- Annual Report 1974.* IITA, Ibadan, Nigeria, 1975, 199 p.
- Ingram, J. S., and Humphries, J. R. O. *Cassava storage: a review.* Tropical Science, 14, 1972, 131-148.
- Kartha, K. K., and Gamborg, O. L. *Elimination of cassava mosaic disease by meristem culture.* Phytopathology, 65, 1975, 826-828.
- Krausz, J. *The superelongation disease of cassava.* PhD thesis, Cornell University, Ithaca, N.Y., 1975, 81 p.
- Krausz, J., Lozano, J. C., and Thurston, H. D. *A new anthracnose-like disease of cassava.* Ann. Proc. of the Am. Phytopath. Soc. 1976 (in press).
- Lozano, J. C. *Status of virus and mycoplasma-like disease of cassava.* In Proceedings of the IDRC/IITA cassava mosaic workshop, International Institute of Tropical Agriculture, Ibadan, Nigeria, 1972, 48 p.
- Lozano, J. C., and Booth, R. H. *Diseases of cassava (Manihot esculenta Crantz).* PANS (Pest Articles and News Summaries), Centre for Overseas Pest Research, London, 20, 1974, 30-54.
- Lozano, J. C., and Sequeira, L. *Bacterial blight of cassava in Colombia: epidemiology and control.* Phytopathology, 64, 1974, 83-88.
- Lozano, J. C., and Wholey, D. W. *The production of bacteria-free planting stock of cassava.* World Crops, 26, 1974, 115-117.
- Lozano, J. C. *Bacteria blight of cassava.* PANS (Pest Articles and News Summaries), Centre for Overseas Pest Research, London, 21, 1975, 38-43.
- The threat of introducing cassava diseases and pests on propagation material.* In Plant health and quarantine problems arising in international genetic resources transfer. FAO (Food and Agriculture Organization), 1976 (in press).
- Lozano, J. C., Bellotti, A., van Schoonhoven, A., Howeler, R., Howell, D., and Doll, J. *Field problems in cassava.* CIAT (Centro Internacional de Agricultura Tropical), Cali, Colombia, 1976.
- Montaldo, A. *Vascular streaking of cassava root tubers.* Tropical Science, 15, 1973, 39-46.
- Singh, K. K., and Mathur, P. B. *Cold storage of tapioca roots.* Central Food Technological Research Institute, Mysore, India, Bulletin, 2, 1953, 181-182.
- Takatsu, A., and Lozano, J. C. *Translocación del agente causal del añublo bacterial de la yuca (Manihot esculenta Crantz) en los tejidos del hospedero.* Fitopatologia, 10, 1975, 13-22.
- Terry, E. R. *Cassava germ plasm resources, disease incidence, and phytosanitary constraints at IITA.* In Nestel, B., and MacIntyre, R., eds., *The international exchange and testing of cassava germ plasm, Proceedings of an interdisciplinary workshop held at CIAT, Palmira, Colombia, 4-6 February 1975.* IDRC-049e, 1975a, 38-40.
- Cassava bacterial blight disease in Africa.* In Proceedings of the IDRC/IITA Workshop on Cassava Improvement in Africa. International Institute of Tropical Agriculture, Ibadan, Nigeria, 1975b (in press).

Field Control of Cassava Mosaic in Coast Province, Kenya

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A series of simple observational trials to study the epidemiology of cassava mosaic in the field was undertaken at the Coast Agricultural Research Station, Mtwapa, during 1973-76 on moderately tolerant cultivar 46106/27 and highly susceptible cultivar F279. The results indicate that control of mosaic in the field in coastal districts of Kenya is possible by the use of mosaic-free planting material, the roguing of infected plants, and by allowing a reasonable degree of isolation of clean plots from infected plots. They also

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