Tropical Root Crops

RESEARCH STRATEGIES FOR THE 1980s

Proceedings of the First Triennial Root Crops Symposium of the International Society for Tropical Root Crops ~ Africa Branch
TROPICAL ROOT CROPS: RESEARCH STRATEGIES FOR THE 1980s

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EDITORS: E.R. TERRY, K.A. ODURO, AND F. CAVENESS

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Postal Address: Box 8500, Ottawa, Canada K1G 3H9
Head Office: 60 Queen Street, Ottawa

Terry, E.R.
Odoro, K.A.
Caveness, F.
International Society for Tropical Root Crops. Africa Branch, Ibadan NG


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The direct effects of climate on the severity of cassava diseases and the survival of cassava pathogens are examined, examples being taken from the experience of cassava bacterial blight in Africa. A proposal for future research strategies in cassava pathology focusing on the ecology of cassava pathogens and other factors limiting cassava productivity in Africa is presented.


All major epidemics have one major characteristic; they are an intensified union of a crop and a pathogen following either genetic, temporal, spatial, geographic, or climatic separation (Budenhagen 1977). In Africa, the type of cassava epidemic that occurs is generally described as new-encounter disease. New-encounter cassava diseases may be subdivided into three classes: those that result when cassava is introduced into a region, those that result when cassava pathogens are introduced into a major cassava-producing region, and those that result when both cassava and its pathogens are introduced separately, usually with the crop being introduced first.

Data from the Americas (CIAT 1980) have indicated that when local, regional, or newly developed cassava genotypes are evaluated for their productivity under different agroecological conditions, significant cultivar, biotic, and ecosystem interactions occur. Also data from Nigeria (Hahn, S.K., personal communication) have shown significant variations in yield performance of two improved varieties in environments that vary widely in seasonal and total precipitation, soil fertility, and disease incidence and severity (Table 1).

**THE AFRICAN CASSAVA BELT**

Cassava is a short-day plant, and its distribution in Africa is therefore largely confined to the areas between latitudes 15° N and 15° S (Jennings 1970). The extent of this African cassava belt is limited geographically not so much by temperature as by rainfall, and the boundaries of its cultivation appear to correspond roughly, although not precisely, to those areas where mean annual rainfall exceeds 750 mm (Jones 1959).

On a regional basis, there are some marked ecological features that characterize the major zones within the cassava belt. Thus this belt can be subdivided on the basis of rainfall distribution and temperature variations into the tropical wet zones and the tropical wet and dry zones.

**THE TROPICAL WET ZONES**

The tropical wet zone typically exists in a belt extending between 0° and 5–10° on both sides of the equator. It is marked by heavy precipitation during the major part of the year, usually ranging from 2000 mm to well over 3000 mm.

Temperatures are uniformly high, with annual means usually 25–27°C and little seasonal variation. Average monthly maximum and minimum temperatures are about 31°C and 25°C, respectively, and the difference between the hottest and coolest months is generally less than 5°C (Brook 1979).

The tropical wet climates may be further divided, on the basis of their seasonal rainfall distribution, into the equatorial zone, where the abundant rainfall is relatively well distributed throughout the year.
and the moist monsoonal zone, where rainfall is also abundant but where a short dry season of not more than 2 months normally occurs.

THE TROPICAL WET AND DRY ZONES

The tropical latitudinal position of the tropical wet and dry climate is from 5°–10° to 15°–25° on either side of the equator. In this climatic zone, annual precipitation is generally less than in the tropical wet zone, and rainfall is more seasonal, with distinct wet and dry seasons. Total precipitation is usually between 1000 mm and 1500 mm with a dry season of at least 2 months, increasing in length with distance from the equator (Brook 1979).

Although the temperature characteristics in this climatic zone are quite similar to those of the wet tropics, the temperatures at elevations of 1500 m and higher are generally lower. In the wet and dry tropical highlands, mean annual temperatures are about 18°C, with the warmest months averaging only about 21°C.

AGROECOLOGY AND CASSAVA BACTERIAL BLIGHT

The short- and long-term economic importance of cassava bacterial blight (CBB), especially with regard to crop losses and epidemic potential, is significantly influenced by seasonal climatic fluctuations, level of susceptibility of favoured cassava cultivars, and the source of Xanthomonas manihotis inoculum (Terry 1977). The most important phase of the CBB epidemic results from the planting of infected cassava stakes. The secondary phase of the disease results from lateral dissemination of X. manihotis cells from diseased plants.

Cassava bacterial blight is more widespread and severe in the savanna and forest-savanna transition ecological zones of Africa than in the deep rain forest. This has been confirmed in survey reports from Cameroon (Persley 1977), Zaire (Hahn and Williams 1973), Republic of Congo (Daniel et al. 1978), Nigeria (Persley 1978), Tanzania (Nyango 1978), and Uganda (Nyitra and Otim-Nape 1978).

Severe incidences of the disease have, however, been reported from the rain forest zones in Nigeria (Williams et al. 1973) and Cameroon (Persley 1977). Sporadic outbreaks of the disease have also been reported in isolated pockets in Togo (Olympio 1978) and Ghana (Korang-Amoakoh and Oduro 1978), and in the latter, although the disease was reported as almost at an epidemic level in 1975–76, its incidence was recorded as almost nil in 1977 in the greater Accra area.

Data from CBB trials conducted in the tropical rain forest region of Nigeria have indicated that the CBB epidemic does not become fully established in this climatic zone (Persley 1978). When first introduced, the disease was severe in susceptible cultivars and generally mild in resistant ones. Also, mortality was high among the susceptible cultivars, especially during periods of heavy rainfall.

The heavy rainfall and almost nonexistent dry season in the tropical wet climatic zones do not provide favourable conditions for the survival of X. manihotis. Therefore, although the disease develops under these conditions, especially when infected planting material is utilized to establish a crop, the poor survival of X. manihotis in soil and debris reduces the inoculum for the succeeding crop. The subsequent use of CBB-free planting material can break the disease cycle and reduce the epidemic potential.

Data from CBB trials conducted in the forest-savanna transition zone of the wet and dry tropics in Nigeria have indicated that with adequate rainfall (Mokwa and Ibadan 1100 mm and 1270 mm, respectively), severe CBB develops in sus-

---

Table 1. Cassava yield and reaction to CBB and CMD in four locations in Nigeria.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Location and rainfall (mm)</th>
<th>1977 Yield (kg/plant)</th>
<th>1978 Yield (kg/plant)</th>
<th>1979 Yield (kg/plant)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMS 30572</td>
<td>Ibadan; 1270</td>
<td>1.49</td>
<td>1.5</td>
<td>1.8</td>
</tr>
<tr>
<td>TMS 30572</td>
<td>Onne; 2500</td>
<td>2.42</td>
<td>2.5</td>
<td>1.0</td>
</tr>
<tr>
<td>TMS 30572</td>
<td>Warri; 2600</td>
<td>0.48</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>TMS 30555</td>
<td>Mokwa; 1100</td>
<td>1.73</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>TMS 30555</td>
<td>Ibadan; 1270</td>
<td>1.09</td>
<td>1.5</td>
<td>1.9</td>
</tr>
<tr>
<td>TMS 30555</td>
<td>Onne; 2500</td>
<td>1.78</td>
<td>3.0</td>
<td>1.8</td>
</tr>
<tr>
<td>TMS 30555</td>
<td>Warri; 2600</td>
<td>0.45</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>TMS 30555</td>
<td>Mokwa; 1100</td>
<td>1.41</td>
<td>1.0</td>
<td>1.4</td>
</tr>
</tbody>
</table>

*CBB and CMD scores are based on a scale of severity, increasing from 1 to 5; NA = not available.*
ceptible cultivars. Where there is a long dry season (5–7 months), the conditions are quite favourable for the survival of *X. manihotis* (Persley 1978), and a sustained CBB epidemic occurs (Table 2).

**STRATEGIES FOR FUTURE RESEARCH**

The ultimate goal of cassava improvement in Africa is to develop varieties with high yield, disease and pest resistance, and adaptability to a wide range of climatic, soil, and cultural characteristics. To achieve this goal, researchers must identify genotypes with moderate or high tolerance or resistance to a combination of the stress factors that affect the productivity of the crop under various ecological conditions.

Takatsu et al. (1978) have demonstrated, through growth-chambre studies in Brazil, that, when temperature does not fall below 22°C at night and 30°C during the day, susceptible cassava cultivars normally develop only mild CBB and generally recover from the disease. However, at lower temperatures both susceptible and resistant cultivars become severely diseased. Furthermore, although plants of resistant cultivars may survive the disease, susceptible plants usually die from it.

Based on these findings, one may presume that, along with the well-documented effect of rainfall on the spread of *X. manihotis* and the severity of CBB (Lozano 1975), temperature plays an indirect role in CBB disease expression in relation to its effect on the growth of the cassava plant.

The African cassava belt is characterized by a great diversity of climatic and edaphic conditions even within the broadly defined wet tropical and wet and dry tropical zones. Temperature and rainfall variations as already indicated result from variations in elevations, ocean currents, prevailing winds, and distances from the equator. Typical examples of such diversity within a given climatic zone are the hill slopes of the Cameroon Peak (4062 m) where mean annual rainfall is often more than 10000 mm and the mean annual temperature is 26.6°C and the highlands of Kenya where mean annual rainfall is about 1000 mm, but where in the Rift valley, with local variations due to relief, the precipitation is about 750 mm and on the exposed slopes of Mount Kenya where it is invariably more than 1500 mm (Hailey 1957).

In the tropical humid climatic zones of Africa, the constantly high temperatures and abundant annual rainfall lead to intense chemical weathering of soils. This results in a complete or nearly complete decomposition of minerals and removal of soluble silica and bases (Brook 1979). The soils are, therefore, for the most part chemically poor, although in the tropical wet zones the soils generally have good physical structures. In contrast in the tropical wet and dry zones, depending on the length of the dry season, the soils become highly leached and are generally of low fertility (Brook 1979).

The differences in the climatic and edaphic conditions inevitably result in variations in relative humidities, minimum and maximum temperatures, soil pH, soil texture, organic matter content, and macro- and micronutrient deficiencies within and between the main cassava-growing areas in Africa. These, in turn, exert significant effects on the growth of the crop and modify its reaction to its major pathogens. Furthermore, as is shown by the

<table>
<thead>
<tr>
<th>Zones</th>
<th>Latitude</th>
<th>Precipitation (mm)</th>
<th>Mean annual temp (°C)</th>
<th>Location</th>
<th>Epidemic potential</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tropical wet</td>
<td>0.5° N/S</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equatorial</td>
<td>0.32° N</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monsoonal</td>
<td>4° N</td>
<td>3000</td>
<td>25–27</td>
<td>Kisangani,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3000</td>
<td>25–27</td>
<td>Zaire</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Year round</td>
<td></td>
<td>Douala,</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>10 months wet;</td>
<td></td>
<td>Cameroon</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 months dry</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tropical wet and dry</td>
<td>5–10° N/S</td>
<td>1000–1500</td>
<td>23–26</td>
<td>Timbo,</td>
<td>+</td>
</tr>
<tr>
<td>Lowland</td>
<td>15–25° N/S</td>
<td></td>
<td></td>
<td>Guinea</td>
<td></td>
</tr>
<tr>
<td>Highland</td>
<td></td>
<td>6 months wet;</td>
<td>18–21</td>
<td>Salisbury,</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3 months dry</td>
<td></td>
<td>Zimbabwe</td>
<td></td>
</tr>
</tbody>
</table>

*Adapted from Brook, R.H. (1979) and Best, Alan and deBlij, H.J. (1977).*
example of CBB in Africa, climatic and edaphic variations also strongly influence the behaviour of the pathogens, in this instance, that of the survival of X. manihotis.

It is proposed, therefore, that the research strategies for progress in cassava pathology focus on the identification of factors limiting cassava productivity with special reference to effect of agroecological factors on cassava growth, effect of agroecological factors on the aggressiveness of cassava pathogens, and effect of agroecological factors on the survival and epidemic potential of cassava pathogens.

At the International Institute of Tropical Agriculture (IITA), breeding of improved cassava involves massive crossing and selection primarily against two major diseases — cassava bacterial blight and cassava mosaic disease (CMD). At present, instead of finalization of clone superiority and dissemination from the Ibadan centre, improved true seeds with variable characteristics from different interpollinated females containing sources of resistance and other desired agronomic traits are introduced to locations in different African countries for selection in local environments. In these locations, superior plants are allowed to interpollinate again and some of the seeds collected are returned to Ibadan where they are grown and reselected.

This system ensures the progressive improvement of the varieties toward adaptation to the disease and other stresses in the many local ecologies. The timespan, however, from the acquisition of the source populations, with genes associated with desirable characters, to the selection of elite clones and their multiplication for distribution to farmers is about 6 years. Many African national cassava programs, because of a serious lack of personnel to establish such a lengthy crop-improvement program and the immediate need for plants with high tolerance to the major diseases, urgently require alternative procedures.

Hitherto, phytosanitary regulations have prohibited the movement of vegetative cassava planting material within the African continent because of the threat of accidental introduction of vegetationally borne pathogens and pests into areas presumed free of these agents. With the recent development of techniques for the production of pathogen-free cassava planting material in tissue culture, the possibility now exists for improved cassava varieties that have been tested in Nigeria under a range of environmental conditions and various levels of disease stress to be introduced into national programs.

The improved IITA-bred varieties proposed for distribution are TMS 30555, TMS 30572, TMS 30786, TMS 30557, TMS 30001, and TMS 30395; they have proved superior in yield and performance in the majority of the environments in which they have been evaluated. Two of these improved varieties, TMS 30555 and TMS 30572, have produced average yields of 40.8 and 36.0 t/ha in 12 months, and the latter had a yield of 68 t/ha in 15 months in Ibadan, Nigeria, on soils where cassava had been consecutively planted for 2 years without fertilizer application (IITA 1979).

The improved varieties are relatively low in cyanide content, have good root shape, and good resistance levels to CBB and CMD. Their quality is rated excellent for consumer acceptance, and their percentage dry matter is relatively high (32% and 36% at 12 and 15 months after planting respectively).

The Inter-African Phytosanitary Council (IAPSC) has reviewed the proposal for the movement of these improved varieties in tissue culture from IITA to African countries whose national programs request them. The indications are that subject to recommendations from the Plant Quarantine Services (PQS), Moor Plantation, Ibadan, the IAPSC will endorse the issue of the Phytosanitary Certificates to legalize the movement of these varieties within Africa.

The short- and long-term benefits from the introduction of improved cassava varieties in tissue culture to national cassava programs include the immediate availability of clonal material for uniform varietal evaluation within a national program, the identification of varieties adapted to local ecologies within 1 or 2 growing seasons, and the possibilities for replacing unimproved low-yielding, disease-susceptible varieties with improved high-yielding varieties adaptable and tolerant to the local ecological stresses. National programs will nevertheless continue to introduce new genotypes as true seed for local selection.

With regard to the desired progress in cassava pathology research, the availability of uniform clonal material will provide the possibilities for investigating variations in cassava pathogens due to ecological differences, and the influences of the ecological stresses on the crop's productivity and on the stability of varietal resistances to major cassava pathogens.

The useful suggestions made by Dr Amare Getahun (IITA systems ecologist) during the preparation of this paper are gratefully acknowledged.