
CASSAVA IMPROVEMENT STRATEGIES FOR RESISTANCE TO MAJOR ECONOMIC DISEASES AND PESTS IN AFRICA

S.K. HAHN, E.R. TERRY, K. LEUSCHNER,
AND T.P. SINGH

INTERNATIONAL INSTITUTE OF TROPICAL AGRICULTURE,
IBADAN, NIGERIA

The cassava diseases of major economic importance in Africa are cassava mosaic, bacterial blight, and anthracnose, and the major cassava pests are cassava mealybug and green spider mite. Methods of screening cassava breeding material for resistance to the diseases and pests in the light of factors determining the disease and pest incidence and their effect on efficiency of screening have been discussed. The role of the presence of pathogenic variation and biotypes of pests in determining the durability of resistance over localities and time has been considered, and the optimum conditions for efficient screening of the breeding materials have been suggested.

En Afrique, les maladies et ennemis du manioc d'une grande importance économique sont respectivement la brûlure bactérienne, l'antracnose et la mosaïque dans le premier cas et la cochenille dans le second. Des discussions ont eu lieu sur des méthodes de sélection du matériel génétique de manioc à la lumière des facteurs déterminant la maladie et l'apparition des insectes et sur le rôle que ces facteurs jouent dans l'efficacité de la sélection. On a envisagé l'existence possible de variation pathogénique et de biotypes d'insectes qui détermineraient la durabilité de la résistance selon le temps ou le lieu. L'étude suggère les conditions optimales requises pour sélectionner efficacement le matériel génétique du manioc.

Cassava is native to Latin America. It was introduced into Africa during the last part of the 16th century and adapted quickly in the traditional tropical African farming systems. Since then, it has become a staple for the continent.

The major biologic constraints in cassava production in Africa are diseases and pests. The major diseases are cassava mosaic (CMD), bacterial blight (CBB), and anthracnose (CAD).

CMD has been observed in Africa and India. In Africa it is widespread and is noticed in all the cassava-growing areas (Hahn 1978), causing yield reductions of up to 90% in severely infected crops. The disease is transmitted by means of an insect vector (*Bemisia* spp.). The actual causal agent has not yet been identified, but a virus is suspected (Storey and Nichols 1938; Bock and Guthrie 1976; Rossel and Thottappilly 1978).

CAD caused by *Colletotricum* spp. is also an important stem disease in the grassland savanna regions of Central Africa, where soils are infertile and acidic (Terry and Goodman 1977).

The major pests of cassava in Africa are cassava mealybug (*Phenacoccus manihoti*) and cassava green spider mite (*Mononychellus tanajoa*). Cassava mealybug (CMB) has been reported from most of the major cassava-growing countries in Central

and West Africa since its presence was first reported in Zaire in 1973 (Hahn and Williams 1973). Cassava green spider mite (CGM) also has become a serious pest throughout major cassava-growing areas in Africa since its presence was first reported from Uganda in 1972 (Nyiira 1975). It is believed that along with cassava both CMB and CGM were introduced from Latin America where they are native. These pests cause more damage in the dry season than in the rainy season and in areas with dry and poor sandy soils than in those with more humid soils.

In the traditional African agricultural systems where inputs are low, the use of vegetative propagating material infected with diseases and pests is quite common. CMB and CGM are widely disseminated by infested stakes, wind, and cassava leaves harvested for vegetables.

Because of the limitations in the use of chemicals to control the pests and diseases in Africa, the development of cultivars resistant to diseases and pests becomes the most appropriate and realistic approach for effective control.

The first steps, therefore, are to:

- Identify factors determining the incidence of diseases and pests upon which field screening

of breeding material for resistance can be based;

- Examine the factors that can influence the efficiency of screening; and
- Examine the role of pathogenic variation in the development of efficient and foolproof screening methods.

FACTORS AFFECTING INCIDENCE OF DISEASES AND PESTS

BIOLOGIC FACTORS

Disease incidence depends on the availability of inoculum, which in turn depends on the density and activity of the vector (*Bemisia tabaci* in the case of CMD). For instance, CMD incidence was observed to be closely related to the number of whiteflies (Leuschner and Terry 1976). Detopping of shoots enhances CMD symptom expression. The young leaves are more susceptible than are older ones so that CMD symptoms decrease as the plant grows older. Incidence varies with the level of resistance of individual plants. The environmental conditions that apparently favour population buildup and activity of whiteflies are rainfall between 150 and 280 mm a month, temperatures within the range of 27–32° C, and solar radiation of 400 g-cal/cm² (Leuschner 1978).

It has been suspected that sucking insects increase CBB incidence. As plants become older, CBB symptoms in terms of tip dieback increase (Hahn 1978), and the older and lower leaves demonstrate more serious symptoms than do young leaves. However, as with CMD, the young shoots are more susceptible than are older ones to CBB, and incidence varies with individual plants depending on their resistance.

The succulent parts of young cassava plant stems are more susceptible to CAD than are the older parts.

Less damage from CMB and CGM is expected at lower populations of the pests and in the presence of their natural enemies.

ENVIRONMENTAL FACTORS

Temperature affects CMD symptom expression; high temperature (35°C) suppresses symptom development (Chant 1959; Terry 1978b). Also, incidence is altered by lime application: 0.5–1.0 t/ha was shown to increase CMD incidence (Edward and Kang 1978). In acidic soils, CMD is less severe. Ambe-Tumanteh (1980) reported that soil nutrients, particularly N, P, and Na, are significantly associated with the severity of CMD incidence ($r = 0.58, 0.54,$ and -0.51 respectively).

CMD incidence is lower during the dry season, in areas at elevations higher than 500 m, and in areas with annual rainfall less than 900 mm or more than 1500 mm.

CBB severity is higher in areas where day and night temperatures average 20–25°C than in areas where they are at 25–30°C. Furthermore, it is higher in areas where temperatures at night are 15–20°C and during the day are 28–30°C than in areas where the night and day temperatures are, respectively, 22–25°C and 30–33°C (Takatsu et al. 1978). The optimum temperature for growth of both *Xanthomonas manihotis* and *X. cassavae* has been shown to be 30°C (Maraité and Weyns 1978). CBB incidence seems to be high in poor sandy soils during the rainy season.

CMB and CGM damage crops much more in the dry season than in the rainy season. Furthermore, they cause more damage to plants in dry and poor sandy soils than to those in wet, fertile soils.

FACTORS AFFECTING EFFICIENCY OF SCREENING

Breeding for resistance to diseases and pests aims at improving the cultivars' resistance in a wide range of environmental conditions and for a long period, the final goal being stable productivity. Screening in the field is generally based on phenotypic expression of disease symptoms by plants that are naturally infected by diseases and infested by pests. Screening is most reliable when done under environmental conditions that closely replicate cassava-growing areas, favour full symptom expression by the genotypes, and have adequate disease inoculum and pest populations. The optimum environment will magnify the differences between genotypes in the manifestation of the symptoms. The selection of the sites and seasons with the optimum conditions is very important for efficient field screening. The site(s) should as much as possible represent the major cassava-growing areas or regions in climate, soils, topography, biologic organisms (diseases and pests), and cultural methods. The environment of the site and seasons of screening should be as uniform as possible. The genotypes to be screened should also be at the most appropriate stage of plant growth for good infection by diseases and infestation by pests for better symptom expression.

To minimize the possible errors in screening or, in other words, to increase efficiency and to have the selected genotypes adapted over a wide range of environments, researchers should ensure that the genotype–environment interaction effect is small.

IS RESISTANCE DURABLE?

Mosaic-resistant breeding materials from IITA have been tested in many countries in West Africa, Central Africa, East Africa, and India and have consistently shown resistance to CMD (IITA 1973–78). This absence of regional variation in resistance and the polygenic nature of resistance to CMD suggest that the resistance is durable for a long time in several localities but whether or not it will prove to be race–nonspecific depends on information on pathogenic variation that is at present not available (Hahn et al. 1980b). The allotetraploid and genetically heterozygous nature of cassava supports the theory that resistance to CMD is durable over localities and years. Results from the studies, particularly on pathogenic variation of CMD, merit further investigation.

Comparative studies among different American and African isolates of *X. manihotis* have shown that there are differences in their virulence (Lozano 1975). Maraite and Weyns (1978) reported that there are a few indications that *X. manihotis* (CBB) is different from *X. cassavae* (cassava bacterial necrosis), which was isolated from the material collected from Rwanda and Tanzania. However, whether these species differ in their reaction to different genotypes of cassava is not yet known. The CBB-resistant materials from IITA, when tested in Kenya, showed resistance (B. Beck 1980, personal communication). The material also showed resistance in Zaire. The CBB resistance developed at IITA thus appears to be effective in several localities. Resistance of cassava to CBB is polygenic. It has held true for the past 7 years in Nigeria. This finding suggests that the resistance is durable for a long time and in several localities. The pathogenic variation in CBB-causal organisms and the reactions of different genotypes of cassava to the possible strains and subspecies need further investigation.

No information on biotypes of CMB and CGM is available. Research in this area would be very useful in breeding tests for resistance to CMB and CGM and for biological control measures. Some cultivars at IITA are supposed to possess genes for resistance to CGM; the progenies raised from several parents produced at IITA showed resistance to CGM in Tanzania.

SCREENING METHODS

In screening cassava breeding materials, researchers need to consider efficiency and should aim at stability of the resistance over years and localities.

Field screening for resistance to CMD must, therefore, be done in an environment where inoculum from diseased cassava is present, whitefly populations are high, and the average temperature is relatively low (below 30°C). It will be most effective in a locality where annual rainfall is 1000–1500 mm, elevation is lower than 500 m, average temperatures are about 20–25°C, and the soils have a pH 4–6 and are rich in N and P, poor in Na. Seedlings for screening need to be raised before the onset of the rainy season or early in the rainy season so that they are exposed to high disease pressure in the middle of the rainy season when whitefly populations are high, temperature is not very high, and plant growth is vigorous.

Detopping of the seedlings enhances CMD-symptom expression. The selected seedlings should be replanted in the following year as a clone for confirmation of resistance. Tests for CMD resistance for 2 years are sufficient in localities with high disease pressure, but at least 4-year tests are needed in localities where disease pressure is low, particularly in the high-altitude areas. Resistance to CMD has shown moderate to high heritability in plants tested under optimum environments; this finding suggests that selection for CMD resistance is effective and, in such environments, is possible at an early breeding stage.

CBB scores depend upon time of planting, age of plant, and time of observation (Hahn 1978) and have shown variation from year to year. CBB screening should be done in the rainy season when the rate of CBB symptom development and severity are high and when plant tissues are succulent. Seedlings should, therefore, be raised before or early in the rainy season as is the case for CMD-resistance screening. The correlation between CMD and CBB is significant and implies that selection for resistance to one of the diseases will result in resistance to the other. If heritability can be manipulated by the provision of favourable testing conditions and with better techniques for CBB screening, the gain in CMD resistance should parallel that in resistance to CBB. If CBB incidence is not high under natural field conditions, artificial inoculation with CBB provides better testing conditions. In the localities where both CMD and CBB are problems, screening for breeding materials for resistance to both diseases at the same time should be done. This method increases efficiency in screening and reduces expenses. Resistance to CBB, like that to CMD, has been shown to be moderately to highly heritable under optimum environments.

CMB and CGM are serious in the dry season. Therefore, screening of breeding materials for

resistance to both pests should be done during the dry season. One problem is that the effects of drought are often difficult to separate from the damage caused by the pests.

Resistance of cassava to CGM has been reported (Nyiiira 1975; Msabaha 1975; and Hahn et al. 1980a) and has been more clearly demonstrated than has that to CMB; however some encouraging

results have been obtained for the latter as well. For instance, mealybug has been reported not to colonize on a related *Manihot* species introduced from Brazil (IITA 1978); also there appear to be some clonal differences in damage caused by CMB in Zaire (IITA 1979), and remarkable varietal differences have been observed in recovery from CMB damage soon after the onset of the rainy season.