A Comprehensive Breeding Approach to Pest and Disease Problems of Cassava

Authors: J.C. Lozano, C.H. Hershey, and A. Bellotti, Plant Pathologist, Breeder and Entomologist, Cassava Program, CIAT, Apartado Aéreo 67-13, Cali, Colombia and R. Zeigler, Technical Adviser (IDRC), Programme du Mais et du Pois, Institut des Sciences Agricoles du Burundi (ISABU-Kisozi), Bujumbura, Burundi.

ABSTRACT

The relationship of edapho-climatic characteristics to cassava genotypes and their pests and diseases is discussed. The stability of genotypes on an ecosystem basis and in relation to their resistance to biotic factors as well as to growers' socio-economic needs and priorities are also discussed. On the basis of these, an improvement program is suggested which integrates several parameters of evaluation.

Cassava (Manihot esculenta Crantz) is a vegetatively propagated crop domesticated and improved by traditional growers for more than 4000 years (Leon, 1977). Traditional clones are the result of a slow process of a nature-man system of improvement in which nature has made the crosses and man the evaluation, selection, and multiplication. What we have observed in relatively unperturbed systems is a biological stability (relative absence of pest outbreaks and low but stable yields) apparently the result of interaction of adapted local varieties and traditional cultural practices (multispecific or multiclonal plots).

Within regional populations great genetic variation often exists. Commonly, many clones have a degree of resistance to most biotic and physical stresses in the ecosystem where they were selected along with the quality required to fit the socio-economic needs of the growers.

Cassava Domestication and Selection

Manihot esculenta originated in America with a major center of diversity in South America and a secondary center in Guatemala and Mexico (León, 1977). It has been disseminated through south Brazil, Paraguay, north of Argentina to central Mexico, Cuba, and the Caribbean Islands.

Early plantations were probably isolated, locally by forests and regionally by mountains. Growers followed a slash and burn agricultural system in which cassava was planted in association with other crop species. In some areas, notably in Brazil, this system has evolved to a multiclonal monocropping system in which several clones are mixed or planted in close association. Land preparation, weed control and selection of the planting material have become more sophisticated since cassava was domesticated. Many planting systems may be found in a relatively small area, and vary regionally also.

Many cassava varieties produce out-cross seed in the normal cropping time. Mature seeds fall to the ground where they lie dormant. As the land is prepared for further cultivation the trash and weedy vegetation are burned. The heat releases the cassava seed from dormancy and the seeds germinate. In Amazonas and other regions the growers notice and care for the most vigorous seedlings and follow their performance comparing them with their "parent" varieties. If the new plant survives (a "what-is-left" integrated evaluation procedure) and if it gives a satisfactory "yield", or if planting material from known cultivars is limiting, stakes from it are used as planting material in the following cycle. Continued satisfactory performance leads to an increasing contribution of the new type to cassava production.

Cassava/Ecosystem Relationships

The most commonly encountered description of cassava before the 1970's was as a rustic crop, resistant to almost all biotic and abiotic problems, and particularly well suited to regions with poor soils and prolonged drought (Phillips, 1974). Treatments of the crop often implied that it was adapted to a wide variety of environments. However, earlier descriptions really reflect the plasticity of the species rather than of a particular cultivar.

Recent experimental results demonstrate that the impression of a strong cassava-ecosystem interaction of traditional cultivars is correct:

1. Etiological and epidemiological investigations show that cassava pests (diseases, insects, mites) are not universal. Their presence and incidence are limited by specific climatic and/or edaphic characteristics that restrict them to ecological zones.

2. When planting regional and introduced genotypes in four edapho-climatic zones and evaluating the most important parameters for cassava production during three consecutive cycles it was found that the local regional varieties generally produced poorly in all other edapho-climatic zones.

3. Mean reactions of groups of clones from contrasting edapho-climatic zones and from similar edapho-climatic zones, showed that native cultivars in each environment had the highest levels of resistance to the limiting factors existing in each zone (Figure 1). No cultivars were resistant to the biotic constraints of more than two edapho-climatic zones. Resistance to the main limiting factors of a given edapho-climatic area is much higher in cultivars from areas similar to the testing site than in those edapho-climatic zones with a substantially different set of limiting factors.

Stability in Cassava

Stability is probably best judged by the continued survival of genotypes in a region. Many examples exist in different cassava growing areas: The clone Rayong I was probably introduced to Thailand earlier than 1960 and it is today grown on over a million hectares (Sinthuprama, 1978); Sta. Catarina was selected in Sao Paulo about 70 years ago and it is currently being planted on more than 300,000 ha in this state and the Campo Cerrado of Brazil; Secundina has been planted for more than 20 years in the north coast of Colombia on approximately 7,000 ha; Chiroza has been grown in Caicedonia, Colombia, on more than 6,000 ha since 1970. In practically any edapho-climatic zone where cassava is grown one or more widely planted native genotypes which have been used for many years are still used.

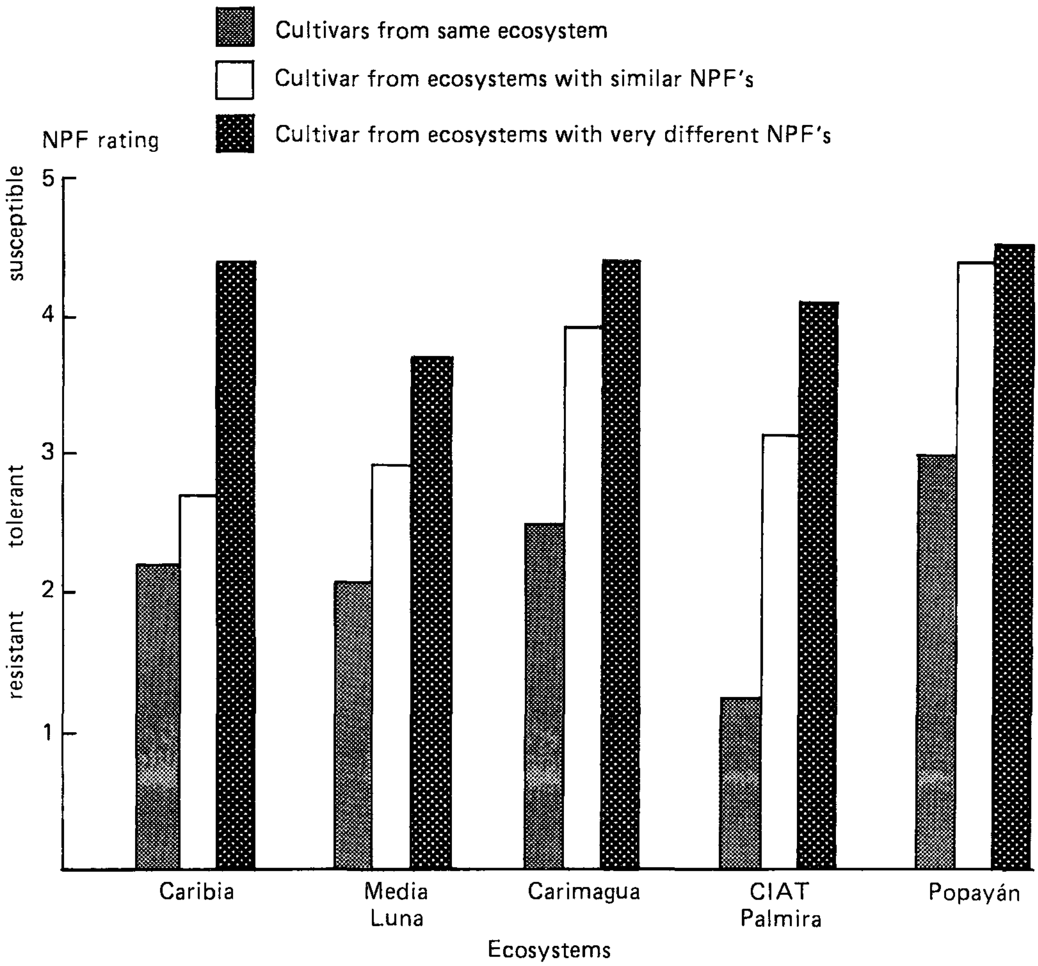

Figure 1. Mean reaction of 25 cassava cultivars (collected or selected in four different edapho-climatic zones and all planted across edapho-climatic zones) to the negative production factors (NPF's) present in each site.

The stability of yield in nine consecutive-year trials has been recorded in the Popayan area for native and introduced genotypes. In the Carimagua zone, yield, cutting, and starch production and the stability of plant reaction after CBB epidemic infections for several growing cycles has also been recorded for introduced and native clones, but generally the data available on other parameters regarding stability and its complexity on cassava have not been investigated in depth.

A Program for Genetic Improvement

Based on considerations of the previously described physical, biological and socio-economic parameters, a basis for genetic improvement of cassava is presented. The discussion focuses on the principles of choice of evaluation sites, evaluation methodology, and parameters of evaluation.

Evaluation Sites

The number of evaluation sites necessary in a breeding program depends upon diversity of the target area, and the breeder's ability to select in any given site for performance in a specified region. In general terms, the evaluation sites should be where soil characteristics (pH, structure, fertility) and climate (rainfall distribution, relative humidity, temperature ranges and photoperiod) are similar to these of the target area. The number of evaluation sites must necessarily be limited by what is practically and economically feasible for a program to manage.

The biological and physical stresses or constraints to production of each edapho-climatic zone are often multiple and complex. To select genotypes with the widest possible adaptation to different constraints within a region, the selection site should ideally include a wide range of stress conditions, in moderate to high levels, and with a degree of season to season repeatability.

An Evaluation Methodology

Evaluation should permit selection of genotypes with durable integrated resistance to most constraints in the target production area. On this basis, ideally, select under field conditions, where stress balance factors provide opportunity for simultaneous considerations of various factors, resulting in an integrated resistance. Artificial inoculations or special cultural practices may be useful to increase intensity or uniformity of given constraints, or even to decrease the intensity if a stress factor appears to have potential of masking all genetic differences in the material being evaluated due to its intensity.

Selection should include periodic evaluations of each constraint during the periods of the growth cycle in which it is expressed (e.g., diseases during rainy periods; insects and mites during dry periods). The durability of the resistance of selected material can be partially confirmed by continuous evaluations during several growing cycles, where planting material is produced in situ from the previous cycle.

Finally, some integrated measure of adaptation/resistance in the edapho-climatic zone is more important than the individual disease or insect evaluations. The integrated measure may be a general evaluation of plant health for the top growth, combined with root yield and quality. Including standard local and selected checks permits rational decisions about relative performance of new materials.

Parameters of Evaluation

The following parameters of evaluation have been taken into consideration in CIAT's Cassava Program. Some have been described previously (Nestel and MacIntyre, 1975).

a. Germination. Record simply by counting number of plants one month after planting.

b. Vigor. Vigor is evaluated subjectively and relative to the particular trial with reference to standard check varieties. A vigor rating is made from 3 to 5 months after planting.

c. Plant type. The evaluation of plant type is divided into three components: number of levels of branching, height of first branch, and plant height.

d. Leaf area. Leaf area index of about 3.0 has been defined as near optimum for cassava (Cock, 1976). Because measure of leaf area is impractical for evaluation of large numbers of genotypes, a simple measure of the length of stems maintaining foliage is used during early evaluation stages to give some idea of the potential of a clone for continued photosynthesis up to the end of the growing cycle.

e. Disease, insect, and mite resistance. Evaluations are based on a damage rating scale, closely related to the level of genetic resistance.

Most appropriate planting time is one which corresponds to that most commonly used by farmers in the target region. Thus, the balance of disease and pest pressure under which evaluation is done will be similar to that under commercial conditions. If the crop is commercially planted during different times of the year, the selection program should conform.

f. Yield and harvest index. A generalization under high productivity environments, select for high harvest index in early selection stages, low productivity environments, select for yield itself, along with reasonable harvest index.

g. Yield of planting materials. Stem piece (cuttings) yield and quality are important for productivity and durability of genotypes so these should be quantified during evaluation.

h. Root quality. Quality of roots may be critical to acceptability of a variety intended for human consumption. Quality is normally less critical for industrial uses.

1. Starch content and quality. Yield of the crop is appropriately expressed either as dry matter or starch production, the two being closely correlated.

2. Pre-harvest root rot. A simple measure of percentage rotted roots at harvest can distinguish varietal differences where environmental conditions permit moderate expression of root rot.

3. Post-harvest root deterioration. An evaluation procedure for physiological deterioration involves scoring 15 cm root pieces after 3 days of storage (CIAT, 1979), with a large number of replicates. The combination of physiological and microbial deterioration can be evaluated after 1 or 2 weeks of storage.

4. HCN content. A rapid picric acid determination gives a good general indication of HCN presence in the roots and is useful when many genotypes are to be evaluated.

5. Cooking quality. Taste, texture, bitterness and fiber can be evaluated subjectively after cooking.

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