CASSAVA BREEDERS' NEEDS FOR GENETIC DIVERSITY

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ABSTRACT
The needs of cassava breeders in terms of genetic diversity are focused in relation to the objectives pursued by national and regional programmes. Genetic diversity has been identified in cassava for most of the important traits. Actual and future needs should be based upon farmer, processor and consumer demands. Those demands are mainly determined by biotic and abiotic factors affecting the crop and by the way cassava is utilized. Presently, the major demands for genetic diversity in cassava are dry matter productivity, resistance to pests and diseases, adaptation to water and cold stress, and root quality for fresh or processed consumption.

INTRODUCTION
Genetic diversity represents the basis upon which genetic improvement is developed, for any crop. Such diversity arises from differential responses of the germplasm to different factors affecting the crop (Hershey and Amaya, 1983). Therefore, the efficient utilization by breeders of the crop diversity will depend on the availability of representative collections, on variation for traits of actual and future importance for the breeding programmes.and on a thorough evaluation across the most important agroclimatic conditions for the species.

Cassava is recognized as a species with wide genetic variability mainly distributed in Latin America. There is a need for basic information on standard evaluation methodology, documentation and divulgation to allow a more fluent interchange of germplasm accessions and related information among cassava breeders worldwide. The most urgent need for the breeders now is to know what is available within their working collections. The characterization and evaluation of the available genetic diversity should take into consideration not only those traits of current importance, but other specific traits, with high potential interest in relation to plant physiology and future market demand.

It is also important to have a minimum level of duplication within the working collections. This would allow the choice of parental material for recombination from a wider range of genetic diversity, avoiding the possibility of crossing among duplications or highly related genotypes.

This paper intends to discuss the needs for genetic diversity from cassava breeders, focusing on the availability of germplasm, the present detailed knowledge of it, and the principal demand by cassava breeding programmes around the world.

AVAILABLE GENETIC DIVERSITY IN CASSAVA
It is estimated that the genetic diversity in cassava is broad with a major concentration of it in Latin America and the Caribbean region. In Africa and Asia the genetic variability is narrower, considering that it originated from scattered introductions from Latin America during the last 400 years, backcrossing among them and selection by farmers. Latin America represents the center of origin for cassava and its natural reservoirs for genetic diversity, a considerable proportion of which has yet to be collected. According to Hershey (1985), what has been

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already collected and is available represents a sufficient range of genetic diversity to develop genetic improvement programmes for the major agronomic traits of importance. Within the species *M. esculenta*, genetic variability has been identified for most of the studied traits, including those of morphologic or agronomic nature, resistance to the principal, pests and diseases, and quality traits. Variation for physiological characteristics has been less frequently studied, but there are indications of a wide range of variability for traits like: reaction to changes in temperature and photoperiod and stomatal sensitivity to variations in air relative humidity (Kawano, 1983; Lozano *et al.*, 1983; Hershey, 1985).

The available genetic diversity in nature is the result of natural selection during the period of evolution, pre- and post-domestication of cassava. Adaptative selection across the wide range of climatic conditions under which cassava has been grown resulted in a broad genetic diversity of clones with specific adaptation to local conditions. This process yielded thousands of landraces, selected for adaptation to specific climatic and soil conditions, pest and diseases, as well as specific local end uses (Hershey, 1988).

The availability of a representative sample of such genetic diversity in working collections is one of the prime needs of cassava breeders to satisfy the demands from national and regional programmes. Most of the time the available genetic diversity reflects the strength of the regional and/or national programmes, like in the case of Brazil.

STUDYING THE AVAILABLE GENETIC DIVERSITY IN CASSAVA

In spite of the considerable number of accessions gathered in regional and national cassava germplasm collections, it is not known whether those collections properly represent the whole range of genetic diversity in nature. The majority of cassava germplasm collections has not been thoroughly evaluated for the available genetic diversity affecting crop development and productivity in predominant environments. Most of the time, accessions are evaluated for their yield and dry matter production potential in a single environment, which usually is not the most representative of the growing conditions for cassava at farmers' fields. In that way, the variability for other factors has not been properly evaluated, limiting an adequate knowledge of the genetic diversity available for the major factors affecting crop productivity and quality.

To characterize the amplitude of genetic diversity within cassava germplasm, there is a need for systematic evaluations across different environmental conditions, and with respect to the major biotic and abiotic factors affecting the crop to attain satisfactory expression of the genetic diversity available for breeding programmes.

Recent studies developed in Brazil by CIAT/CNPMF showed that the variability for traits such as resistance to root rots, mycoplasm and water stress, previously considered restricted, could be expressed in a wide range when the germplasm is subjected to adequate environmental pressure allowing the expression of the mentioned limiting factors. A restricted genetic diversity in terms of HCN content in the roots and root quality has been detected within Brazilian cassava germplasm collections. That could be a consequence of a restricted genetic base available in the collections for those traits or the bias produced by farmers' selection toward particular end-use preferences.

Evaluation of the available genetic diversity with respect to agronomic traits, resistance to pests and diseases; adaptation and quality under different environments, together with the information or geographic origin of accessions, is as important as the available range of variability. Limited knowledge of what is available may limit the progress made by genetic improvement programmes when compared to the predominant varieties grown by the farmers.

A proper evaluation of the genetic diversity within germplasm collections also allow to eliminate duplications and to have a better knowledge on genetic distances among non-duplicated accessions. Taking into consideration those two elements it is possible to make a more efficient use of the genetic diversity in breeding programmes involving the recombination of genotypes.

PRESENT AND FUTURE DEMANDS FOR GENETIC DIVERSITY BY CASSAVA BREEDERS

The needs for genetic diversity by cassava breeders should be based on the perceived demand by the end-users of the crop: farmers, processors and consumers. Farmers will preferably look at the crop productivity which in turn is affected by biotic and abiotic factors of the ecosystem. The industry and the consumers basically demand product quality throughout the year for processing or fresh consumption.

It is difficult to establish a pattern for the breeders' needs in terms of genetic diversity, since they change across countries or across regions within countries as a function of the principal constraints for cassava production and the transformation process that cassava is subjected to, before it is used or consumed.

Once the range of genetic diversity within cassava has been identified for the major factors affecting crop productivity and quality breeders' demands should be considered as a function of present and future needs for a genetic improvement programme. There are traits of general importance across breeding programmes, and others being more specific reflecting particular growing and/or utilization conditions.

Cassava has been relatively little explored genetically, in spite of the existing breeding programmes started as early as 1940 (Fukuda and Porto, 1991; Fukuda, 1992). General demand for genetic diversity is still centered around root yield potential, root dry matter content, precocity, yield stability and reaction to pests and diseases. Recently, there has been increasing interest in root quality, post-harvest deterioration, sprouting ability, photosynthetic and nutrient use efficiency.

The demand for specific traits is a function of the ecosystem to which the breeding programme is directed, and the end uses for the crop's product. In the first case, certain biotic and abiotic constraints characterize the target growing environments. For each region there will be one or a few forms for the utilization of cassava, either fresh human consumption, industrial processing or animal feeding.

Considering biotic constraints, there is always a need for genetic diversity for resistance to pests and diseases affecting the crop. As a consequence of the apparently restricted range of genetic diversity available, resistance to mycoplasm, root rots (mainly for Brazil), and African cassava mosaic virus (for Africa and India), seem to be the most important traits at the moment. Resistance to cassava bacterial blight is also important for breeding programmes throughout the tropics, although sources of resistance are already being identified and used by cassava breeders.

With pests, there seems to be a need for genetic diversity to develop resistance to mites, thrips, mealybugs, white fly and lacebugs, particularly for those programmes in regions where those pests severely limit cassava production.

Abiotic factors are represented by the predominant edaphoclimatic conditions in the region, and they directly affect genotypic adaptation. There is a considerable demand by cassava breeders in relation to resistance to cold weather, water stress, adaptation to acid soils and soils with excess water. For those climates with prolonged dry or cold seasons there is a need to store planting material over those periods. The ability to maintain viable planting material being strongly influenced by the genotype. Genetic diversity is also needed for lodging resistance, particularly in windy climates.

Starch quality in an important factor influencing most of the end uses of the product. For fresh consumption there is also a need to consider low levels of cyanide as well as good organoleptic characteristics of the cooked product. For processing, the content and quality of starch as well as the root flesh colour are important. There is a growing demand for genetic diversity in terms of starch quality that would allow cassava processing into modified starches and other derived products. In that sense, variability for starch granule size, capacity for agglutination and relationship between amylose and amylopectin is being screened at the moment within the most advanced breeding programmes. A successful characterization and expansion of the range of genetic diversity could incorporate cassava into new markets for end products.

Root colour preferences vary across regions, and should be taken into account not only by cassava breeders, but also by cassava curators. Yellow roots are preferred in northern Brazil and certain parts of West Africa. In the case of Brazil, they are preferred for the production of yellow 'farinha' (cassava flour) with the bonus of a higher vitamin A content.

Finally, to attend to regional preferences and the growing demand of cassava for animal feed, there is a need to look at the range of genetic diversity within the species for leaf protein content and quality.

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