OUTPUT 2
Genetic stocks and improved gene pools developed and transferred to national programs.

The overall objective of this output is to produce genetically improved cassava germplasm, by recombining selected parental genotypes and then evaluating the segregating progenies under adequate environmental conditions. Recombinant seed and/or vegetative propagules from elite clones are then shipped to our collaborators in Africa, Asia and Latin America. The activities described below may not follow the exact order used to describe them in the respective work plan. This change has been made for more logical and, hopefully, easier to understand description of the research carried out. In addition to germplasm we are also producing information and developing technologies that will make the breeding process more efficient.

Activity 2.1 Selection of progenitors based on previous cycle results and information from other outputs (i.e., resistance/tolerance, root quality traits, etc.).

Rationale

The selection of parents to build populations for future breeding work represents the core of our improvement efforts, since it will determine the genetic progress we will achieve in the future. There are two types of populations developed: open pollinated and controlled crosses. We generally employ open pollination (polycrosses) to develop populations for target ecosystems. We have consistently developed polycrosses for the sub-humid tropics, acid soil savannas, semi-arid tropics, mid-altitude and highland tropics, and sub-tropics. In the case of controlled crosses, we used them to develop progenies for specific traits, special studies or the combination of elite experimental material with local landraces that need to be improved, but they can also be used for adaptation to target ecosystems as well.

Specific Objectives

a) *To identify, a set of elite clones, based on information of evaluation trials at several locations, and new objectives defined for the project. These clones are recombined to start a new cycle of selection.*
b) *To include as progenitor, for each agro-ecological zone, at least one genotype with high-carotene, yellow roots*
c) *To base the selection of parental lines increasingly on information from the performance of their progenies (≈ general combining ability).*

Materials and Methods

Only genotypes that have been selected over 2 consecutive years in *Advanced Yield Trials* are selected to participate as parents for the following generation. Among those genotypes, we select clones with outstanding performance for the most important agronomic traits. After the analysis of variance is conducted with data across two years, those genotypes exceeding at least one standard deviation from the overall mean are considered as parents for the next generation. Sometimes we also include landraces or already released cultivars that can contribute special features to the

progenies generated. Lately, thanks to the modifications introduced to the evaluation process selection of parents is greatly affected by data of the progenies they produce (≈ general combining ability).

The information provided by pathologists, entomologists and quality specialists in relation to sources of resistance or special traits is used to select genotypes for controlled crosses. These controlled crosses are developed upon specific requests from National Programs that want their main landrace, or released varieties, crossed to genotypes with specific traits; or requests from CIAT scientists that want to pyramid genes, or develop segregating progenies for gene tagging.

As will be described below, one of the major changes introduced in the cassava breeding scheme at CIAT has been to take and record data on all progenies starting at the first evaluation stage (*Clonal Evaluation Trials*). The kind of information obtained allows a gross estimation of *general combining ability* (simply defined, it is the capacity of an individual to produce a good progeny) of parental lines employed in generating the clones included in those trials. This information is increasingly influencing the decisions of materials that will continue to be used as parents and those that will not.

Results

The parents selected for the development of gene pools targeted to specific ecosystems is presented in Table 2.1. The agronomic performance of these materials is described further down in this document. Seed will be harvested from July, 2003 through December, 2003. F1 plants will grow until the planting of the trials early in 2004. A major decision to take in the genetic improvement of crops is how to choose materials for use as parents that will produce new varieties with increased production potential and adequate adaptation to the environmental conditions under which they will be cultivated.

The principal criterion for selecting parents to date has been their performance *per se*. Unfortunately, however, good clones do not necessarily give rise to good progeny, hence the need to precisely estimate the traits that the progeny of each individual will produce. Until now, data was recorded starting at the *Preliminary Yield Trials*, which meant that no balanced information was available on ***all*** progeny produced by a given individual, but only on those that had passed the first stages of selection. The new modality implies taking data for all and each clone evaluated, whether or not it will be eventually selected. This permits the development of a solid database for selecting parents in terms of the progeny they produce (which, from the genetic viewpoint, is what really matters) and not merely based on their innate traits, as was done in the past.

During this year, the 58 genotypes listed in Table 2.1 were selected to produce a new generation of crosses. These materials had stood out for their excellent performance *per se*, and for demonstrating good levels of *general combining ability* in relation to the results observed in the respective *Clonal Evaluation Trials* (see sections *2.4.1, 2.4.2, and 2.4.3* for more detail). The agronomic performance of some of these materials *per se* is also described below. At the bottom of the table parental lines for special purpose crosses have also been listed. The seed produced from the current crossings will be harvested until December 2003.

Table 2.1. Parental lines to be used in crosses for different ecosystems, relevant for cassava production in the world.

#	General purpose crosses		
	Sub-humid tropics	**Inter-regional**	**Acid-soil savannas**
1	CG 1141-1		CM2177-2¶
2	CM 2772-3		CM 2772-3
3	CM 3306-4	CM 4919-1	CM 4574-7
4	CM 3306-19	CM 6754-8¶	CM 6438-14¶
5	CM 4919-1	SSM 1411-5	CM 6740-7
6	CM 6119-5	SM 1438-2	CM 6921-3
7	CM 7514-8	MTAI 8‡	CM 7951-5
8	CM 7514-7		SM 909-25
9	CM 6754-8¶		SM 1219-9
10	CM 4365-3		SM 1363-11
11	SM 1210-5		SM 1460-1
12	SM 1411-5		SM 1565-15
13	SM 1433-4		SM 1741-1
14	SM 1438-2		SM 2219-11
15	SM 1511-6	CM 6438-14¶	HMC-1
16	SM 1565-17	CM 6740-7	MBRA 383
17	SM 1665-2	CM 7951-5	MCOL 2737
18	SM 1669-5	SM 1219-9	MECU 64§
19	SM 1669-7	MBRA 383	MECU72§
20	MTAI 8 (Rayong 60) ‡		MPER 335§
21	MTAI 16 (Kasetsart 50) ‡		MPER 415§
#	**Specific purpose crosses**		
	Yellow roots with low HCN levels	**Resistance to white flies**	**High-altitude environments**
1	CM 489-1	MECU 72	CM 7514-7
2	CM 2772-3	CG 489-4	CM 7951-5
3	CM 3750-5	CG 489-23	SM 909-25
4	SM 1433-4	CG 489-31	SM 1219-9
5	MBRA 1A	CG 489-34	SM 1460-1
6	MCOL 1734		SM 1557-17
7	MCOL 2056		SM 1741-1
8	MCOL 2061		MBRA 383
9	MCOL 2206		MECU 72
10	MCOL 2316		
11	MCOL 2564		
12	MMAL 66		
13	MTAI 2 (Rayong 2)		

¶ Forage materials. § Resistance to white flies. ‡ Result of the CIAT-Thailand collaboration.

Planting materials were also selected from these parents to seed the *F1* in July 2002. In addition to crossing these lines they were also self-pollinated to begin an S_2 recurrent selection scheme to improve each of them for tolerance to inbreeding. The justification for this approach is given later when the description of a cassava-breeding

scheme based on the production of doubled-haploids described in Output 4.

Because project activities expanded to areas where CIAT had not previously worked intensely (e.g., Middle Magdalena River and Urabá, in Colombia), hybridizations for these areas will, this year, be conducted as follows: (1) polycrosses and crosses for the two most important cassava-producing regions (Sub-humid and Acid Soil Savannas). Similar needs exist for inter-Andean valleys that can be fulfilled by materials for the Acid Soil Savannas. (2) For new regions, for which the project had not developed specifically adapted materials, production of *interregional* crosses, combining the best five materials of the North Coast with clones adapted to the Acid Soil Savannas and vice versa. These progenies are also expected to produce germplasm with broad adaptation.

For environments affected by white flies sources carrying resistance to whitefly (MECU 64, MECU 72, MPER 335 and MPER 415) have been included. This pest has become the one true constraint to cassava cultivation in that region of Colombia. For the high-altitude tropics, crosses will be carried out within a group of clones recently identified as excellent based on their cooking quality, good acceptability to farmers, and, in some instances resistance to white flies (MECU 72).

Activity 2.2 Establishment of crossing blocks and production of recombinant seed from previously established blocks.

Rationale

Populations developed for specific ecosystems represent the basis for our cooperation with National Programs and **IITA** (International Institute of Tropical Agriculture, Ibadan, Nigeria). The development of genetic stocks is gaining importance through the years. Genetic stocks are produced based on the recombination of a set of genotypes that excel for a particular trait, and we would like to upgrade that trait beyond its natural range of variation (i.e. look for transgressive segregation in broader adaptation). Stocks developed for inheritance studies or to support molecular mapping of specific traits are constructed by the recombination of contrasting genotypes (i.e. resistance to ACMV, African Cassava Mosaic Virus). Often times our aim is to pyramid genes responsible for different sources of resistance (i.e. bacterial blight). As we shift our emphasis from applied breeding to more basic research supporting breeding (i.e. molecular marker assisted selection or MAS) genetic stocks will become even more important.

Parental population development in the future will concentrate more in targeting specific crosses between genotypes selected by NARS and complementary sources of genetic information from our genetic enhancement program or our global germplasm collection.

Specific Objectives

a) *To produce large number of seed by sexual crosses (either polycrosses or controlled) recombining desirable traits from selected parental materials, and deliver them to NARS in Africa, Asia and Latin America.*

Materials and Methods

For polycrosses we use the design developed by Wright 1965 for polycrosses in forage species. For this type of design there is a need to have a number of clones equal to a prime number minus one (i.e. 12, 16, 18, etc.). The design allows for each genotype to have the same probability of being surrounded by any other genotype of the selected group. Knowledge on flowering capacity is important in order to select a group of materials with synchronized flowering. When there are considerable differences we have to implement delayed planting and/or pruning of the earliest flowering genotypes. At harvest the seed from different plants of the same genotype are combined together and named as a half-sib family (**SM**).

For controlled crosses, we plant 10 to 20 plants depending on the flowering capacity of the genotype in question. The fruit developed from each flower has the potential to produce 3 seeds, but in average we obtain no more than 1 seed per pollination. This is due to the sensitivity of the stigma to the manipulation during pollination. Seeds from the same cross are mixed together and name as a full-sib family (**CM**). Because the number of CM families produced in the last few years has reached 10,000, we had began utilizing a new code for full-sib families (**GM**).

Results

A total of 91279 recombinant cassava seeds was produced at CIAT's Experiment Station, Palmira, during June 2001 to October 2002 (Table 2.2).

Table 2.2. Production of recombinant cassava seed at CIAT, Palmira, Valle del Cauca, Colombia, between June 2001 and October2002.

Purpose of cross	Controlled Crosses	Poli-crosses	TOTAL
Wide adaptation	3253		3253
Self pollinations	5085		5085
Yellow roots	5200		5200
Specific adaptation to:			
Sun-humid environment	9775	21434	31209
Acid soil savannas	5236	20591	25827
Mid-altitude valleys	3471	17234	20705
Total	**32020**	**59259**	**91279**

From each cross, a given number of botanical seed was obtained to initiate selection (stage *F1* in Figure 2.1). About 14000 seeds of the total produced, were planted (Table 2.3) to initiate stage *F1*. Of these, about 62% (i.e., 8500) could be transplanted, because either some seed did not germinate or the emerged plantlets were too weak to survive transplanting.

Table 2.3.Cassava seed processed for producing F1 plants for various purposes at CIAT, Palmira Valle del Cauca, Colombia, between June 2000 and August 2001.

Purpose of crosses	**Planted seed**	**Transplanted seedlings**
Sub-humid environment (A)	3971	2266
Acid soil savannas (B)	3866	2645
Mid-altitude valleys (C)	3844	2168
Para Tolima-Huila (A+C)	1063	725
Para Magdalena Medio (A+B)	1085	741
Total	**13829**	**8545**

Although the recombinant seed was produced at CIAT, the generated seedlings were transplanted to fields outside the Experiment Station and under conditions of isolation from other cassava crops. Thus, the generated *F1* plants grew and were maintained under conditions where possibilities of contamination from frogskin disease were minimized. This strategy, as can be seen in the description of results from different *Clonal Evaluation Trials*, was highly successful in virtually eliminating the incidence of this disease from the nurseries for cassava improvement at CIAT. The production of botanical seed within the CIAT Experiment Station did not represent high risk because this disease, which is probably induced by a virus, viroid or phytoplasm, is not transmitted through botanical seed.

Activity 2.3 Generation and distribution of advanced breeding materials for National Programs.

Rationale

Breeding for Asia has mainly centered on the issue of increased productivity of dry matter per hectare. Yield and root dry matter concentration have been the primary traits for selection, with almost no emphasis given to pests and diseases, or cooking quality. The results obtained in Asia for 15 years, has revealed the possibility to select for broader adaptation of genotypes. We have the case of *Rayong 60* and *Kasetsart 50* with good performance in a range of Asian countries. The production of germplasm for Asia has been moved from Thailand to Colombia due to budget constraints. However, because of the development attained by several NARS in Asia, the provision of recombinant material from Colombia can satisfy their needs. A CIAT soil scientist based in Thailand still coordinates the cassava network for Asia, but covering a broader spectrum of activities.

For Africa, our breeding efforts have been traditionally channeled through our collaboration with the International Institute of Tropical Agriculture (**IITA**) in Nigeria.

As a result extensive germplasm with Latin American "blood" has been introduced to Africa in a long introgression project financed by the International Fund for Agriculture Development (**IFAD**). The purpose of this special project was, among several others, to introgress Latin American cassava germplasm into Africa, in order to increase the genetic base of the crop in that continent, particularly for drought tolerance. This introgression process requires crosses to combine the desirable traits of Latin American germplasm, with resistance to the African Cassava Mosaic Virus (**ACMV**) disease.

Materials and Methods

The same approaches as the ones implemented for other regions of the word (polycrosses and controlled crosses) have been implemented, but a greater proportion of segregating progenies from controlled crosses is usually produced. Elite germplasm identified from the evaluations across the Asian region is periodically sent back to Colombia, to be used as a parental material in new cycles of selection.

Table 2.4. Shipments of recombinant seed produced within the project from September 2001 through September 2002.

Continents	Genotypes in-vitro	Crosses (families)	Plants (in-vitro)	Seeds in the shipment
Latin America				
In-vitro	200		15555	
Hybrid seed		130		8926
Asia				
In-vitro	635		1270	
Hybrid seed		668¶		34865
Europe + USA				
In-vitro	9		45	
Hybrid seed				
Total				
In-vitro	843		16870	
Hybrid seed		798		43791

¶ Hybrid seed from four crosses with wild relatives.

Results

A considerable fraction of the seed produced by the project has been transferred to National Programs in different regions of the world. As shown in Table 2.2, close to 91279 recombinant seeds were produced between June 2001 and October 2002 and about 50% of that seed (43,791) has been shipped to our collaborators (Table 2.4). The retirement of our cassava breeder stationed in Thailand, implied that since 1998 an increasing proportion of recombinant seed originated in CIAT-HQ. In the future, we

foresee that the flux of improved germplasm between CIAT-HQ, and the Thai breeding program will continue, and it will be through us that other National Programs will receive progenies involving the latest selections in Thailand. In November 2000, two scientists from Thailand came to CIAT to receive training in tissue culture (for recovering the shipments of *in vitro* plants) and to be exposed to the breeding scheme we are now following. Upon their return to Thailand they had been receiving several shipments of vitroplants containing the core collection of the germplasm bank. The last shipment of vitroplants from the core collection was successfully sent during 2002. Two more scientists from Thailand arrived in September 2002 to undergo further training in biotechnology.

Because of a self-imposed restriction for in-vitro shipments of cassava germplasm CIAT shipped a limited number of vitro-plants in the last two years. This restriction, however, has been gradually eliminated and therefore CIAT will increase the shipment of vitro-plants. To recover the lost time, we have produced about 8000 vitro-plants from a set of the best 31 clones available from our breeding program. Several plants from each clone have been or will be sent before the end of the year to countries in Asia, Latin America and the Caribbean and to IITA. As a result of this comprehensive on-station participatory evaluation and selection with the farmers, and NARS partners of the various countries, promising improved genotypes with desirable characteristics for end users will be identified (as has been the case in the past) under the local environmental conditions in each of the participating countries.

Activity 2.4. Selection of recombinant progenies for broad and specific adaptation within major agro-ecosystems (sub-humid; semi-arid; highland and acid soil savanna).

Rationale

Our strategy for cassava germplasm development is centered on the development of improved gene pools for specific edapho-climatic zones with importance for cassava production, as defined in Table 2.5. The most relevant ecosystems are the semi-arid and sub-humid tropics, for which we devote the majority of our efforts. The main selection activity is conducted in sites selected to represent the conditions of the target ecosystem. For every genotype that was tested in those sites, a copy was maintained at CIAT-HQ. This location is considered to be free of bacterial blight and some important viruses, and to maintain that condition, the introduction of vegetative material from other areas is restricted. In case vegetative material has to be brought to HQ, then it has to pass through quarantine, which usually takes more than a year.

Specific Objectives

a) *To modify the evaluation procedure to make it more efficient and to adapt it to the new breeding objectives.*
b) *To develop and evaluate superior germplasm adapted to particular ecosystems.*
c) *To develop genetic stocks useful for other CIAT projects.*
d) *To evaluate diallel crosses for quantitative genetics analyses.*

Materials and Methods

For each of the zones we conduct a recurrent selection program, with a progressive set of stages as described in Figure 2.1**.** As the stages progress, we give more emphasis to traits of lower heritability, because we have more planting material for each genotype, and the evaluation can be conducted in bigger plots with replications. Certain selection criteria are of general importance across ecosystem (i.e. yield potential, dry matter content), while others are specific for each ecosystem (i.e. pest and diseases).

Traditionally, the progenies generated from the crossing blocks (***F1***) were planted in screen houses and transplanted to the field after 2 months at CIAT. At 6 months after planting, 2 stakes were harvested from each plant and given a consecutive number according to the plant. One of the stakes was planted at CIAT, the other one, was planted at the main selection site (***F1C1***). Selection was conducted at harvest on individual plants at the main selection site. Planting material taken from the selected genotypes, at CIAT, was used subsequently to establish a non-replicated, 6-plant plot, both at CIAT and at the main selection site (***Clonal Evaluation*** stage). Evaluation was done using the central 3 plants. Selections were transferred to the following stage (***Preliminary Yield Trial)*** and planted in non-replicated, 20-plant plots. Evaluation was done in the central 6 plants, and selections were then passed to the ***Advanced Yield Trials*** at 1 or 2 sites, with 3 replications of 25-plant plots. Genotypes selected over 2 consecutive years at the *Advanced Yield Trial* level were considered as ***"elite genotypes"*** and incorporated in the germplasm collection and the crossing blocks. Since each year a new breeding cycle was initiated, all the stages were simultaneously being conducted in each site.

Some modifications have been already implemented. A major constraint of the traditional evaluation methodology was that the first three stages of selection (*F1C1*, *Clonal Evaluation,* and *Preliminary Yield Trial*) were based on non-replicated plots. In addition large amount of material was maintained at HQ just to have duplicates of the very few materials that would reach the status of *"elite genotype",* in each cycle. Therefore, the changes introduced will speed up the selection process, allow for the evaluation of larger number of progenies and, hopefully, will increase the efficiency of the selection process. The main changes are as follows:

1) The *F1* plants will be grown for 10 months rather than 6. At that age they can produce up to 8-10 stakes. The stakes will be sent to the proper evaluation site for the *Clonal Evaluation*. This implies that the *F1C1* stage is eliminated and that no duplicate of each genotype is necessarily maintained at CIAT-HQ.

2) The *Clonal Evaluation Trials* will be based on up to eight plants, rather that six as before. An important modification for the sub-humid environment is that most measurements at the *Clonal Evaluation Trial* will be carried out in two stages: at the normal harvest time only two plants will be harvested to measure % of dry matter. This trait varies considerably with the time of harvest or age of the plant. Therefore to estimate it correctly, the plants need to be harvested at the proper time. The remaining six plants of each plot will be harvested just prior to normal planting time (one week before). Yield potential will be estimated visually (as had been done traditionally at the *F1C1* and *Clonal Evaluations* stages) based on the volume of roots produced by the six plants or, if possible, by weighing the total production of roots. Few other traits will also be taken using visual scores: plant

architecture, foliar health (for insects and diseases separately), above ground biomass (for an estimate of harvest index), and root aspect. A selection index software will be used to make an efficient and fast selection of the approximately 1000-2000 genotypes evaluated at this stage, for each ecosystem.

Table 2.5. Main ecosystems for cassava production, representative production regions, and main breeding sites.

Description	Representative Countries / Regions	Evaluation Sites
Sub-humid tropics (rainfall: 800- 1500 mm /year, bimodal rainfall distribution)	Colombia (Atlantic Coast & Santanderes); NE. Brazil; NE. Thailand; Dominican Republic, Haiti; N. and W. Venezuela; Mexico (Yucatan Peninsula); subhumid belt of Africa.	Caracolí Santo Tomás Betulia Barrancabermeja
Acid soil savannas (rainfall: 1500 – 3000 mm/year, short dry period, low pH)	Plains of Colombia & Venezuela; Brazil (Cerrado); Mexico (Tabasco); Cuba; W. African savannas; Philippines; Panama (Ocu)	La Libertad Matazul Sder de Quilichao Barrancabermeja
Humid tropical lowlands (rainfall: above 3000 mm/year, no clear dry period)	Amazon basin (Brazil, Colombia, Peru); W. Java & Sumatra; Malaysia; S. Vietnam; Equatorial West Africa	La Libertad Putumayo
Mid-altitude tropics (800-1400 masl)	Andean zone; central Brazilian highlands; mid-altitude areas of Nigeria, Cameroon, East Africa	Palmira Sder de Quilichao Barrancabermeja Tolima-Huila
High-altitude tropics (1400-2000 masl)	Andean zone; Rwanda; Burundi	Popayán Mondomo Armenia
Subtropics (latitudes higher than the tropics)	S Brazil; Argentina; China; N Vietnam; Cuba; Paraguay; S Africa	Sta Catarina (Brazil)
Semiarid (rainfall: below 800 mm/year, unimodal)	NE Brazil; NE Colombia; (Guajira) semiarid belt of West Africa; Tanzania; Mozambique; Ecuador (Coast)	Guajira Santo Tomas NE Brazil Huila

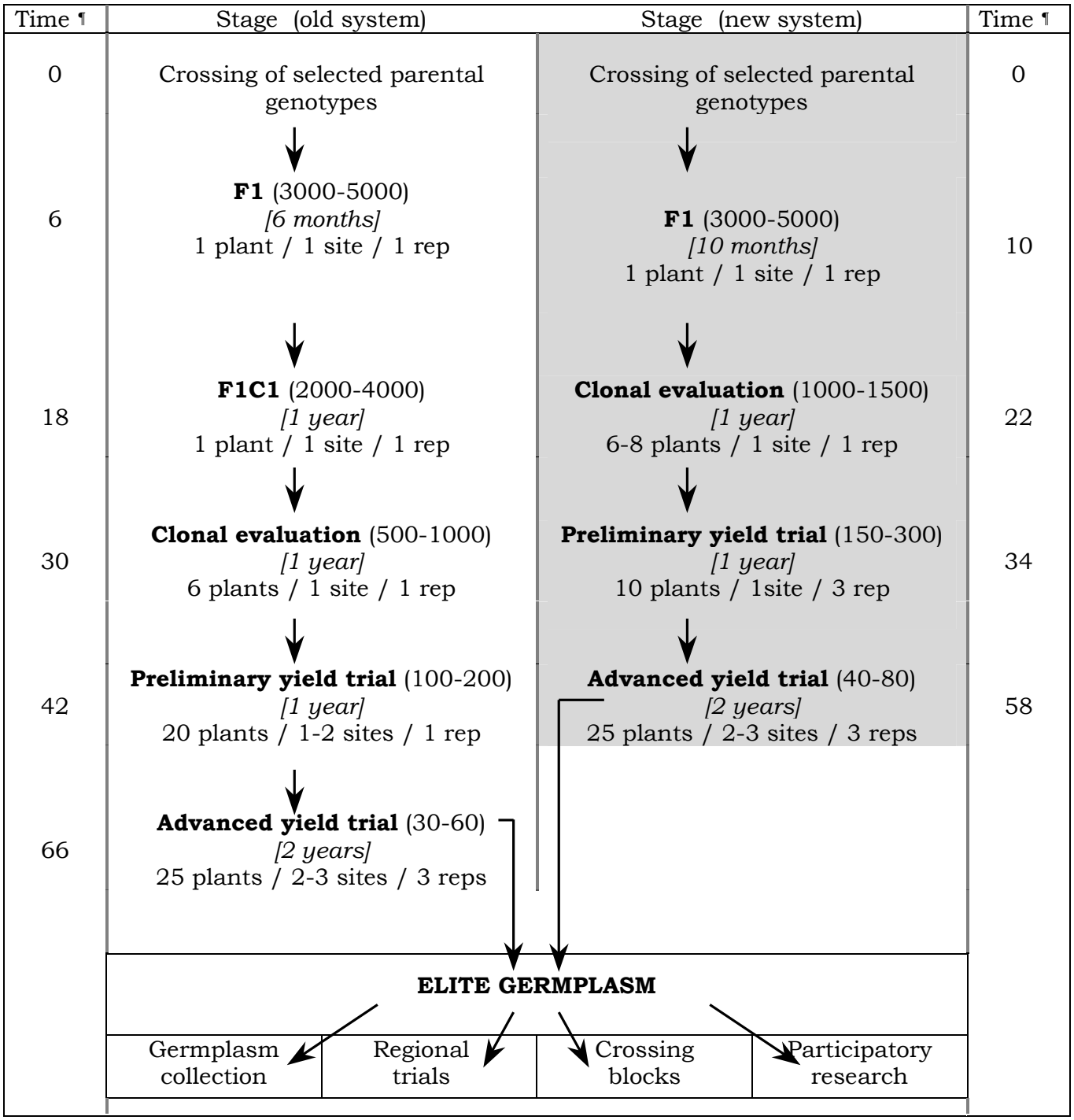
masl; meters above sea level

3) The changes described above allow taking stakes from no less than six plants (except for those cases were stakes did not germinate or plants died), rather than three, as in the past. These six plants will produce more than 30 cuttings, which will be used for the first replicated trial based on three replications and two row plots with ten plants per plot. It is recognized that this evaluation will result in some competition effect among neighboring plots. However, it is hoped that the number of replications will neutralize most of these effects. Also, row spacing between plots can be increased and the plant-to-plant distance within the plot reduced. This will maintain the density unchanged, while favoring competition among plants from the same genotype.

4) A final important modification to the evaluation process is that data will be taken and analyzed for **all** the progenies evaluated. In the past, data was taken only for those families that went beyond the *Clonal Evaluation* stage. Therefore it was difficult to estimate *combining ability* of parental materials, because most of the crosses did not produce data (they had been discarded in the field before any data was taken). The changes introduced will allow us, in the future, to base the selection of the parental materials on its breeding value (*general combining ability*) rather that its performance *per se*, or empirical appreciation of their potential as progenitor.

The main advantages of the new evaluation scheme can be summarized as follows:

- The duplication of materials maintained at CIAT-HQ is avoided until they reach status of "elite genotype".
- The selection of large number of segregating progenies, at the *F1C1* stage, which was based on single plant observations, is avoided.
- The time required to reach the stage of replicated trials is minimized.
- The total length of each cycle of selection is reduced by almost a year.
- Data records will allow for selecting parental material based on *general combining ability*.
- The total cost for each cycle of selection should be reduced.
- Selection will be less subjective by using appropriate software (specifically developed for that purpose).
- For environments with rains concentrated in one season, there is a possibility of selecting clones able to maintain high dry matter upon the arrival of the rains.



¶ Time in months after germination of botanical seed.

Figure 2.1. Basic cassava breeding schemes applied for each of the priority ecosystems. On the right is the new scheme currently under implementation (shaded area). Later stages of selection are made following the old system (shaded area on left).

Preparing new F1 field
About 12,000 recombinant, botanical seeds were germinated early in 2002, and approximately 8,500 of the resulting plantlets were transplanted at the Colombian Centro de Investigación de la Caña de Azucar (CENICAÑA). This material represents the *F1* stage described in Figure 2.1.

Basic description of the selection index used for ranking the segregating clones in different types of trials.

Below, results for each agroecological area are presented, together with results of the best genotypes according to a ***selection index***. This index is a tool for genetically improving crops, and integrates, into a single value, information on various relevant traits. In most cases, the index was estimated according to the following formula:

Selection index = [FRY ∗ 10] + [DMC ∗ 8] - [PT ∗ 3] + [HI ∗ 5]

where,
FRY = fresh root yield
DMC = dry matter content
PT = plant type using a 1(excellent) to 5 (very poor) visual scale
HI = harvest index

In this formula, the weighting of each variable is evident**.** ***Fresh root yield*** is multiplied by 10 to maximize the influence of this trait on the end-result. ***Dry matter content*** is multiplied by 8, also to increase its relevance in the selection process. This is important because roots with high dry matter content can be dried more quickly, or else, starch extraction made significantly easier. In both cases, processing costs are reduced.

Plant type integrates several important aspects for cassava: (1) plant health, inasmuch as a plant with a lot of foliage is not likely to have been severely attacked by leaf diseases and pests (at least, not during evaluation); (2) photosynthesis was functioning up to evaluation time; and (3) general plant architecture, as on this depends the quantity of vegetative seed (stakes) produced and the ease with which the farmer can care for the crop. Because a 1 to 5 score is used (where 1=excellent and 5=very poor plant type), the formula uses a negative term for this trait.

Finally, the ***harvest index*** estimates how much of the plant biomass represents the product with economic value. For now, the index is estimated in terms of the ratio of root production to the plant's total biomass.

A technical clarification: these indexes are severely affected by the unit by which each trait is measured, for example, dry matter content, which fluctuates around 35.0%, would have a much greater effect than does the harvest index, which fluctuates between 0 and 1. To avoid this problem, each variable is converted into what are statistically known as *standardized values*, which obviate the issue of units.

The most relevant results obtained in six major cassava-producing regions of

Colombia during the cycle that finished with harvests during March to May, 2002 are summarized below.

Diallel mating designs were used as part of the Clonal Evaluation stage at each environment.

An important aspect of the hybridization strategies executed during the last two years were the production and planting of recombinant seed following an scheme of diallel crosses. Therefore, not only did we produce a group of progenies with such high potential that some will hopefully surpass the agronomic performance so far reached, but also we could begin a genetic study without precedent for cassava. These diallel trials were harvested during the first semester of 2002 and produced information essential for understanding the mode of inheritance of traits with agronomic relevance. Two Ph.D. students: a woman from Vietnam and a man from Uganda are using this data for their respective dissertations.

The diallel trials for the North Coast (Table 2.6), Acid Soil Savannas (Table 2.7) and inter-Andean valleys (Table 2.8) were recently harvested. As a result, the *Clonal Evaluation* stage for March-May 2001 to March-May 2002 for the three environments has been represented by these relevant studies.

Table 2.6. Parents involved in the diallel experiment for the sub-humid environment of the North Coast of Colombia. The code assigned to each cross is above the diagonal¶.

Parental Clones	CM 6754-8	CM 8027-3	SM 805-15	SM 1565-17	SM 1411- 5	SM 1219-9	SM 1657-12	SM 1665-2
Rayong 60	CM 9106	CM 9148	CM 9178	CM 9966	CM 9958	GM 266	GM 289	GM 291
CM 6754-8		CM 9921	CM 9945	CM 9907	CM 9954	GM 236	GM 237	GM 238
CM 8027-3			CM 9703	CM 9926	CM 9923	GM 246	GM 247	GM 248
SM 805-15				CM 9949	CM 9946	GM 250	GM 251	GM 252
SM1565-17					CM 9957	CM 9952	GM 280	GM 281
SM 1411-5						GM 255	GM 272	GM 273
SM 1219-9							GM 258	GM 259
SM 1657-12								GM 287

¶ Only 30 plants were used to represent each F1 cross in the diallel study. Remaining plants from each cross were planted in an ordinary *Clonal Evaluation Trial.*

For scientific validity, a singular planting was carried out: from each crossing, 30 of the best F1 plants grown in CENICAÑA were selected to obtain at least eight stakes of excellent quality. Six of those stakes were used to plant the trials and the others were planted in nurseries to serve as seed source. The six stakes for the trials were distributed in three replicates located at two representative sites. Every F1 (with a few exceptions) from the diallel cross experiment were made up of 30 genetically different individuals conforming a full-sib family (both parents known and in common). Each individual was represented in the trials by six plants, as mentioned above. Many of these families can provide the basis for molecular marker studies that will facilitate future work on cassava genetic improvement. It should be pointed out that in addition

of the30 individual clones from each F1 cross, sister clones could also be found in the *Clonal Evaluation Trials*.

Table 2.7. Parents involved in the diallel experiment for the acid-soil savannas in the Eastern plains of Colombia. The code assigned to each cross is above the diagonal ¶.

Parental Clones	MTAI-8 Rayong 60	CM 7033-3	CM 4574-7	CM 6740-7	MPER-183	SM 1219-9	SM 1565-15	SM 2058-2	SM 2219-11
HMC-1	CM 8035	GM 244	GM 224	GM 234	CM 9733	GM 264	GM 277	GM 299	GM 303
MTAI-8		CM 9127	GM 226	GM 235	GM 307	GM 266	GM 279	GM 301	GM 305
CM 7033-3			GM 219	GM 227	GM 245	GM 240	-.-	GM 241	GM 243
CM 4574-7				CM 9460	GM 225	GM 220	GM 221	GM 222	GM 223
CM 6740-7					CM 9642	CM 9901	GM 229	GM 232	GM 233
MPER-183						GM 265	GM 278	GM 300	GM 304
SM 1219-9							GM 256	GM 261	GM 263
SM 1565-15								GM 275	GM 276
SM 2058- 2									GM 298

¶ Only 30 plants were used to represent each F1 cross in the diallel study. Remaining plants from each cross were planted in an ordinary *Clonal Evaluation Trial*.

Table 2.8. Parents involved in the diallel experiment for the mid-altitude valleys of Colombia. The code assigned to each cross is above the diagonal ¶.

Parental Clones	SM 1219-9	SM 1741-1	SM 1278-2	SM 1636-24	SM 1673-10	HMC-1	MPER-183	MECU-72
CM 6740-7	CM 9901	CM 9903	GM 228	GM 230	GM 231	GM 234	CM 9642	GM 308
SM 1219-9		CM 9953	GM 254	GM 257	GM 260	GM 264	GM 265	GM 309
SM 1741-1			GM 269	GM 284	GM 292	GM 296	GM 297	GM 313
SM 1278-2				GM 267	GM 268	GM 270	GM 271	GM 310
SM 1636-24					GM 283	GM 285	GM 286	GM 311
SM 1673-10						GM 293	GM 294	GM 312
HMC-1							CM 9733	GM 314
MPER-183								GM 306

¶ Only 30 plants were used to represent each F1 cross in the diallel study. Remaining plants from each cross were planted in an ordinary *Clonal Evaluation Trial*.

2.4.1. Selections for the Sub-Humid Tropical Environment

For logistic reasons, improvement activities developed for several regions of the Northern Coast of Colombia were centralized initially in Barranquilla. Many of the materials evaluated there can then be transferred to the more humid region in the Departments of Córdoba and Sucre, and to the Middle Magdalena (Department of Santander). The results for this eco-region are described in Tables 2.9 to 2.24 Table 2.9 lists all trials, whereas the other tables show results specific to each one.

Table 2.9. Trials conducted in the sub-humid ecosystem (North Coast of Colombia) in the 2000-2001 cycle¶.

Trial	Site	N° of genotypes	N° of reps	**Observations**
F1	CIAT-Palmira	2267 (1)	1	Plants are left growing in the field for 10 months.
Clonal Evaluation	S. Tomás	1350 (8)	1	See Table 2.11 to 2.13
Diallel Trial	Pitalito	1080 (1)	3	Planted again this cycle
Diallel Trials	S. Tomás Pitalito	1080 (1) 1080 (1)	3 3	See Table 2.14
Preliminary Yield Trial	Pitalito	225 (10)	3	See Tables 2.18 to 2.20
Advanced Yield Trial	Santo Tomás	88 (25)	3	Eliminated by poor germination originated back in a 1999 flood.
Regional Trials §	Sub-humid Humid Urabá	40 (25) 40 (25) 40 (25)	3 x 4 3 x 4 3 x 3	See Table 2.21 (four locations) See Table 2.22 (four locations) See Table 2.23 (three locations)

¶ Values in parentheses refer to the number of plants per plot. § A total of 11 locations were involved in the Regional Trials

A total of 2267 of seedlings from botanical seeds (targeting this environment) were transplanted at CENICAÑA in an isolated field surrounded by sugar cane. Several more seeds had been put to germinate but many did not germinate or died soon after. The planting of the *F1* stage is isolated to reduce as much as possible infection by diseases that can be found at later stages of the evaluation process. Seedlings from botanical seed are considered to be disease-free and efforts are made to maintain this condition for as long as it can possibly be done. Table 2.10 describes the families for the *Clonal Evaluation Trial* that will be planted in 2003, their progenitors and the number of clones representing each family.

A summary of the results from the *Clonal Evaluation Trial* for the Sub-Humid environment harvested this year is presented in Table 2.11. The effect of harvesting time is apparent from the last two columns of that Table. In the March harvest, conducted during the middle of the dry period, dry matter content averaged 32.40% across the whole experiment. After the rains began in May, cassava showed a typical decrease in dry matter content with an average of 29.57%.

Table 2.10. Families, progenitors and number of genotypes representing each family planted as F1 in CENICAÑA for the Sub-humid environment. The specific male progenitor of SM families is not known but pollen came from a group of selected clones.

	Family	Mother	Father	# clones		Family	Mother	Father	# clones
1	CM 9775	CM 7514-7	MNGA 19	61	26	SM 2828	CM 7389-9	Unknown	55
2	CM 9791	SM 1433-4	MNGA 19	63	27	SM 2829	CM 7395-5	Unknown	43
3	CM 9794	SM 1438-2	MNGA 19	58	28	SM 2832	SM 805-15	Unknown	39
4	CM 9797	SM 1511-6	MNGA 19	41	29	SM 2834	SM 1411-5	Unknown	41
5	CM 9912	CM 7514-8	SM 1433-4	64	30	SM 2835	SM 1431-2	Unknown	35
6	CT 54	R 5	KU 50	32	31	SM 2836	SM 1433-4	Unknown	33
7	CT 57	R 60	KU 50	32	32	SM 2839	SM 1565-17	Unknown	39
8	CT 59	R 90	R 60	76	33	SM 2882	CM 3372-4	Unknown	54
9	GM 281	SM 1665-2	SM 1565-17	48	34	SM 2947	CM 6754-8	Unknown	49
10	GM 288	SM 1657-12	SM 2192-6	23	35	SM 2948	CM 8027-3	Unknown	50
11	SM 2546	SM 890-9	Unknown	76	36	SM 2949	SM 805-15	Unknown	35
12	SM 2547	SM 1068-10	Unknown	70	37	SM 2951	SM 1433-4	Unknown	38
13	SM 2612	SM 1600-4	Unknown	61	38	SM 2952	SM 1438-2	Unknown	52
14	SM 2615	CM 4365-3	Unknown	42	39	SM 2954	SM 1521-10	Unknown	43
15	SM 2618	CM 7389-9	Unknown	51	40	SM 2955	SM 1565-17	Unknown	22
16	SM 2620	CM 7514-8	Unknown	55	41	SM 2956	SM 1619-3	Unknown	29
17	SM 2621	SM 643-17	Unknown	35	42	SM 2957	SM 1657-12	Unknown	33
18	SM 2626	SM 1201-5	Unknown	37	43	SM 2958	SM 1657-14	Unknown	21
19	SM 2629	SM 1422-4	Unknown	59	44	SM 2959	SM 1665-2	Unknown	11
20	SM 2667	CM 6438-14	Unknown	54	45	SM 2960	SM 1754-21	Unknown	29
21	SM 2733	SM 1210-10	Unknown	51	46	SM 2962	SM 2192-6	Unknown	31
22	SM 2773	SM 737-38	Unknown	86	47	SM 2963	MTAI 8	Unknown	40
23	SM 2777	SM 1210-10	Unknown	50	48	SM 2964	MVEN 25	Unknown	53
24	SM 2779	SM 1411-5	Unknown	58	49	SM 2982	CM 2772-3	Unknown	28
25	SM 2783	SM 1511-6	Unknown	47	50	SM 3000	CG 1141-1	Unknown	34

Table 2.11. Results of the selection carried out in the *Clonal Evaluation Trial* at Santo Tomás, Department of Atlántico, from 1967 clones evaluated during May 2001 to May 2002.

Parameter or	Yield (t/ha)		Harvest Index	Plant type	Dry matter content (%)	
Genotye	Fresh roots	Dry matter	(0 to 1) ¶	(1 to 5) §	March	May
Results from the 1967 clones evaluated						
Maximum	68.58	19.58	0.86	5.00	42.07	38.25
Minimum	0.00	0.00	0.15	1.00	16.39	16.30
Mean	23.89	6.89	0.57	2.77	30.92	27.72
Std. Dev.	9.27	2.74	0.10	0.93	3.39	3.64
Results from the 277 clones selected						
Maximum	68.58	19.58	0.86	4.00	40.24	38.25
Minimum	12.63	3.63	0.40	1.00	21.64	19.24
Mean	35.22	11.02	0.62	2.39	32.40	29.57
Std. Dev.	7.81	2.20	0.08	0.69	2.71	2.79
Best 10 clones selected across the entire Clonal Evaluation Trial						
GM 290-9	52.47	16.72	0.70	3	33.3	29.3
CM 9907-80	68.58	19.58	0.63	2	29.1	27.1
CM 9907-38	50.98	14.82	0.71	2	30.6	26.0
CM 9907-41	39.32	12.34	0.86	1	32.0	29.8
CM 9958-40	38.39	13.04	0.67	2	34.9	31.9
CM 9966-45	37.44	10.81	0.73	1	29.3	28.1
GM 290-54	47.60	14.86	0.56	2	31.8	29.9
CM 9957-75	30.33	10.52	0.85	2	35.3	33.2
GM 259-69	39.87	12.64	0.62	2	30.4	34.1
GM 236-40	39.03	11.75	0.65	2	31.1	28.2

¶ The harvest index is obtained by dividing the production of commercial roots by total biomass (roots + aerial parts). Preferred harvest indexes are > 0.5.

§ Plant type integrates under one value, plant architecture, leaves health, and capacity to produce stakes on a scale where 1 = excellent and 5 = very poor is used.

Selection of the 277 clones that passed to the next stage of evaluation was based on the **Selection Index** described above. The superiority of the selected fraction is apparent. Mean fresh root production was 35.22 t/ha in the selected fraction against 23.89 from the entire population. Converted to dry matter productivity these figures were 11.02 and 6.89 t/ha, respectively. Likewise, the average harvest index was considerably higher in the selected fraction (0.62) than in the whole trial (0.57). Finally dry matter content was about 2% higher in the selected fraction than in the total of clones evaluated, regardless of the harvesting time. The contributions of the Ministry of Agriculture and Rural Development of Colombia and of the Fondo Nacional Avícola (FONAV) of the Federación Nacional de Avicultores de Colombia (FENAVI) have been fundamental to the project's significant growth, enabling the project to now identify, with more certainty, outstanding germplasm.

Plant type was evaluated twice, when the two harvestings took place. Table 2.11 presents only the result of the first evaluation date for this trait. There was an excellent phenotypic correlation (ρ=0.628) between the two measurements. Also dry

matter content measured in March and in May showed good positive correlation (ρ=0.706). The two measurements of harvest index showed the highest correlation coefficient (ρ=0.740). Finally, fresh root yield showed the lowest correlation (ρ=0.533), although this value is considered to be quite acceptable for a complex trait such as yield.

Worth mentioning is the fact that three out of the ten best clones came from the same family (CM 9907). This situation is adequate to illustrate a weakness of the current scheme. Because of logistical reasons, planting the different clones from the same family together, one after the other, greatly facilitates the planting operations, which is quite cumbersome given the size of the experiment. Proceeding this way, however, creates an undesirable confounding effects because all the clones from a given family are grouped together in the same part of the field. It is possible, therefore, that family CM 9907 was favored by being located in the best part of the field. Since the average of each family's performance is used to get indications of the *general combining ability* of their progenitors, it is convenient to avoid planting all the clones from a given family together but, split in three more or less equal-sized groups. In this way, the *Clonal Evaluation Trial* will be divided into the equivalent of three replications. Since the selection is based on individual clones, this procedure may not help in the selection process. However, the average of each family (as shown below in Table 2.12) will certainly be more precise by dividing the family in the three proposed groups.

Table 2.12 shows the average for each of the 52 families planted in the *Clonal Evaluation Trial* harvested in May 2002. The total number of clones making up the family and the proportion that was selected is also provided. All this information is very valuable for identifying progenitors that tend to produce better (or worse) progenies. Family CM 9923 was made up of 34 clones, and 24 of them were selected (70.6%). About 14% of the clones were selected in the whole trial (277 out of 1967). Therefore, a family that showed such a high degree of success is quite remarkable.

Several families (CM 9703, GM210, GM 237, GM 280, and GM 281) were represented by several clones, of which none was selected. This suggests that for one reason or another, these families were genetically inferior to the rest of the families, and therefore, that the parents that originated them lacked enough positive genetic attributes. On the other hand, in addition to the already mentioned CM 9923, families GM 290 and CM 9946, showed excellent performances. Moreover, the information presented in Table 2.12 allows making some inference about the reasons for the general performance of a given family. For instance, CM 9954 had the best average for plant type (1.57) and CM 9945 the worst (3.46). Family GM 237 had an even worse average for plant type (4.75) but it was represented only by two clones. Harvest indexes in some families were adequate (GM291, GM 248 and CM 9926), while in others was undesirably low (GM237, GM 216, and GM 212).

Dry matter content is a variable of great economic relevance in this region. Families CM 9921 and GM 212 presented an average of 31.8%, followed by GM 218 and CM 9923 with 31.2%. In contrast, GM 237, GM 281, and GM 280 had a average of low dry matter content in the roots. The most important trait (root productivity) showed sharp contrasts. Families CM 9923, CM 9926 and GM 290 produced more that 30 t/ha of fresh roots. On the other hand, families GM 237, GM 280, and GM 290 produced less than 15 t/ha.

Table 2.12. Results from the *Clonal Evaluation Trial* (Santo Tomás, Atlántico), of 1967 genotypes. The averages of each of the 52 families, number of clones representing them and proportion of selected clones is presented.

Family	# clones	% select. Clones	% Fol. Ret.	Yield		% DM	Plant Type (1-5)	HI (0-1) ¶	SI §	Family	# clones	% select. Clones	% Fol. Ret.	Yield		% DM	Plant Type (1-5)	HI (0-1) ¶	SI §
				Fresh (t/ha)	DM (t/ha)									Fresh (t/ha)	DM (t/ha)				
CM 8209	70	11.0	8.6	22.2	6.59	29.8	2.69	0.51	-3.0	GM 236	36	11.0	30.6	24.2	7.05	29.6	2.65	0.65	5.9
CM 9106	5	20.0	40.0	21.4	6.14	28.0	2.90	0.65	-2.2	GM 237	2	0.0	0.0	3.4	1.07	21.1	4.75	0.36	-61.9
CM 9148	31	3.0	9.7	20.8	6.11	28.9	3.24	0.53	-9.0	GM 238	52	17.3	23.1	30.0	8.16	28.1	3.21	0.66	5.3
CM 9178	40	4.9	27.5	20.8	5.97	28.9	3.01	0.57	-5.6	GM 239	16	37.5	50.0	28.0	8.58	31.1	2.34	0.57	11.3
CM 9703	18	0.0	11.1	21.4	6.13	29.6	3.03	0.56	-4.2	GM 246	42	14.3	16.7	25.5	7.48	29.9	2.61	0.61	6.3
CM 9907	50	28.0	18.0	28.4	8.05	28.9	2.58	0.64	9.1	GM 247	16	37.5	37.5	22.2	6.62	29.6	2.81	0.67	3.2
CM 9921	15	40.0	33.3	26.5	8.28	31.8	3.03	0.65	9.76	GM 248	27	18.5	25.9	23.6	6.75	28.3	2.91	0.69	2.5
CM 9923	34	70.6	17.3	32.2	9.93	31.2	2.03	0.59	19.2	GM 249	43	16.8	46.5	22.1	6.89	30.7	2.81	0.54	-0.5
CM 9926	21	19.0	19.1	30.9	8.61	28.5	3.00	0.67	9.2	GM 250	29	10.3	10.3	25.7	7.45	29.6	2.78	0.58	3.2
CM 9945	25	4.0	28.0	19.7	5.74	29.5	3.46	0.64	-5.4	GM 252	21	4.8	19.5	21.9	6.02	27.4	3.12	0.63	-5.7
CM 9946	8	42.9	37.5	23.1	7.24	30.8	2.31	0.54	4.5	GM 253	57	3.5	52.6	22.0	6.71	30.2	2.90	0.56	-1.4
CM 9949	35	11.0	28.6	22.6	6.38	28.4	2.71	0.54	-4.1	GM 255	31	9.7	0.0	24.8	6.87	28.1	2.77	0.52	-3.6
CM 9952	41	17.0	7.3	29.7	7.80	26.3	2.88	0.64	3.7	GM 258	29	17.2	44.8	24.9	7.21	29.6	2.97	0.60	1.8
CM 9954	15	6.7	26.7	25.5	7.15	28.7	1.57	0.51	6.66	GM 259	55	21.8	1.8	26.7	7.44	27.7	2.70	0.63	3.4
CM 9957	47	23.4	6.4	26.3	7.95	30.8	2.59	0.58	10.0	GM 262	62	16.4	53.2	24.6	6.89	28.3	2.62	0.59	0.7
CM 9958	59	35.6	22.0	27.0	8.09	30.6	2.28	0.58	9.95	GM 266	61	6.6	32.8	23.4	6.56	28.3	2.75	0.58	-1.5
CM 9966	44	16.0	22.7	26.1	7.42	28.6	2.69	0.59	2.3	GM 273	28	17.9	0.0	26.6	7.74	29.6	2.75	0.62	6.2
GM 210	15	0.0	20.0	18.2	5.51	30.1	3.13	0.51	-9.67	GM 274	16	12.5	50.0	27.0	7.99	30.3	2.69	0.55	5.2
GM 211	71	11.3	18.3	20.7	6.42	31.0	2.87	0.52	-3.1	GM 280	9	0.0	0.0	9.31	2.53	25.3	3.33	0.57	-27.3
GM 212	56	1.8	16.1	20.4	6.39	31.8	3.05	0.48	-4.7	GM 281	39	0.0	18.0	14.0	3.30	23.0	3.04	0.62	-22.7
GM 213	79	7.6	1.3	20.7	5.89	28.4	2.51	0.51	-5.7	GM 282	76	2.6	56.6	19.4	5.11	27.2	2.82	0.59	-8.4
GM 214	67	12.0	0.0	21.3	6.51	31.1	2.63	0.51	-0.71	GM 287	24	8.3	29.2	24.3	6.47	27.4	3.08	0.63	-2.5
GM 215	37	5.4	10.8	20.6	5.81	28.6	2.82	0.54	-6.62	GM 288	46	26.0	32.6	27.4	8.04	29.5	2.63	0.58	6.1
GM 216	29	3.4	27.6	17.0	5.09	26.1	2.53	0.42	-18.8	GM 290	66	44.0	40.9	32.7	9.22	29.0	2.77	0.65	12.8
GM 217	57	8.8	5.3	20.4	5.54	27.9	2.75	0.57	-6.5	GM 291	31	12.9	12.9	26.7	7.12	26.6	2.95	0.70	2.4
GM 218	30	6.7	63.3	21.8	6.72	31.2	2.93	0.52	-1.8	GM 302	53	26.4	24.4	27.4	8.01	29.2	2.75	0.56	3.4

¶ HI = **Harvest Index** (Root production / total biomass).

§ SI = **Selection Index** (combines several variables of economic relevance)

The reason for selecting 277 clones has a justification. The next phase of selection will include 300 clones, which will be evaluated in three separate trials of 100 genotypes each. The 23 additional clones (300-277= 23) will be included to carry out an experiment to compare three different selection procedures:

a) A group of 21 clones with the best selection index.
b) A group of 21 clones with the highest root yield.
c) A group of 21 clones with the highest harvest index.

The best 21 clones (based on selection index) are, obviously among the 277 selected clones because that was precisely the selection criteria utilized. However, few clones (14 to be precise) where among the best 21 clones for yield or harvest index, but had not been selected by the selection index. These clones were included, therefore, to make this comparison possible. Table 2.13 presents the characteristics of the three groups that will be used for the contrasts of selection criteria. It should be pointed out that two or more of the groups shared some clones. Nine additional clones will be used as check, making up the total of 300 clones (277+14+9=300).

Table 2.13. Results of the selection from the *Clonal Evaluation Trials* (Santo Tomás, Atlántico), using three different criteria.

Parameters	Yield (t/ha)		Dr matter (%)	Plant type (1 a 5)	Harvest index (0 a 1)
	Fresh roots	Dry matter			
Statistics of the best 21 clones for Harvest Index					
Maximum	40.1	12.2	34.3	4.50	0.86
Minimum	11.5	2.3	18.8	1.00	0.62
Mean	26.22	6.97	26.75	3.43	0.77
St. Dev.	8.38	2.70	3.81	0.94	0.05
Statistics of the best 21 clones for Yield					
Maximum	68.6	19.6	32.8	4.00	0.79
Minimum	39.4	9.8	20.4	1.00	0.53
Mean	49.76	13.58	27.94	2.38	0.68
St. Dev.	6.72	2.46	3.24	0.74	0.06
Statistics of the best 21 clones for Selection Index					
Maximum	68.6	19.6	34.8	4.00	0.75
Minimum	31.6	10.7	27.7	1.00	0.54
Mean	46.01	14.13	31.40	1.81	0.66
St. Dev.	8.57	2.03	2.19	0.73	0.06

Table 2.14. Results of the diallel trials conducted in Pitalito y Santo Tomás (Atlántico). Each F1 cross was composed by 30 clones. Three replications per location were used.

Cross	Trips (1 - 5)	Stakes/pl. (Number)	Fresh roots (t/ha)	Harvest index (0 - 1)	Dry matter (%)	Plant Type (1 - 5)	Root Type (1 - 5)
1x2	3.03	8.98	34.93	0.54	27.45	3.18	2.89
1x3	2.70	10.58	26.51	0.43	29.47	2.97	3.21
1x4	2.27	11.23	31.45	0.45	28.78	2.95	2.92
1x5	1.63	11.87	42.29	0.57	26.45	2.66	2.78
1x6	1.75	12.29	36.51	0.47	29.10	2.64	3.01
1x7	1.91	12.13	42.35	0.55	28.14	2.71	2.82
1x8	2.72	8.68	38.14	0.55	26.27	3.35	3.18
1x9	2.93	10.55	45.68	0.56	27.00	3.11	2.79
2x3	2.40	9.26	32.82	0.54	29.05	2.84	2.86
2x4	2.63	9.88	27.69	0.47	27.05	3.13	3.18
2x5	2.04	11.66	35.48	0.55	26.64	2.59	2.97
2x6	2.23	10.67	37.98	0.53	28.26	2.80	2.78
2x7	2.28	11.40	34.76	0.52	27.64	2.68	2.94
2x8	2.86	9.08	31.63	0.52	28.19	3.29	3.11
2x9	2.68	9.38	36.25	0.52	28.12	2.99	2.85
3x4	2.47	10.50	34.22	0.49	28.57	2.82	2.94
3x5	1.65	9.87	40.99	0.59	27.07	3.00	2.84
3x6	2.22	11.47	38.90	0.49	29.23	2.57	2.92
3x7	1.95	11.24	39.37	0.54	28.59	2.76	2.89
3x8	2.61	11.05	34.77	0.49	28.36	3.00	3.08
3x9	2.59	9.49	41.16	0.59	27.74	2.99	2.94
4x5	2.04	9.40	37.29	0.56	25.29	3.23	3.09
4x6	2.21	10.88	35.59	0.51	28.38	2.74	2.95
4x7	1.73	11.20	34.01	0.46	27.93	2.97	3.15
4x8	3.12	8.44	35.53	0.53	27.74	3.45	3.10
4x9	2.93	9.27	31.49	0.51	27.20	2.99	3.20
5x6	1.64	11.95	40.98	0.52	28.00	2.69	2.83
5x7	1.36	12.38	42.59	0.54	25.66	2.71	2.98
5x8	1.97	9.48	35.96	0.57	26.81	3.19	3.02
5x9	1.94	11.32	40.65	0.58	24.74	2.82	2.90
6x7	1.76	12.76	37.49	0.46	28.07	2.76	3.01
6x8	2.44	11.11	38.58	0.51	27.93	2.82	3.08
6x9	2.29	10.62	41.28	0.56	28.40	2.51	2.74
7x8	1.94	11.48	42.87	0.54	26.36	2.74	2.79
7x9	1.58	10.64	39.48	0.52	27.98	2.69	2.99
8x9	2.57	10.25	42.70	0.55	26.89	3.04	2.83
Max.	3.12	12.76	45.68	0.59	29.47	3.45	3.21
Min.	1.36	8.44	26.51	0.43	24.74	2.51	2.74
Mean	2.25	10.62	37.23	0.52	27.63	2.90	2.96
St.Dev.	0.46	1.14	4.39	0.04	1.11	0.23	0.13

It should be remembered that along with the *Clonal Evaluation Trial* an ambitious experiment of diallel crosses was also harvested in May this year. In Table 2.14 the averages (combined across the two locations) of the most important traits are presented.

From the breeding viewpoint, the results from the diallel study from nine parents are equivalent to the *Clonal Evaluation Trial*. The only difference being that, rather than having all the plants from a given clone planted in one-row plot, in the diallel experiment these plants were scattered in three replications at two locations. Also six rather than eight plants were used to represent each clone in the diallel. Best performing clones will also be included in *Preliminary Yield Trials*. The experiment was planted again this year.

The diallel experiment included 36 crosses from nine parents (9*8/2=36). Each cross was represented by 30 clones (with a few exceptions). The trials were planted in two locations (Santo Tomás and Pitalito), with three replications each.

Eleven of the 36 families yielded more than 40 t/ha. Progenitors 2 (CM 6754-8) and 4 (SM 805-15) did not participate in any of these high-yielding families, whereas parents 5 (SM 1565-17) and 9 (SM 1665-2) were involved in five of these eleven families with superior yields.

Regarding the reaction to trips, the best crosses (low average scores) involved parents 5 (SM 1565-17) and 7 (SM 1219-9). For dry matter content parents 3 (CM 8027-3) and 6 (SM 1411-5) were the best based on the averages of their progenies, whereas parent 5 (SM 1565-17) was characterized by progenies with low dry matter content in the roots.

Table 2.15. Results of all the crosses with a common parent from the diallel trial conducted in two locations in the Sub-Humid environment (Santo Tomás y Pitalito. Atlántico).

Progenitor	Trips score (1 - 5)	Stakes per plant (Number	Fresh roots (t/ha)	Harvest Index (0 - 1)	Dry matter (%)	Plant type (1 - 5)	Root type (1 - 5)
1=MTAI 8	2.37	10.79	37.2	0.51	27.83	2.95	2.95
2=CM 6754-8	2.52	10.04	33.9	0.52	27.80	2.94	2.95
3=CM 8027-3	2.32	10.43	36.1	0.52	28.51	2.87	2.96
4=SM 805-15	2.42	10.10	33.4	0.50	27.62	3.04	3.07
5=SM 1565-17	1.78	10.99	39.5	0.56	26.33	2.86	2.93
6=SM 1411-5	2.07	11.47	38.4	0.51	28.42	2.69	2.92
7=SM 1219-9	1.81	11.65	39.1	0.52	27.54	2.75	2.95
8=SM 1657-12	2.53	9.95	37.5	0.53	27.32	3.11	3.03
9=SM 1665-2	2.44	10.19	39.8	0.55	27.26	2.89	2.91
Maximum	2.53	11.65	39.8	0.56	28.51	3.11	3.07
Minimum	1.78	9.95	33.4	0.50	26.33	2.69	2.91
Mean	2.252	10.623	37.2	0.524	27.626	2.899	2.961
St. Dev.	0.291	0.636	2.34	0.020	0.651	0.130	0.053

The data for each cross can be further consolidated to produce the averages of all the crosses involving a given parent, which are presented in Table 2.15. As it is frequently the case results from Table 2.15 demonstrate the difficulties in producing a perfect genotype. For instance the progenies of parent 5 (SM 1565-17) were outstanding yield wise and showed excellent reaction to trips. However, they also showed the lowest dry matter content in the entire experiment. Progenies from parent 6 (SM 1411-5) had a superior plant type (the lowest average score = 2.69), the highest dry matter content (28.42%), but low harvest index (0.51). It is clear that the results presented in Table 2.15 agree with those from Table 2.14 with the averages of each individual F1 family.

It should be remembered that results from Table 2.14 are averages across 30 clones making up each F1 family, and those from Table 2.15 grouping together the averages of all the progenies with a parent in common. The range of variation among individual clones is much larger. For instance, the highest average for yield in Table 2.14 was 45.68 t/ha (cross 1 x 9), but the highest yield by an individual clone was equivalent to 134 t/ha (Santo Tomás trial). When we perform the analysis of the segregation within each family (that is, among the 30 clones from each F1 family), some interesting results are expected to surface.

Advantages of the new scheme: implications for industry

In the North Coast, the *Clonal Evaluation Trial* was handled in a particular fashion. Because of the bimodal distribution of rainfall, which begins end of April to early May, cassava is traditionally harvested in February or March. Plants harvested at this time cannot be used as seed source because the stakes have deteriorated by the time the rains arrive in May. Consequently, the *Clonal Evaluation Trial* (based on six plants) used to be evaluated during the dry season, using three plants. The remaining three plants were left as seed source, being cut in May.

This situation meant that seed (produced from only three plants) was limited and, as a result, the following evaluation stage could not be made with replicates. The previous year, for the first time, the procedure for conducting the *Clonal Evaluation Trial* was modified considerably. First, the number of plants representing each clone was increased to eight. Of these eight plants, two were harvested in March, mainly to measure dry matter content during the optimal time for taking this measure. When the rains arrive, the cassava plant reinitiates its growth, thus extracting energy that had been accumulated in the roots. As a consequence, dry matter content drops to the extent that starch and chip-drying industries usually either reject the roots or pay low prices for them.

The new procedure, for the *Clonal Evaluation Trial* requires the measuring of dry matter content in each clone on two occasions: during the dry season (March) and after the rains arrive (May). The previous year a group of 20 clones was selected because of their high dry matter content and capacity to maintain it after the rains arrive. These clones were planted again this cycle

Capacity of maintaining high dry matter content with the arrival of the rains
The new breeding scheme requires measuring dry matter content in the roots of each clone

twice: in the middle of the dry period and after the arrival of the rains. This situation offers the possibility of selecting clones that have the capacity of maintaining high dry matter content after the initiation of the rains. Last year a group of 20 clones was selected for this trait and they will continue to be evaluated and crossed among themselves to evaluate the possibility of improving this important trait.

Capacity of retaining leaves for a longer period of time in the absence of biotic or abiotic stresses.

Another significant result obtained from the *Clonal Evaluation Trial* from the previous year was the observation about the capacity of some genotypes to retain leaves for longer periods during plant growth observed by the end of October. At that time, the crop was 5½ months old and a differential capacity to retain leaves was already obvious.

Table 2.16. Effect of leaf retention in 5½-month-old cassava on traits measured 5 months later (at harvest) in the *Clonal Evaluation Trial*, Santo Tomás, Department of Atlántico, Colombia.

Leaf retention	Fresh root yield (t/ha)	Dry matter yield (t/ha)	Dry matter content (%)	Plant type (1 - 5)	Harvest index (0-1)
Yes	26.62	7.74	29.59	2.72	0.60
No	23.05	6.63	28.84	2.80	0.57

During the current season the evaluation for leaf retention was conducted slightly later than the previous year, which proved to be undesirable because leaf senescence was already occurring in clones that obviously had retained the leaves for a longer period of time. The end result was that the data was probably not as reliable as in 2001. Still an clear effect on root yield could be observed. In Table 2.16 the mean performances of the clones that retained the leaves versus those that did not are presented. The former yielded more that three t/ha of fresh roots than the latter (about 1 t/ha of dry matter). Although the date for evaluation proved to be not at the optimum time, consolidating information on the positive effect of leaf retention on yield and other characteristics of agronomic relevance is gradually emerging.

The connection of leaf retention with the new breeding scheme originates in the number of plants representing each clone. In the new system eight plants (rather than one as was the case in the old system) are used to represent each clone. The differences in leaf retention became very apparent because there were eight identical plants showing the trait, and that helped to call the attention of the scientists when visiting the field.

Possibility of a gross estimation of General Combining Ability for progenitors.

One of the most important advantages of the new breeding scheme is that data from all progenies are taken and recorded from the very first evaluation stage. This produced a more balance data of all the progenies produced by a given progenitor, which is a valuable

approach for determining its breeding value.

Table 2.17. Progenitors of clones included in the *Clonal Evaluation Trial* (Santo Tomás, Atlántico) described in Table 2.10.

Progenitor	Number of clones produced	% of clones selected
CM 523-7	511	6.80
CM 6754-8	231	16.45
CM 8027-3	318	23.10
SM 805-15	289	9.24
SM 1219-9	465	13.19
SM 1411-5	305	25.70
SM 1565-17	399	12.24
SM 1657-12	155	13.20
SM 1665-2	400	15.43
SM 2192-6	465	19.24
MTAI 8	394	15.16
Total	3932	-.-
Mean	-.-	15.43

Table 2.17 is a summary of the information provided earlier in Table 2.12. In Table 2.17 the number of clones derived from a given progenitor and the proportion of them that were eventually selected is presented. Progenies of clone CM 523-7 (the old and venerable ICA-Catumare variety) where not competitive, since only 6.80% of them survived. This is not a surprise because CM 523-7 is adapted to the Acid Soil Savannas environment and adapts poorly to the Sub-Humid conditions. This clone was included as progenitor for this region, however, because of its known resistance to bacteriosis (*Xanthomonas axonopodis* pv. *manihotis*). This disease is not common in the drier environments but occasionally appears when rains are more abundant. The inclusion of CM 523-7, therefore, aimed at introgressing some level of resistance to bacteriosis in the germplasm adapted to the Sub-Humid conditions. Most of the progenies were rejected, but few (and that is enough) survived and passed to the following stage of evaluation.

SM 1411-5 and CM 8027-3 produced progenies that had a much higher chances of being selected. A very poor performance was shown by the progenies of SM 805-15 in addition to that of CM 523-7. It is this consolidated information that allows us to guide the decision of what parents to use or not to use in the production of a new generation of promising genotypes. For instance, SM 805-15 has not been included in the list of progenitors for the Sub-Humid environment (Table 2.1). SM 1411-5 has been included and current data supports that decision. On the other hand, we have contrasting results from other clones. For instance, SM 1565-17 was not very outstanding based on information from Table 2.17 (with only 12.24% of its progeny being selected). But this clone was highlighted for its high yield potential and reaction to trips in the diallel analysis (Table 2.15), but also because of its low dry matter content. That is probably the reason why a lower proportion of their progenies

was selected. Exactly the opposite situation is faced by CM 8027-3, with poor performance regarding reaction to trips and fresh root productivity (Table 2.15), but the highest dry matter content. Because of the high emphasis given to dry matter content by the Selection Index, it is, therefore, not surprising that a higher proportion of its progenies was selected. This clone has not been included in the list of parents for this year, but it will be re-introduced next year.

Table 2.18. Results of the best five out of 20 selected from the **Experiment 1** of the *Preliminary Yield Trials* conducted in Pitalito (Atlántico).The trials included three replications of 10-plant plots and 75 genotypes. In italics clones used as check.

Clones or parameters	Plant type (1-5)	Root type (1-5)	Harvest Index (0-1)	Dry matter content (%)	Fresh root yield (t/ha)	Dry matter yield (t/ha)	Selection Index
SM 2545-22	3.7	2.0	0.64	32.3	36.5	11.8	39.69
SM 2618-8	2.0	2.3	0.50	31.6	30.5	9.7	30.9
SM 2548-22	1.7	1.7	0.57	29.6	28.3	8.5	28.66
SM 2619-4	2.0	3.0	0.45	34.4	26.9	9.2	28.06
SM 2616-6	2.7	2.7	0.58	32.7	25.7	8.5	22.37
Statistics of the 20 clones selected.							
Maximum	4.0	3.0	0.6	34.6	36.5	11.8	39.69
Minimum	1.3	1.7	0.4	23.5	18.4	5.6	8.34
Mean	2.33	2.32	0.52	30.48	26.29	8.00	18.32
St.Dev.	0.72	0.41	0.06	2.97	4.07	1.29	8.47
CG 1141-1	*1.7*	*2.7*	*0.51*	*30.3*	*21.3*	*6.6*	*13.11*
CM 3306-4	*4.0*	*2.7*	*0.38*	*34.2*	*16.7*	*5.7*	*-6.45*
M TAI 8	*1.7*	*2.0*	*0.54*	*30.1*	*25.2*	*7.6*	*20.36*
Statistics of the 75 clones evaluated in Experiment 1.							
Maximum	4.3	4.0	0.6	34.6	36.5	11.8	39.69
Minimum	1.3	1.7	0.2	20.9	7.3	1.7	-41.41
Mean	2.73	2.76	0.46	29.29	20.51	6.03	0.00
St.Dev.	0.72	0.55	0.08	3.23	5.70	1.80	16.44

The best 225 clones selected from the *Clonal Evaluation Trial* harvested the previous year were planted in three different *Preliminary Yield Trials* identified as Experiments 1, 2 an 3. Each of these trials included 75 clones that were evaluated in 10-plants plots with three replications. The most relevant results of these trials are presented in Tables 2.18, 2.19, and 2.20. One of the advantages of using the selection index with standardized values, described above, is that by definition an average performance has a value of zero. This can be confirmed in the right column of these Tables, where the population mean of the 75 clones was, in every case, zero. A positive selection index suggests better than average performance. A negative value, on the other hand, indicates an undesirable general performance.

Table 2.19. Results of the best five out of 20 selected from the **Experiment 2** of the *Preliminary Yield Trials* conducted in Pitalito (Atlántico). The trials included three replications of 10-plant plots and 75 genotypes. In italic clones used as checks.

Clones or parameters	Plant type (1-5)	Root type (1-5)	Harvest Index (0-1)	Dry matter content (%)	Fresh root yield (t/ha)	Dry matter yield (t/ha)	Selection Index
SM 2771-5	2.7	1.7	0.49	34.3	46.2	15.9	42.94
SM 2773-32	2.3	3.7	0.64	39.0	25.5	10.0	31.10
SM 2775-4	2.3	1.7	0.55	33.8	32.0	10.8	25.60
SM 2773-21	1.7	2.7	0.52	34.5	28.0	9.6	25.13
SM 2629-36	2.3	2.3	0.58	33.4	29.7	9.9	22.52
Statistics of the 20 clones selected.							
Maximum	3.3	3.7	0.6	39.0	46.2	15.9	42.9
Minimum	1.0	1.3	0.4	24.5	20.5	7.1	11.4
Mean	2.28	2.20	0.53	33.17	28.66	9.47	18.72
St.Dev.	0.60	0.64	0.06	2.83	5.74	1.88	7.69
CG 1141-1	*2.7*	*2.0*	*0.48*	*32.3*	*27.5*	*8.9*	*9.96*
CM 3306-4	*3.7*	*2.0*	*0.44*	*32.7*	*21.4*	*7.0*	*0.08*
M TAI 8	*2.3*	*2.0*	*0.5*	*31.3*	*25.8*	*8.1*	*10.8*
Statistics of the 75 clones evaluated in Experiment 2.							
Maximum	4.00	3.67	0.71	39.05	46.20	15.86	42.94
Minimum	1.00	1.00	0.32	22.70	7.29	1.89	-40.50
Mean	2.71	2.40	0.49	30.51	23.36	7.17	0.00
St.Dev.	0.62	0.61	0.08	3.62	6.69	2.28	16.19

It can be observed in Table 2.18 that the average selection index of the 20 selected clones (out of the 75 evaluated) was clearly larger than zero (18.32), indicating the superiority of their performance compared with the rest of the experiment. The three checks included in the trial (CG 1141-1, CM 3306-4, and MTAI 8) had an average of 9.01. MTAI 8 was the best check with a selection index of 20.36, demonstrating that this excellent clone is still very competitive in the region. The best five clones, however, had an average selection index of 29.93. Yield wise the 20 selected clones produced an average of 8 t/ha of dry matter, whereas the three checks produced an average of 6.63 t/ha (20% superiority). Dry matter content of the best five and the 20 selected clones were, respectively 32.12 and 30.48%, whereas the average for the three checks was 31.53%.

For the **second experiment**, the results are presented in Table 2.19. The mean selection index for the 20 clones selected was 18.72, similar to the one in Experiment 1. The checks had a mean of 6.94. Yield in the second experiment was higher than in the first with an average of more that one t/ha of dry matter productivity, compared with Experiment 1. The mean dry matter productivity of the 20 clones selected was 9.47 t/ha, compared with 8 t/ha of the three checks (18% superiority). The best five clones yielded an impressive 11.2 t/ha of dry matter. Dry matter content of these clones was 35.0%, in comparison with 32.1% for the checks.

Table 2.20. Results of the best five out of 20 selected from the **Experiment 3** of the *Preliminary Yield Trials* conducted in Pitalito (Atlántico). The trials included three replications of 10-plant plots and 75 genotypes. In italic clones used as checks.

Clones or parameters	Plant type (1-5)	Root type (1-5)	Harvest Index (0-1)	Dry matter content (%)	Fresh root yield (t/ha)	Dry matter yield (t/ha)	Selection Index
CM 9456-21	2.7	1.3	0.54	29.9	37.19	11.16	29.54
SM 2781-6	1.0	1.3	0.51	27.4	35.36	9.43	29.04
CM 9456-12	2.7	1.7	0.66	31.3	30.57	9.55	28.46
SM 2783-26	1.3	1.0	0.46	29.0	35.59	10.38	28.35
SM 2782-4	2.7	1.3	0.57	31.5	32.71	10.23	27.81
Statistics of the 20 clones selected.							
Maximum	4.3	3.0	0.7	31.7	37.2	11.2	29.5
Minimum	1.0	1.0	0.4	22.9	22.3	6.9	10.3
Mean	2.37	1.68	0.54	29.44	30.63	8.96	20.29
St.Dev.	0.91	0.61	0.06	2.16	4.55	1.20	6.15
CG 1141-1	*2.3*	*2.0*	*0.48*	*31.0*	*15.99*	*5.03*	*-0.32*
CM 3306-4	*4.7*	*2.3*	*0.42*	*33.4*	*16.67*	*5.57*	*-9.2*
M TAI 8	*3.0*	*2.0*	*0.50*	*30.9*	*25.10*	*7.78*	*10.2*
Statistics of the 75 clones evaluated in Experiment 3.							
Maximum	5	3.33	0.66	33.42	37.19	11.16	29.54
Minimum	1	1	0.33	17.61	9.01	1.728	-39.00
Mean	3.05	2.09	0.49	28.11	22.45	6.34	0.00
St.Dev.	0.98	0.58	0.06	3.94	6.90	2.14	15.99

Results of **Experiment 3** are presented in Table 2.20. Mean performance of the 20 selected clones (average Selection Index = 20.29) was markedly superior to that of the three checks (average Selection Index = 0.23). The superiority of the selected material is mainly due to higher productivity of fresh roots (30.63 versus 19.25 t/ha). Dry matter content in the selected material, however, was lower than in the checks (29.44 versus 31.7 %).

The 20 selected clones from each experiment were pooled together in a 60-genotype *Advanced Yield Trial,* which will be planted in 25-plants plots with three replications at two locations (See Figure 2.1). Hopefully, the trial will be conducted for two consecutive years until their best entries are considered suitable for the last stage of selection (*Regional Trials*)

The *Advanced Yield Trial* stage was not conducted this year because of a flood in 1999 that created a vacuum in the evaluation process. Therefore, the next stage of the evaluation process (see Figure 2.1) is the *Regional Trials*. In this cycle, 40 clones were included and evaluated in up to 11 locations. Four in the truly sub-humid environments of Atlántico and Magdalena Departments; four in the more humid conditions of the Córdoba and Sucre Departments; and the remaining three locations in the Urabá region.

Table 2.21 summarizes the results of the *Regional Trial* in the Atlántico and Magdalena Departments (Pitalito, Baraona, Caracolí, and Santo Tomás). Averages of fresh root production, dry matter content and harvest index across the four locations are provided. Also, the ranking (based on the selection index) for each individual location is included in the right columns. The order in which the clones are presented was based on the selection index taking into account the averages across the four locations.

One striking feature of the data presented in Table 2.21 is the sharp contrasts in the ranking of each material in different locations. The best material (across locations) occupied the 17th, 30th, 1st, and 13th order in each of the four locations, respectively. This is a common feature of cassava, which frequently exposes large genotype by environment interaction. This is particularly true for those clones in the top of the table. At the bottom, however, the results are much more consistent. In general, results from Caracolí tended to be contrasting with those from the other three locations.

The best clone (across the four environments using the selection index) was SM 1759-29. This clone, however, showed the high interaction by environment interaction mentioned above. The same is true for the second clone (CM 3306-19), which ranked 34th, 1st, 22nd, and 23rd at each location. The third (CM4919-1) and fourth (SM 1411-5) clones had a more consistent performance across locations. With the exception of the first clone (SM 1759-29) all the clones on top of the table had been included as parents for the crossing nursery of this year (Table 2.1). Worth mentioning is the position occupied by MTAI 8. Until recently, this clone was second to none in the region. But the Table 2.21 ranked eight. It is not clear if the gradual decrease of the competitiveness of this clone is due to the genetic superiority of newer materials; a result of some decline of its performance due to contamination of non-pathogenic organisms; or a combination of these two reasons.

In Table 2.22, the results of the *Regional Trials* conducted in the more humid region of Córdoba and Sucre Departments are presented. The sharp changes in the ranking at different locations observed in the top of Table 2.21 is not seen here. The best clones (SM 1665-2) ranked 5th, 4th, 1st, and 11th in the four locations. Similar results were observed in the following top performing clones. This would suggest that genotype by environment in this region was not as important as in the previous one, therefore, allowing for an easier identification of the best clones. As was the case for the Atlántico and Magdalena Departments, the clones at the bottom of the Table showed a consistently poor performance also in the case of the Córdoba and Sucre Departments.

A different kind of genotype by environment can be observed when we compare the results from Tables 2.21 and 2.22. If the best ten clones from each location are taken into account, only four clones (CM 4919-1, CM 3306-19, SM 1669-7, and SM 1973-25) were shared by the two regions. The best clone from Table 2.21 occupied the 34th position in Table 2.22. Likewise, the best clone in Table 2.22 ranked 19th in Table 2.21. The situation on CM 6754-8, sencond in Córdoba-Sucre, was 27th in the Atlántico-Magdalena. This situation has been noticed before and used as an example of the genotype by environment interaction considering these large regions in the north coast of Colombia.

Table 2.21. Results of the *Regional Trial* for the sub-humid conditions in Atlántico and Magdalena Departments. Ranking of clones is based on selection index estimated from across locations average.

Clone		Fresh roots	Dry matter	Harvest index	Ranking based on selection index at each individual location			
		(t/ha)	(%)	(0 a 1)	Pitalito	Baraona	Caracolí	S.Tomás
1	SM 1759-29	32.49	29.06	0.58	17	30	1	13
2	CM 3306-19	25.72	28.04	0.68	34	1	22	23
3	CM 4919-1	24.71	27.79	0.69	3	7	18	5
4	SM 1411-5	27.92	27.28	0.60	4	21	8	3
5	SM 1565-17	30.24	25.55	0.64	21	10	16	29
6	CM 6119-5	22.36	29.32	0.62	15	5	11	2
7	SM 805-15	24.42	28.14	0.62	24	3	23	17
8	M TAI 8	25.85	27.27	0.64	10	6	26	18
9	SM 1669-7	21.31	29.89	0.59	7	23	2	7
10	SM 1973-25	21.94	29.49	0.58	1	9	14	19
11	SB 0216-9	25.74	27.50	0.60	39	2	19	20
12	SM 643-17	20.50	30.53	0.55	8	8	4	14
13	M VEN 25	27.33	26.79	0.58	9	26	7	4
14	CM 7514-8	22.79	27.92	0.65	20	11	24	8
15	SM 1511-6	23.50	27.33	0.65	12	15	5	6
16	SM 1650-7	19.28	30.20	0.58	35	13	6	1
17	CM 4843-1	23.76	27.10	0.64	29	12	21	22
18	SM 1778-45	23.51	27.85	0.59	18	16	25	9
19	SM 1665-2	23.68	26.30	0.69	31	4	33	27
20	MCOL 1505	23.36	27.58	0.59	19	17	30	16
21	SM 1669-5	21.92	27.99	0.61	14	14	28	15
22	CM 6740-7	24.94	26.44	0.61	2	33	38	10
23	M BRA 384	24.68	27.07	0.57	6	20	37	25
24	SM 1438-2	21.72	28.19	0.57	5	34	15	11
25	CM 8475-4	22.21	27.89	0.54	13	24	31	24
26	SGB 765-4	21.18	28.39	0.53	11	25	10	26
27	CM 6754-8	20.22	26.87	0.69	25	27	12	32
28	CM 523-7	19.04	28.52	0.58	16	32	32	12
29	SM 1778-53	21.11	27.42	0.53	27	22	35	28
30	CM 8027-3	19.56	27.03	0.61	26	35	13	34
31	MCOL 2215	16.19	28.80	0.59	23	31	3	36
32	CG 1141-1	20.06	27.44	0.54	36	19	9	38
33	SM 1627-16	19.25	27.59	0.54	33	29	17	30
34	CM 3306-4	17.25	28.44	0.53	28	28	27	33
35	SGB 765-2	17.07	27.55	0.59	22	18	20	37
36	SM 1973-23	18.63	25.67	0.61	32	36	36	31
37	CM 6758-1	17.81	26.34	0.53	30	37	39	21
38	SM 1624-2	14.86	28.00	0.43	37	39	34	35
39	M PER 183	19.74	22.61	0.54	38	40	40	39
40	SM 1657-14	15.96	25.39	0.45	40	38	29	40
Maximum		32.49	30.53	0.69	33.78	45.50	65.94	30.39
Minimum		14.86	22.61	0.43	14.17	16.22	13.67	9.50
Mean		22.09	27.61	0.59	23.90	26.28	19.49	18.71

Table 2.22. Results of the *Regional Trial* for the sub-humid to humid conditions in Córdoba and Sucre Departments. Ranking of clones is based on selection index estimated from across locations average.

	Clone	Fresh roots	Dry matter	Harvest index	Ranking based on selection index at each individual location			
		(t/ha)	(%)	(0 a 1)	Sahagun	C. Oro	Corozal	La Unión
1	SM 1665-2	31.11	30.81	0.59	5	4	1	11
2	CM 6754-8	28.96	31.62	0.59	1	12	11	7
3	CM 4843-1	29.19	31.52	0.56	11	1	8	4
4	SM 1669-7	23.17	34.99	0.53	8	3	6	12
5	CM 3306-19	28.36	30.45	0.58	6	21	2	19
6	SM 1973-25	28.32	32.37	0.48	16	2	26	2
7	SM 1438-2	24.39	33.64	0.49	33	15	3	3
8	CM 4919-1	25.63	31.06	0.57	10	6	24	8
9	SM 643-17	19.86	35.55	0.52	27	9	9	6
10	SM 1973-23	23.53	32.68	0.53	13	16	13	10
11	M TAI 8	24.67	31.98	0.53	7	8	27	14
12	SM 1669-5	23.46	32.17	0.54	15	7	14	23
13	CM 523-7	23.00	32.53	0.54	19	14	4	20
14	CM 6119-5	20.50	33.82	0.53	12	13	10	27
15	CG 1141-1	20.92	33.59	0.53	25	10	16	13
16	SM 1565-17	31.14	26.75	0.56	3	28	7	35
17	M BRA 384	28.46	28.77	0.52	32	17	20	9
18	SM 1411-5	22.78	32.01	0.52	31	5	12	25
19	SB 0216-9	25.33	31.41	0.47	14	23	34	1
20	SM 1511-6	21.36	32.54	0.53	9	20	25	22
21	SM 1650-7	23.35	31.99	0.49	36	24	5	5
22	SGB 765-2	20.93	33.32	0.49	23	19	22	15
23	CM 8027-3	20.77	32.63	0.50	22	na	15	26
24	MCOL 2215	17.21	34.99	0.48	28	18	23	24
25	MCOL 1505	22.19	31.33	0.51	20	34	19	16
26	SM 805-15	23.31	30.73	0.50	2	31	32	31
27	CM 3306-4	18.18	35.21	0.42	26	25	18	21
28	SM 1778-53	20.36	33.21	0.43	18	27	21	32
29	CM 7514-8	17.96	33.56	0.47	29	22	31	17
30	SM 1627-16	20.49	32.25	0.46	4	36	33	28
31	CM 6758-1	21.15	32.14	0.44	21	29	17	33
32	M VEN 25	19.63	31.51	0.51	37	11	28	30
33	SM 1624-2	15.89	33.05	0.41	24	32	35	36
34	SM 1759-29	17.82	32.11	0.37	35	30	37	18
35	SM 1778-45	14.56	32.42	0.42	30	35	38	29
36	CM 6740-7	18.54	28.58	0.49	17	38	30	38
37	SGB 765-4	13.86	33.42	0.37	34	37	29	39
38	CM 8475-4	15.50	31.61	0.40	38	33	36	37
39	SM 1657-14	13.67	27.23	0.41	40	26	40	34
40	M PER 183	12.03	23.74	0.37	39	39	39	40
Maximum		31.14	35.55	0.59	29.28	38.11	37.61	41.56
Minimum		12.03	23.74	0.37	7.06	12.33	5.83	14.78
Mean		21.79	31.88	0.49	14.69	23.89	22.06	26.51

na = not available

Table 2.23. Results of the *Regional Trial* for the humid conditions in the Urabá Region. Ranking of clones is based on selection index estimated from across locations average.

Clone		Fresh roots	Dry matter	Harvest index	Ranking based on selection index at each individual location		
		(t/ha)	(%)	(0 a 1)	Carepa	Necoclí	Mutatá
1	SM 1565-17	40.68	33.83	0.67	1	23	26
2	SM 1511-6	35.62	37.02	0.63	7	14	3
3	SM 1411-5	37.31	35.68	0.65	25	1	11
4	SM 1669-7	31.39	38.72	0.64	18	19	2
5	SM 1438-2	33.95	38.36	0.57	11	6	7
6	SGB765-4	36.60	36.32	0.60	2	17	na
7	CG 1141-1	31.45	38.78	0.62	22	5	4
8	SM 1665-2	34.75	35.68	0.68	17	16	5
9	CM 7514-8	31.54	37.34	0.66	13	3	16
10	SM 1669-5	33.61	36.20	0.66	9	12	8
11	M VEN 25	34.26	36.96	0.57	10	7	20
12	CM 3306-4	31.05	37.78	0.63	23	18	6
13	CM 3306-19	36.23	33.66	0.71	21	10	10
14	SM 1973-25	31.82	37.70	0.59	4	24	15
15	SM 805-15	37.25	34.61	0.60	8	9	27
16	SM 1650-7	30.83	37.39	0.60	12	15	14
17	SM 1624-2	30.74	38.65	0.51	37	22	1
18	SGB 765-2	33.43	35.57	0.61	20	4	32
19	SM 1973-23	31.88	36.09	0.63	6	20	28
20	CM 4919-1	32.04	34.66	0.67	3	32	24
21	M COL 2215	27.72	37.88	0.60	5	11	35
22	SM 1627-16	28.46	37.38	0.60	31	8	13
23	SM 1778-53	29.85	37.40	0.54	29	21	9
24	SB 0216-9	31.67	36.13	0.53	32	2	37
25	SM 1759-29	28.70	37.37	0.54	15	35	17
26	M COL 1505	33.43	34.35	0.56	30	13	34
27	CM 6119-5	26.54	36.63	0.65	14	30	18
28	CM 6740-7	30.70	35.16	0.56	na	36	na
29	CM 8027-3	26.51	36.56	0.58	27	29	23
30	SM 643-17	26.08	37.30	0.54	19	38	30
31	CM 6754-8	27.31	34.87	0.62	26	39	25
32	M TAI 8	26.20	34.88	0.61	33	34	29
33	CM 8475-4	24.97	36.94	0.51	16	40	12
34	CM 523-7	28.80	34.35	0.53	36	33	19
35	CM 4843-1	27.47	33.69	0.59	28	25	40
36	SM 1657-14	26.70	34.99	0.49	35	31	33
37	CM 6758-1	27.16	35.11	0.43	40	26	31
38	SM 1778-45	22.59	35.86	0.54	34	28	39
39	M BRA 384	22.35	34.17	0.57	39	27	36
40	M PER 183	29.88	29.62	0.58	38	37	38
Maximum		40.68	38.78	0.71	73.15	42.22	30.56
Minimum		22.35	29.62	0.43	30.09	16.67	8.33
Mean		30.74	36.04	0.59	43.47	31.28	17.46

na = not available

It should be obvious that these interactions resulting in sharp contrasts in the rankings creates huge problems to the breeder. It becomes very difficult to decide which clone is really adapted to these conditions. However, some criteria are used for overcoming this problem. For instance three out of the four clones that were among the best ten in Tables 2.21 and 2.22 had been included as parents in the crossing nursery of this year (Table 2.21). CM 6754-8 has also been included as progenitor because of its known outstanding performance in the Córdoba-Sucre region, and in spite of its recognized lack of adaptation to the drier region of Atlántico-Magdalena.

Finally in Table 2.23, the results from the same *Regional Trials* conducted in the Urabá Region are presented. This area is an excellent environment for growing cassava and has an interesting future. The Urabá Region is known for its banana and plantain production, with large volume of it being exported. Recently, international regulations ruled out the possibility of stapling the boxes used for banana and plantain packaging. The industry, therefore, began importing large volumes of starch for gluing the boxes. Cassava offers an ideal alternative source for preparing these adhesives. Furthermore, CLAYUCA is conducting promising studies to produce the adhesives with flour (not starch) from cassava roots. The cassava flour should be a very competitive product against the imported starch.

As was the case in the Atlántico-Magdalena region, there was a sharp contrast in the ranking of clones at the top of the table, for the three locations where the trials were conducted. The best clone (SM 1565-17) was 1st, 23rd and 26th. The second best clone (SM 1511-6) was 7th, 14th, and 3rd. So defining the best clones for the region offers some difficulties, which are not present when deciding which are the clones poorly adapted. Only one clone (SM 1669-7) is among the ten-best clones in the three regions were these trials were conducted. The three remaining clones that were among the ten best in Tables 2.21 and 2.22 occupied the 13th (CM 3306-19), 14th (SM 1973-25) and 20th (CM 4919-1) rank in the Urabá region.

Table 2.24. Rankings of the eight clones selected for their good performance across the 11 locations where Re*gional Trials* for the Sub-Humid environment were conducted.

Clone	Regions in the Northern Coast		
	Atlántico Magdalena	Córdoba Sucre	Urabá
SM 1411-5	4	18	3
SM 1669-7	9	4	4
SM 1665-2	19	1	8
SM 1438-2	24	7	5
SM 1565-17	5	16	1
SM 1973-25	10	6	14
CM 3306-19	2	5	13
CM 4919-1	3	8	20

In Table 2.24 we summarize the results of the *Regional Trials*. A group of eight clones has been selected based on its across-regions performance. In spit of the difficulties created by

the genotype by environment interactions, it should be clear that, eventually, it is possible to identify genotypes with an adequate and wide adaptation to the environments covered. All these clones (except for SM 1973-25) had been included as parents in the crossing nursery for this year. Many of these materials were also identified as genetically superior based on the peroformance of their progenies in the *Clonal Evaluation Trial* (Table 2.17) or in the Diallel Study (Table 2.15).

2.4.2 Selections for the Acid-Soil Savannas Environment

As for the Caribbean coastal eco-region, only the most relevant experiments conducted for this environment are described below (Table 2.25) followed by the respective results for each type of evaluation. As for Barranquilla, many of the improvement activities developed for the Villavicencio area also benefiting other regions.

The F1 stage was planted back in CIAT-Palmira, this a result of the measures taken to control both the white flies and frog skin disease. Many botanical seeds were planted but only 2267 produced vigorous enough seedlings to be transplanted to the F1 plot (Table 2.25). Plants that produce at least seven stakes in May next year, will be used for the *Clonal Evaluation Trial* of year 2003.

Table 2.25. Trials conducted in the Acid Soil Savannas in the 2001-2002 cycle¶.

Trial	Site	N° of genotypes	N° of reps	**Observations**
F1	CIAT-Palmira	2267	1	See Table 2.26
Clonal Evaluation	La Libertad	1211 (7)	1	See Table 2.27 and 2.28
Diallel study	La Libertad	1360 (6)	3	See Tables 2.31-2.34
Preliminary Yield Trial	La Libertad	252 (10)	3	See Tables 2.35-2.37
Advanced Yield Trial	La Libertad	70 (25)	3	See Table 2.38
Regional Trials	La Libertad	32 (25)	3	See Table 2.39
	Santa Cruz	32 (25)	3	See Table 2.39
	Cabuyal	32 (25)	3	Harvesteed but not analyzed yet
	Camural	32 (25)	3	See Table 2.39
	Bca de Upía	32 (25)	3	See Table 2.39

¶ Values in parentheses refer to the number of plants per plot. § Genotypes involved in the diallel experiment.

A description of the origin of the 1211 clones of the *Clonal Evaluation Trial* is provided in Table 2.26. In the year 2000, a total of 3572 botanical seeds had been planted for the Acid

Soil Savannas region. Many did not germinate or else, produced weak seedlings that died early before or soon after transplantation to the field. Eventually, only 1211 of the 1239 plants grown were vigorous enough to produce the seven stakes required for the *Clonal Evaluation Trial* planted for this cycle (Table 2.26). Most of the progenitors utilized to generate the *Clonal Evaluation Trial* have had an outstanding performance (as it will be demonstrated later in this Section); or else had been included for specific purposes.

Because of the prevalence of foliar diseases such as cassava bacterial blight (*Xanthomonas axonopodis* pv. *manihotis*) and superelongation (induced by the fungus *Sphaceloma manihoticola*), evaluations must ensure optimal disease pressure. It is desirable to eliminate, as early as possible in the improvement process, those genotypes susceptible to these diseases. Thus, in the *Clonal Evaluation Trial*, the furrows were located, one behind each other, in a single row and separated by plants that served as spreaders of these diseases. These spreader plants permitted not only high pressure, but also ensured uniform distribution of the diseases. Planting material for spreader plants were stakes chosen from plants that had been discarded, precisely for being susceptible to these diseases, during the previous cycle. The high mortality of spreader plants observed 1-2 months after planting demonstrates that their spreading role has been adequately fulfilled early in the season. Figure 2.2 illustrates the way the spreader plants were located through the *Clonal Evaluation Trial.*

There is a slight difference in the way the *Clonal Evaluation Trial* is harvested in the Acid Soils Savannas, compared with the drier environment of the Northern Coast of Colombia. There is no marked period without rains, therefore, the harvest can be carried out in one step. This is the reason why only seven (rather than eight) plants were used to represent each clone. All the plants were harvested together in May. One other difference for this trial is that Plant Type incorporates a heavy component of reaction to foliar diseases mentioned above. The large number of progenies that could be evaluated in this trial are the results of the financial support by the Ministry of Agriculture of Colombia and the Poultry Growers Association of Colombia (FANAVI). It also reflects the relative success that the measures taken to control Frog Skin Disease at the F1 stage.

As in the case of the previous region, selection in the Acid Soils Savannas was also conducted through a selection index:

Selection index = [FRY ∗ 10] + [DMC ∗ 8] - [PT ∗ 8] + [HI ∗ 5]

where, FRY = fresh root yield
DMC = dry matter content
PT = plant type using a 1(excellent) to 5 (very poor) visual scale
HI = harvest index

The weight given to plant type has been increased to 8 (it was 5 in the sub-humid eco-region), because of the heavier pressure to select for materials resistant to foliar diseases present in the acid soils savannas.

Table 2.26. Origin of the 1239 plants from which 1211 clones were obtained for *the Clonal Evaluation Trial* harvested in May, 2002 at CORPOICA – La Libertad (Villavicencio, Meat Department). SM families have unknow fathers, but it is certain that they come from a selected group of clones in the policross plots

	Family	Mother	Father	Planted	Transplanted
1	CM 6787	CM 523-7	CM 2177-2	50	32
2	CM 9474	CM 6370-2	CM 6921-3	30	44
3	CM 9831	CM 2177-2	HMC 1	52	18
4	CM 9903	SM 1741-1	CM 6740-7	75	46
5	CM 9918	CM 7951-5	SM 1219-9	69	24
6	CM 9940	SM 1219-9	SM 653-14	87	33
7	CM 9953	SM 1741-1	SM 1219-9	75	33
8	GM 115	SM 2075-1	MPAN 135	100	30
9	GM 240	CM 7033-3	SM 1219-9	60	14
10	GM 276	SM 1565-15	SM 2219-11	65	36
11	SM 2366	CM 6934-4	Unknown	75	47
12	SM 2610	SM 1363-3	Unknown	100	40
13	SM 2632	CM 4574-7	Unknown	75	45
14	SM 2634	CM 6438-14	Unknown	75	48
15	SM 2640	SM 1543-17	Unknown	75	38
16	SM 2642	SM 1565-15	Unknown	75	24
17	SM 2649	CM 6370-2	Unknown	50	16
18	SM 2658	SM 1460-1	Unknown	75	15
19	SM 2739	SM 1822-5	Unknown	75	20
20	SM 2792	SM 1565-15	Unknown	75	13
21	SM 2841	CM 7073-7	Unknown	67	19
22	SM 2842	SM 1583-8	Unknown	87	22
23	SM 2844	SM 1779-8	Unknown	75	15
24	SM 2846	SM 1811-38	Unknown	81	32
25	SM 2847	SM 1812-56	Unknown	75	26
26	SM 2848	SM 1820-8	Unknown	88	25
27	SM 2850	SM 1855-21	Unknown	75	9
28	SM 2852	SM 1861-18	Unknown	76	7
29	SM 2853	SM 1862-25	Unknown	75	4
30	SM 2854	SM 1870-31	Unknown	78	28
31	SM 2855	SM 1871-26	Unknown	75	13
32	SM 2857	MCOL 2298	Unknown	72	6
33	SM 2870	SM 1741-1	Unknown	70	32
34	SM 2899	SM 2059-7	Unknown	72	38
35	SM 2965	CM 4574-7	Unknown	74	38
36	SM 2966	CM 6740-7	Unknown	67	12
37	SM 2968	SM 1219-9	Unknown	85	42
38	SM 2970	SM 1479-8	Unknown	78	19
39	SM 2971	SM 1690-13	Unknown	60	4
40	SM 2972	SM 1779-8	Unknown	57	20
41	SM 2973	SM 1822-12	Unknown	76	20
42	SM 2974	SM 1855-21	Unknown	84	29
43	SM 2976	SM 1861-18	Unknown	67	27
44	SM 2977	SM 1862-25	Unknown	77	21
45	SM 2978	SM 1870-31	Unknown	77	19
46	SM 2979	SM 1871-33	Unknown	60	8
47	SM 2980	SM 2219-11	Unknown	85	27
48	SM 2982	CM 2772-3	Unknown	75	43
49	SM 3022	CM 2772-3	Unknown	71	18
TOTAL				**3572**	**1239**

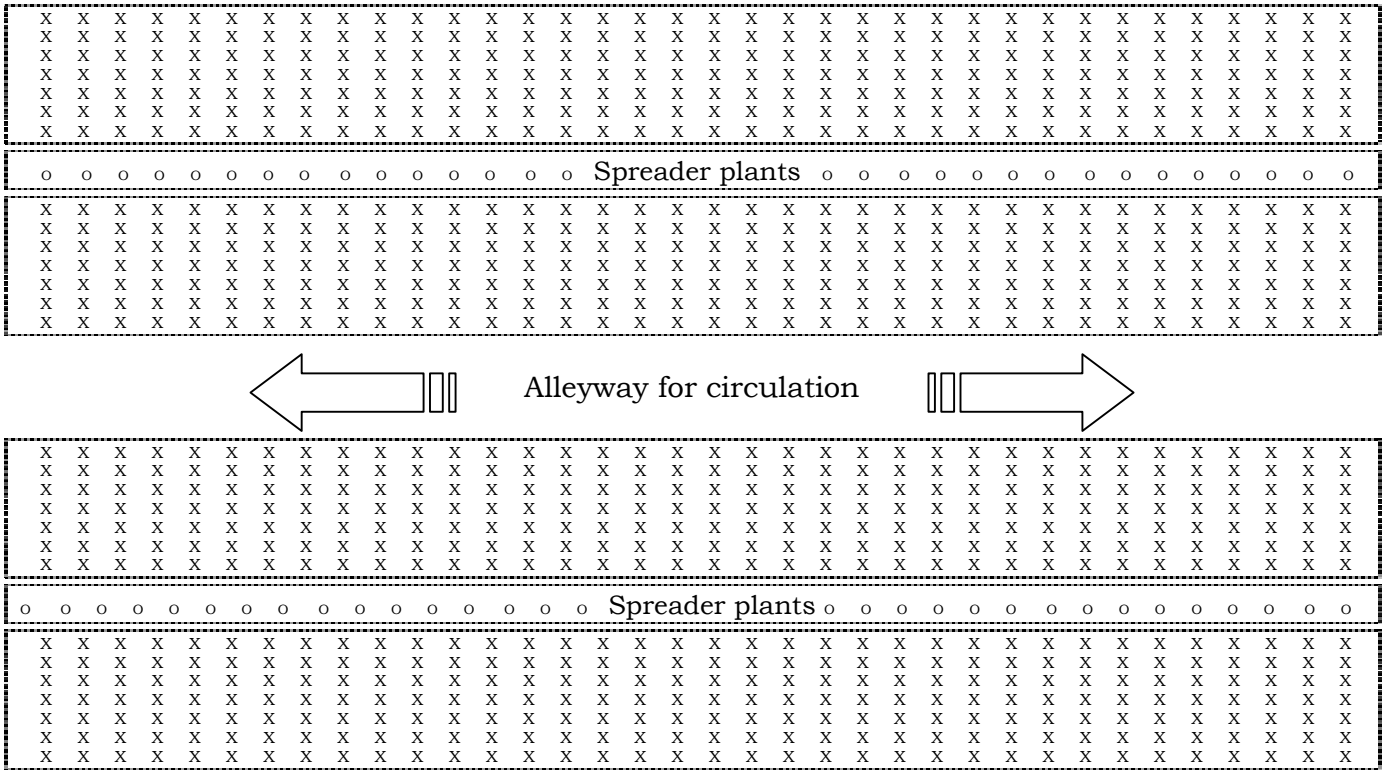


Figure 2.2. Illustration of the way spreader plants were positioned in the *Clonal Evaluation Trial* at CORPOICA – La Libertad, to provide uniform and high disease pressure.

Results of the *Clonal Evaluation Trial* are presented in Tables 2.27 and 2.28. Good development of leaf diseases could be observed early, together with a wide range of variation for both cassava bacterial blight and super-elongation. The fraction selected (Table 2.27), reacted well to leaf diseases (average for plant type = 2.53), compared with the average for the whole population (3.98). Similarly, good selection pressure was achieved for dry matter productivity (6.87 versus 3.06 t/ha), as for dry matter content (32.31% versus 28.71%), and harvest index (0.48 versus 0.38).

Data from Table 2.28 is useful for understanding why some families fail to contribute with clones worth to be selected, while others are outstanding. For instance, none of the 14 clones from family CM9733 was selected. These clones had a very low fresh-root yield (2.50 t/ha), and poor dry matter content (22.34%). Moreover, the average for plant type was 5.0. This means than all and every one of the clones was rated 5, suggesting that they had a very poor reaction to foliar diseases and/or very undesirable plant architecture. In contrast, the 38 clones from family GM 221 yielded 18 t/ha of fresh roots, with good level of dry matter content (32.80%). This family also showed the second best rating for plant type (2.66). All these factors contributing to the high proportion of selected clones from this family (84.2).

Table 2.27. Relevant results from the selection performed in the *Clonal Evaluation Trial* planted in CORPOICA – La Libertad(Villavicencio, Meta Department).

Clone or Parameter	Fresh roots	Dry matter	Harvest Index	Plant Type ¶	Dry matter
	(t/ha)	(t/ha)	(0 a 1)	(1 a 5)	(%)
Results of the best 12 clones selected					
GM 235-55	36.14	12.59	0.55	1	34.8
GM 219-48	33.14	10.89	0.53	1	32.9
GM 233-72	31.14	11.11	0.58	2	35.7
GM 227-74	32.29	9.99	0.47	1	30.9
GM 229-73	25.14	8.75	0.53	1	34.8
GM 256-66	32.00	10.77	0.53	2	33.6
CM 9901-56	20.86	7.20	0.63	1	34.5
GM 223-39	34.14	10.20	0.53	2	29.9
GM 219-50	24.86	8.03	0.56	1	32.3
GM 240-48	35.71	10.15	0.47	2	28.4
GM 221-41	24.00	8.80	0.45	2	36.7
CM 9460-74	19.94	6.97	0.48	1	35.0
Statistices of the 172 clones selected.					
Maximum	36.14	12.59	0.66	5.00	37.63
Minimum	12.74	3.78	0.28	1.00	26.37
Mean	21.35	6.87	0.48	2.53	32.31
St. Dev.	5.00	1.58	0.06	0.87	2.19
Statistices of the 1211 clones evaluated					
Maximum	36.14	12.59	0.77	5.00	38.54
Minimum	0.03	0.01	0.00	1.00	16.49
Mean	10.10	3.06	0.38	3.98	28.71
St. Dev.	7.06	2.28	0.13	1.08	4.11

¶ Leaf diseases and plant type were classified visually on a scale where 1 = excellent and 5 = very poor. A score of 3 represents a performance similar to the average of the population being evaluated.

The information from Table 2.28 can be used to produce information of all the progenies from a given parent (parents are used in generating more than one family). The averages of the progenies derived from each progenitor are presented in Table 2.29. Progenitors CM 4574-7, and SM 1565-15 are outstanding based on the excellent selection index averages of their progenies. Also, clones CM 7033-3 and SM 2219-11 produced progenies with a performance that was better than the average (selection indexes 2.31 and 2.64, respectively). Progenies from SM 1219-9 were marginally superior to the mean of the population (selection index= 0.44). The rest of the progenitors produced progenies that, across different variables introduced into the selection index, were mediocre. It was surprising to see that the progenies of CM 6740-7 had a poor performance (selection index = -4.22). This might be because this clone is better adapted to the conditions in the "*piedemonte*", than in the more stressful savannas where this trial was conducted.

Table 2.28. Results of the *Clonal Evaluation Trial* presented as average for each family represented in the trial. A few clones (15) were representing small families and have been omited from this list.

Family	# clones	Selected Clones (%)	Fresh Roots (t/ha)	Dry Matter (t/ha)	Dry Matter (%)	Plant Type (1-5)	Foliage Yield (t/ha)	Harvest Index (0-1)	Frog Skin (#)	Selection Index
CM 8035	36	5.6	7.32	2.03	26.99	4.67	9.83	0.41	0	-9.85
CM 9460	41	34.1	11.96	3.56	28.52	3.00	18.34	0.37	14	8.67
CM 9642	38	15.8	5.76	1.59	23.38	4.37	10.77	0.26	1	-15.89
CM 9733	14	0.0	2.50	0.61	22.34	5.00	6.53	0.22	0	-27.73
CM 9901	30	10.0	8.66	2.67	30.04	3.63	11.87	0.39	0	-1.63
GM 219	36	75.0	16.31	5.18	31.31	2.39	20.24	0.42	0	24.62
GM 220	35	65.7	15.70	4.95	31.43	3.14	17.93	0.46	0	20.34
GM 221	38	84.2	17.92	5.89	32.80	2.66	22.40	0.45	1	28.77
GM 223	46	54.3	14.42	4.37	30.26	3.28	17.07	0.46	1	15.78
GM 224	28	28.6	11.06	3.35	29.02	4.43	18.60	0.33	0	-0.89
GM 225	31	6.5	5.91	1.73	26.75	4.29	13.41	0.27	0	-14.70
GM 226	38	26.3	10.62	3.31	30.67	3.79	15.64	0.38	10	2.60
GM 227	48	25.0	10.86	3.31	29.76	4.13	14.72	0.39	0	1.61
GM 229	46	30.4	11.71	3.64	30.56	3.57	20.20	0.35	0	5.54
GM 232	16	12.5	7.23	2.18	28.64	4.44	12.20	0.34	0	-10.17
GM 233	46	30.4	12.01	3.73	30.04	4.02	16.20	0.40	0	5.35
GM 234	8	12.5	5.37	1.39	26.48	4.63	9.14	0.25	0	-18.63
GM 235	27	7.4	6.21	1.92	26.68	4.44	9.25	0.33	0	-12.80
GM 240	28	14.3	9.93	2.98	29.41	3.68	14.57	0.39	1	1.03
GM 241	13	53.8	12.51	4.00	31.41	3.15	18.11	0.39	0	10.85
GM 243	27	18.5	8.92	2.60	27.76	4.52	13.51	0.35	0	-6.46
GM 245	10	10.0	5.24	1.47	27.59	4.70	9.69	0.29	0	-17.79
GM 256	40	42.5	13.80	4.39	31.40	3.58	18.99	0.41	0	12.48
GM 261	21	23.8	10.70	3.32	29.95	4.29	12.22	0.45	0	1.99
GM 263	42	19.0	10.70	3.23	30.32	3.86	12.51	0.46	0	3.88
GM 264	30	23.3	9.30	2.78	28.55	4.47	14.01	0.37	1	-4.63
GM 265	15	0.0	2.71	0.72	24.51	4.87	7.07	0.24	0	-25.94
GM 266	29	13.8	9.03	2.70	29.40	4.60	11.96	0.42	0	-3.55
GM 275	16	25.0	10.97	3.30	28.87	3.94	15.18	0.39	0	2.55
GM 276	33	21.2	10.70	3.34	30.94	3.73	14.87	0.41	0	3.74
GM 277	14	28.6	11.37	3.51	30.76	3.86	13.63	0.45	0	5.68
GM 278	25	0.0	5.13	1.32	25.19	4.84	11.33	0.30	0	-18.93
GM 279	26	11.5	8.35	2.39	27.65	4.50	13.96	0.35	0	-7.85
GM 298	28	14.3	8.70	2.54	28.43	4.25	10.23	0.44	0	-3.60
GM 299	27	14.8	8.32	2.30	26.82	4.63	10.25	0.41	0	-7.39
GM 300	19	5.3	3.49	0.84	22.92	4.79	7.94	0.24	0	-24.07
GM 301	21	4.8	7.53	2.11	26.79	4.43	8.39	0.44	0	-7.47
GM 303	26	42.3	15.00	4.39	29.13	3.81	16.53	0.47	1	14.59
GM 304	20	0.0	6.41	1.69	25.97	4.50	12.73	0.33	0	-13.58
GM 305	32	37.5	11.77	3.65	30.01	4.25	15.60	0.42	0	4.10
GM 307	26	0.0	2.72	0.61	21.54	4.96	7.31	0.24	0	-26.83

The performances of the progenies from HMC-1, MPER 183 and MTAI 8 were also very undesirable (selection indexes -6.11, –20.61, and –7.69, respectively). MTAI 8 had been included because of its high dry-matter productivity and dry matter content. It does not possess resistance to the foliar diseases common in the acid soil savannas. This probably contributed to the poor results from its progenies. This situation illustrates the difficulty for combining several desirable traits in one cassava clone. HMC-1 and MPER 183 were included as progenitors because of their good cooking quality characteristics. However, the results obtained are very discouraging regarding the real usefulness of these lines for this eco-region.

Table 2.29. Averages of all the progenies derived from a common progenitor based on the data produced by the *Clonal Evaluation Trial* at CORPOICA – La Libertad (Villavicencio, Meta Department).

Progenitor	Number of clones	Seleced Clones (#)	Selected Clones (%)	Plant type (1 - 5)	Fresh roots (t/ha)	Foliage yield (t/ha)	Harvest Index (0 - 1)	Dry matter (%)	Selection Index
CM 4574-7	293	141	0.481	3.37	12.99	17.95	0.39	30.10	10.65
CM 6740-7	300	68	0.227	4.02	8.86	13.63	0.34	28.23	-4.22
CM 7033-3	162	56	0.346	3.76	10.63	15.14	0.37	29.54	2.31
SM 1219-9	270	71	0.263	4.01	10.06	13.46	0.40	29.45	0.44
SM 1565-15	225	85	0.378	3.66	11.76	16.84	0.39	30.24	6.33
SM 2058-2	148	21	0.142	4.39	8.13	10.92	0.39	27.49	-6.88
SM 2219-11	300	86	0.287	4.02	10.96	14.36	0.41	29.20	2.64
HMC 1	183	37	0.202	4.44	8.78	12.32	0.36	27.51	-6.11
MPER 183	198	10	0.051	4.70	4.43	9.64	0.27	24.47	-20.61
MTAI 8	209	31	0.148	4.45	7.88	11.14	0.38	27.44	-7.69

Table 2.30 presents phenotypic correlation values among different relevant traits. Worth mentioning is the high correlation between root productivity and plant type (ρ= -0.607); foliage production (ρ= 0.796); and harvest index (ρ= -0.676). Plant type also had good correlations with foliage productivity (ρ= -0.544); Harvest Index (ρ= -0.372); and surprisingly, dry matter content (ρ= -0.460).

A second diallel study was conducted in the acid-soil savannas environment. The ten parents involved in this study were listed in Table 2.7. As for the diallel in the northern coast, each F1 cross was represented by 30 clones, two environments were used, with three replications each. The trials were both planted in CORPOICA-La Libertad, but with two very contrasting soil conditions. The results of these trials are presented in Table 2.31 and 2.32, for the high- and low-fertility environments, respectively. The differences in soil fertility resulted in little development of foliar diseases in the trial with good soil fertility, but excellent disease pressure in the trial planted in soils with edaphic limitations. Likewise, productivity was very contrasting with average fresh-root yields of 28.31 and 12.10 t/ha, respectively

Table 2.30. Phenotypic correlacions for relevant traits evaluated in the *Clonal Evaluation Trial* (CORPOICA – La Libertad) from 1211 genotypes.

	Fresh root production (t/ha)	Fresh foliage production (t/ha)	Harvest Index (0-1)	Dry matter content (%)
Plant type (1 a 5)	-0.607	-0.544	-0.372	-0.460
Fresh root production		0.796	0.676	0.544
Harvest Index				0.507

Looking at the best ten crosses (based on fresh-root yield) from Table 2.31, the parents that more frequently participated in these crosses were 7 (participating in five of those crosses) and 1 and 4 (related to four crosses each). Looking at the worst ten yielding crosses, frequent progenitors were number 5 and 8 (participating in four families each) and parent 10 (which produced three of these poor families). The average fresh-root production for the high-soil fertility trial was 28.31 t/ha, ranging from 37.51 (cross 7x10) down to 20.40 t/ha (cross 1x8). It must be remembered that these averages are coming from 30 plants in three replications (90 observations). Therefore an average of 37.51 t/ha is quite remarkable.

Results from the low-fertility trial (Table 2.32) are contrasting with the ones from the first environment. It is interesting to note how the soil fertility affected the capacity of the plants to protect themselves from the foliar diseases. It is well known that under good nutrition the plants can better react against biotic stresses, and that the contrary is also true. The two trials were less than a km away, so the differences in disease pressure can be reasonably explained by the soil fertility factor.

Some results are obvious from the summary presented in Table 2.32. Cross 8x9 had very little level of resistance to super-elongation disease (SED), with an average rating of 4.18. Cross 9x10 had also a high rating (4.12). One immediate conclusion is that, at least, parent 9 had very low levels of resistance to SED. On the other hand, progenitors 1 and 5 produced progenies with good reaction to the disease.

In relation to dry matter content, parent 5 was outstanding in the high-fertility soil trial participating in seven of the 12 best crosses. Parent 10 was the second best, participating in four of the best F1 crosses for this trait. On the other hand, dry matter content under low soil fertility favored crosses from parent 1 (five F1 crosses out of the 12 best); followed by parent 4 (participating in four outstanding crosses); and parents 2, 5 and 7 (with three families each). It is possible that the relatively better performance for the progenies from parent 1, under low-soil fertility roots is due to its outstanding reaction to diseases. If that were the case, this would be another evidence of how adaptation to a particular environment [in this case defined by the prevalent foliar diseases] results in higher dry matter content in the roots.

Table 2.31. Average of each F1-cross from the diallel study planted under high soil fertility conditions at CORPOICA-La Libertad (Villavicencio, Meta Department).

F1 Cross	Plant height (cm)	Plant type (1-5)	Root type (1-5)	Dry matter (%)	Harvest Index.	FR yield (t/ha)
1x2	301.42	2.81	3.08	32.71	0.44	32.68
1x3	296.97	2.94	3.36	30.95	0.43	27.22
1x4	311.28	2.96	3.04	32.82	0.46	32.09
1x5	267.90	3.18	3.69	34.30	0.39	21.77
1x6	268.33	3.01	3.04	31.50	0.48	36.44
1x7	314.33	2.72	2.80	31.26	0.46	33.72
1x8	258.50	3.51	3.76	32.11	0.38	20.40
1x9	286.42	3.59	3.14	31.28	0.41	31.91
1x10	272.22	3.17	3.47	32.08	0.45	30.97
2x3	303.64	2.70	3.35	31.85	0.41	27.15
2x4	293.11	3.15	3.57	32.18	0.40	26.68
2x5	269.89	3.14	3.06	33.66	0.37	26.61
2x6	284.83	3.11	2.88	30.29	0.43	31.05
2x7	294.39	2.98	3.01	31.59	0.45	34.60
2x8	254.86	3.56	3.61	31.70	0.44	26.44
2x9	292.89	3.28	3.43	29.96	0.42	28.73
2x10	242.72	3.26	3.22	33.11	0.46	30.44
3x4	259.25	2.93	3.26	32.15	0.46	26.78
3x5	265.89	3.13	3.18	33.39	0.39	27.66
3x6	259.51	2.64	2.87	30.09	0.45	31.66
3x7	237.22	3.37	3.28	31.14	0.47	24.42
3x8	258.20	3.49	3.75	29.99	0.39	21.82
3x9	279.25	3.18	3.10	30.42	0.42	29.08
3x10	219.22	3.41	3.20	31.78	0.52	26.12
4x5	262.47	3.24	3.31	31.71	0.45	30.12
4x6	257.39	3.04	2.83	31.44	0.51	34.19
4x7	243.50	3.14	2.83	32.47	0.54	34.19
4x8	241.00	3.53	3.63	33.56	0.42	21.88
4x9	276.17	3.14	3.56	31.05	0.41	27.41
4x10	256.28	3.22	3.22	33.57	0.49	32.88
5x6	256.28	2.97	3.24	34.64	0.40	24.21
5x7	257.53	3.10	3.57	33.83	0.42	23.20
5x8	225.42	3.52	3.47	33.19	0.48	27.57
5x9	244.39	3.01	3.44	31.08	0.41	26.22
5x10	241.78	3.43	3.43	33.18	0.37	20.56
6x7	269.11	2.86	3.41	31.60	0.45	22.12
6x8	238.36	3.59	3.25	33.23	0.45	25.00
6x9	284.61	2.88	3.23	30.06	0.43	31.38
6x10	249.67	2.94	3.03	32.92	0.49	31.96
7x8	244.08	3.58	3.16	31.53	0.47	33.76
7x9	263.44	3.40	3.22	31.25	0.41	29.54
7x10	256.22	2.97	2.72	34.10	0.48	37.51
8x9	268.47	3.51	3.35	31.10	0.46	27.20
8x10	220.53	3.79	3.53	32.48	0.46	24.32
9x10	283.89	3.31	3.66	31.34	0.36	22.26
Maximum	314.33	3.79	3.76	34.64	0.54	37.51
Minimum	219.22	2.64	2.72	29.96	0.36	20.40
Mean.	265.17	3.19	3.27	32.04	0.44	28.31
St.Dev.	23.25	0.28	0.27	1.23	0.04	4.47

Table 2.32. Average of each F1-cross from the diallel study planted under low soil fertility conditions at CORPOICA-La Libertad (Villavicencio, Meta Department).

F1 cross	SED (1-5)	CBB (1-5)	Plant type (1-5)	Dry matter (%)	Harvest Index (0-1)	FR yield (t/ha)
1x2	2.26	2.48	2.79	32.78	0.45	18.97
1x3	2.17	2.52	2.67	31.61	0.37	12.61
1x4	2.36	2.46	3.00	32.35	0.43	15.11
1x5	2.20	2.54	2.86	34.49	0.37	14.01
1x6	2.73	2.43	3.26	31.49	0.39	8.31
1x7	2.57	2.63	2.52	32.25	0.44	19.37
1x8	2.49	2.57	3.58	32.20	0.37	11.49
1x9	3.24	2.56	4.08	30.61	0.35	10.90
1x10	3.00	2.33	3.27	32.96	0.34	10.51
2x3	2.97	2.75	3.15	31.37	0.35	10.97
2x4	3.32	2.49	3.59	30.42	0.36	10.23
2x5	2.46	2.52	2.87	34.18	0.44	16.15
2x6	2.93	2.97	3.81	30.96	0.44	14.71
2x7	3.10	2.70	3.04	32.97	0.46	15.24
2x8	3.52	2.88	4.29	28.39	0.41	8.58
2x9	3.89	2.67	4.46	24.33	0.25	4.88
2x10	3.36	2.50	4.04	31.98	0.45	14.14
3x4	2.47	2.63	3.13	32.32	0.48	15.71
3x5	2.23	2.65	3.34	31.69	0.40	11.94
3x6	2.78	3.21	3.74	29.75	0.33	9.60
3x7	2.39	2.89	3.97	29.47	0.35	11.81
3x8	2.64	2.86	4.11	30.28	0.42	7.19
3x9	3.48	2.79	4.29	27.01	0.33	8.54
3x10	2.83	2.69	3.94	29.98	0.41	10.32
4x5	3.01	2.59	3.74	32.48	0.43	12.82
4x6	3.11	2.97	4.10	31.12	0.33	8.88
4x7	2.54	2.61	3.44	32.49	0.49	15.77
4x8	2.81	2.65	4.14	31.67	0.51	15.61
4x9	3.46	2.85	4.58	27.15	0.36	6.94
4x10	3.23	2.45	4.08	32.05	0.45	14.51
5x6	2.28	2.78	3.21	31.62	0.44	14.96
5x7	2.19	2.50	3.25	32.50	0.50	17.64
5x8	2.90	2.76	3.94	31.63	0.47	18.27
5x9	3.31	2.66	4.23	26.47	0.39	11.79
5x10	2.93	2.40	3.92	31.18	0.39	11.12
6x7	2.64	2.75	3.54	29.86	0.44	15.12
6x8	2.53	3.16	4.27	30.53	0.46	16.99
6x9	3.46	2.84	4.49	25.20	0.30	5.12
6x10	3.07	2.67	4.14	30.73	0.39	9.80
7x8	2.77	2.74	4.04	31.65	0.48	17.79
7x9	3.51	2.64	4.39	28.20	0.30	8.53
7x10	3.07	2.69	3.99	32.90	0.44	13.40
8x9	4.18	2.51	4.64	23.11	0.24	3.26
8x10	3.67	2.66	4.37	31.29	0.47	12.71
9x10	4.12	2.13	4.97	23.91	0.18	2.06
Maximum	4.18	3.21	4.97	34.49	0.51	19.37
Minimum	2.17	2.13	2.52	23.11	0.18	2.06
Mean	2.94	2.66	3.76	30.52	0.40	12.10
St.Dev.	0.52	0.20	0.59	2.65	0.07	4.15

Parent 4 produced families with excellent harvest indexes in the two environments where the diallel trials were planted. For the same trait parent 10 produced good progenies in the low-fertility field and parent 7 in the high-fertility field. Parent 9 produced five of the worst families for harvest index in the low-fertility trial, and parent 5 in the high-fertility conditions. This last observation is not surprising because parent 5 (SM 1565-15) is particularly well adapted to the savanna conditions where it shows excellent canopy development. When progenies from this clone are grown in high fertility soils the canopy development may prove to be too excessive, resulting in low harvest index.

For plant type, progenitors 1, 2, 3, 6, and 7 produced the best progenies in the high-fertility trial. In the low-fertility conditions, on the other hand, parent 1, followed by parents 2 and 5 had a superior performance based on the results of their progenies. The good level of resistance to SED found in parent 5 may have contributed to the good rating for plant type, as well.

Table 2.33 Averages of the nine F1-cross families produced by each of the ten parents evaluated in the diallel experiments conducted at CORPOICA – La Libertad (Villavicencio, Meta Department). For each parent, the first line presents the result of the low-fertility trial, and the second line for the high fertility conditions.

Progenitor	SED. (1 - 5)	CBB (1 - 5)	Plant type (1 - 5)	Root type (1 - 5)	Dry matter (%)	Harvest Index (0 - 1)	Fresh roots (t/ha)
1	2.56	2.50	3.11	3.45	32.30	0.39	13.47
CM 4574-7	-.-	-.-	3.10	3.26	32.11	0.43	29.69
2	3.09	2.66	3.56	3.68	30.82	0.40	12.65
CM 6740-7	-.-	-.-	3.11	3.25	31.89	0.42	29.38
3	2.66	2.78	3.59	3.68	30.39	0.38	10.96
CM 7033-3	-.-	-.-	3.09	3.26	31.31	0.44	26.88
4	2.92	2.63	3.76	3.61	31.34	0.43	12.84
SM 1219-9	-.-	-.-	3.15	3.25	32.33	0.46	29.58
5	2.61	2.60	3.49	3.34	31.80	0.43	14.30
SM 1565-15	-.-	-.-	3.19	3.38	33.22	0.41	25.32
6	2.84	2.86	3.84	3.68	30.14	0.39	11.50
SM 2058-2	-.-	-.-	3.00	3.09	31.75	0.45	29.78
7	2.76	2.68	3.57	3.43	31.37	0.43	14.96
SM 2219-11	-.-	-.-	3.12	3.11	32.08	0.46	30.34
8	3.06	2.75	4.15	3.69	30.08	0.43	12.43
HMC 1	-.-	-.-	3.57	3.50	32.10	0.44	25.38
9	3.63	2.63	4.46	4.25	26.22	0.30	6.89
MPER 183	-.-	-.-	3.26	3.35	30.84	0.41	28.19
10	3.25	2.50	4.08	3.76	30.78	0.39	10.95
MTAI 8	-.-	-.-	3.28	3.28	32.73	0.45	28.56

The information from Tables 2.31 and 2.32 has been consolidated in Table 2.33 where the averages of the nine F1 crosses derived from each of the ten progenitors is presented, individually for each environment. Each average is based theoretically on 810 data points (nine crosses, 30 genotypes per cross, and three replications). Therefore, these figures are very solid and reliable.

For resistance to SED, parents 1 (CM 4574-7), 5 (SM 1565-15), and 3 (CM 7033-3) showed the best reaction (low score). On the other hand, parents 8 (HMC-1), 2 (CM 6740-7), 10 (MTAI 8), and 9 (MPER 183) were mediocre based on the reaction of their progenies to the disease. Worth mentioning is that similar conclusions were drawn from the *Clonal Evaluation Trial* (Table 2.29). In was a surprise to find out that the progenies from MTAI 8 presented good levels of reaction to the bacterial blight (CBB), with a score of 2.50 also found in the first parent (CM 4574-7). M TAI 8 was developed in Thailand (where it was named Rayong 60) and it was not known to have resistance to the disease. This situation may be due to some sort of recessive resistance in MTAI 8 (already suggested in the literature) or else, because the levels of CBB were not has high as for SED, therefore, resulting in misleading results. Progenies from SM 2058-2 presented high ratings for CBB, suggesting that this clone is very susceptible to the disease. This would also support what was concluded from the data in Table 2.32 where, five of the worst crosses for CBB included SM 2058-2 as one of the progenitors.

Progenitors 7 (SM 2219), 5 (SM 1656-15), and 1 (CM 4574-7) produced the progenies with highest average productivity in the low-environment trial. MPER 183, on the other hand, produced progenies with very low root productivity (almost half as much as those from the previously mentioned parents). Poor performances in the low-fertility trial were shown by the progenies of MTAI 8 and CM 7033-3. In the high-fertility conditions the progenies from SM 2219-11 showed the highest root-productivity, followed by those from CM 4574-7, SM 1219-9, and CM 6740-7. In this environment the progenies from SM 1565-15, HMC-1 and CM 7033-3 yielded poorly. Many of these conclusions agree with those drawn from the *Clonal Evaluation Trial* (Table 2.29).

Table 2.34. Phenotypic correlations measured in the low-fertility diallel trial conducted at CORPOICA-La Libertad (Villavicencio, Meta Department). Correlations were estimated using averages for each family across the three replications.

	CBB (1-5)	Plant type (1-5)	Root type (1-5)	Fresh root yield (t/ha)	Dry matter (%)	Harvest index (0-1)
SED (1-5)	-0.10	0.77	0.77	-0.73	-0.74	-0.58
CBB (1-5)		0.20	0.01	0.07	-0.10	0.13
Plant type			0.69	-0.64	-0.73	-0.42
Root type				-0.94	-0.82	-0.83
FR yield					0.80	0.88
Dry matter						0.73

Taking advantage of the huge volume of information from these diallel trials the phenotypic correlations shown in Table 2.34 were obtained. Very high correlations with root productivity were found for root aspect score (ρ= -0.94), harvest index (ρ= 0.88), dry matter content (ρ= 0.80), reaction to SED (ρ= -0.73), and plant type score (ρ= -0.64). Negative correlations here are due to the fact that in the scores 1= excellent and 5=very poor performance.

It is also worth mentioning the little association between reaction to CBB and SED. Although there seems to be a negative association (ρ= -0.10), the relationship is weak enough to suggest that it is feasible to obtain genotypes with good levels of reaction to both disease, that is that the traits are likely to be independently inherited and controlled. CBB and root yield showed a low correlation probably because the disease level was not high enough this year.

Table 2.35. Results of the best five clones in **Experiment 1** of the *Preliminary Yield Trials* conducted at CORPOICA – La Libertad (Villavicencio, Meta Departament).

Clone or parameter	Plant type (1 - 5)	Fresh roots (t/ha)	Fresh foliage (t/ha)	Harvest index (0 - 1)	Dry matter (%)	Dry matter (t/ha)
SM 2786-10	2.67	34.58	23.54	0.60	35.48	12.24
SM 2636-6	1.00	24.64	16.09	0.61	32.68	8.12
SM 2636-26	2.00	37.40	30.47	0.55	31.22	11.70
SM 2638-20	1.67	25.94	26.25	0.50	35.28	9.17
SM 2632-4	1.33	23.02	23.75	0.50	34.68	8.07
Statistics of the best 20 clones selected						
Maximum	3.67	37.40	30.52	0.61	37.96	12.24
Minimum	1.00	16.04	14.06	0.46	31.22	5.65
Mean	2.45	25.96	23.57	0.53	34.01	8.81
St.Dev..	0.71	5.62	5.93	0.05	1.82	1.74
Statistics of the 84 clones evaluated						
Maximum	4.67	37.40	31.72	0.61	38.09	12.24
Minimum	1.00	2.40	2.92	0.22	23.13	0.82
Mean	3.13	16.28	16.97	0.47	31.88	5.32
St.Dev..	0.72	7.91	6.98	0.08	2.89	2.67
Average of four checks (Brasilera, Catumare, Reina y HMC 1)						
Mean	3.83	9.14	12.01	0.38	30.16	2.91

The second stage of evaluation according to the diagram illustrated in Figure 2.1 is the *Preliminary Yield Trial*. Similar to what was done in the northern coast the 240 clones selected the previous year from the *Clonal Evaluation Trial*, were split in three different experiments with 80 entries each. The trials had 10-plant plots and three replications each. Four checks (HMC 1, Brasilera, ICA-Catumare or CM 523-7 and CORPOICA-Reina or CM 6740-7) were also included in each trial. Tables 2.35, 2.36, and 2.37 present the most relevant results from these trials.

In **Experiment 1**, family SM 2636 with seven representatives had a prevalent presence among the 20 selected clones. This family comes from the little known clone SM 593-5. The average performance of the 20 selected clones was clearly superior to those of the four checks. For instance for dry matter production the averages were, respectively, 8.81 and 2.91 t/ha (Table 2.35). The selection index for the 20 selected clones was 29.13, whereas for the four checks the same parameter was very deficient: -27.00 (data not shown).

Results from **Experiment 2** are presented in Table 2.36. The full-sib family CM 9460 (derived from the cross CM 6740-7 x CM 4574-7) participated in six of the best 20 clones. Also, family SM 2792 (derived from SM 1565-15) was represented by four clones in the fraction of 20 selected. On average the 20 selected clones yielded almost 8 t/ha of dry matter, compared with 2.37 t/ha for the four checks. Selection indexes from the selected group versus the checks was also very contrasting: 24.47 versus –30.5 (data not shown).

Table 2.36. Results of the best five clones in **Experiment 2** of the *Preliminary Yield Trials* conducted at CORPOICA – La Libertad (Villavicencio, Meta Departament).

Clone or parameter	Plant type (1 - 5)	Fresh roots (t/ha)	Fresh foliage (t/ha)	Harvest index (0 - 1)	Dry matter (%)	Dry Matter (t/ha)
CM 9461-1	2.67	22.71	15.21	0.59	37.81	8.59
SM 2787-1	2.33	36.98	28.44	0.56	29.94	11.07
CM 9460-12	2.00	22.60	23.23	0.49	34.28	7.75
CM 9460-41	3.33	33.13	31.98	0.51	33.52	11.10
CM 9461-3	3.67	25.94	22.92	0.52	36.71	9.52
Statistics of the best 20 clones selected						
Maximum	4.00	36.98	31.98	0.66	37.81	11.10
Minimum	2.00	13.85	7.92	0.45	29.94	4.49
Mean	2.95	23.26	19.65	0.54	34.45	7.95
St.Dev..	0.60	5.69	5.56	0.06	2.14	1.67
Statistics of the 84 clones evaluated						
Maximum	5.00	36.98	31.98	0.68	37.81	11.10
Minimum	1.67	2.81	2.14	0.26	27.76	0.85
Mean	3.43	15.40	15.58	0.49	33.02	5.12
St.Dev..	0.73	7.24	6.90	0.08	2.30	2.47
Average of four checks (Brasilera, Catumare, Reina y HMC 1)						
Mean	4.42	7.24	9.69	0.42	31.72	2.37

The most relevant results from **Experiment 3** are presented in Table 2.37. Family CM 9464 (SM 1411-5 x CM 4574-7) contributed with six of the 20 selected clones. It is interesting to note that one of these parents (SM 1411-5) is not adapted to this eco-region, but has an outstanding performance in the sub-humid environment of the northern coast of Colombia. This result is useful to highlight the advantages frequently observed when crossing materials adapted to different eco-regions. Other family with good representation among the 20

selected clones was CM 9461 (derived from the cross CM 6921 x CM 4574-7). Four of the selected clones belong to this family.

As in the other two experiments, the selected fraction had a much better performance than the four checks. Dry matter yield was 7.25 t/ha versus 3.32 t/ha for the checks. Selection indexes were 24.84 and –10.31 for the selected fraction and the four checks, respectively.

Table 2.37. Results of the best five clones in **Experiment 3** of the *Preliminary Yield Trials* conducted at CORPOICA – La Libertad (Villavicencio, Meta Departament).

Clone or parameter	Plant type (1 - 5)	Fresh roots (t/ha)	Fresh foliage (t/ha)	Harvest index (0 - 1)	Dry matter (%)	Dry matter (t/ha)
CM 9462-17	2.67	34.90	30.31	0.53	32.15	11.27
SM 2727-31	3.67	31.88	20.63	0.60	35.10	8.95
CM 9464-29	3.00	24.17	20.21	0.54	34.97	8.01
CM 9464-19	1.67	14.17	10.00	0.58	31.39	3.22
CM 9461-15	3.33	26.88	17.29	0.60	31.44	7.43
Statistics of the best 20 clones selected						
Maximum	4.67	34.90	35.10	0.61	40.46	11.27
Minimum	1.67	14.17	10.00	0.46	27.10	3.22
Mean	3.35	23.64	21.32	0.52	33.43	7.25
St.Dev..	0.66	5.49	5.86	0.05	3.18	1.79
Statistics of the 84 clones evaluated						
Maximum	3.97	15.30	15.48	0.48	32.57	4.79
Minimum	5.00	34.90	35.10	0.66	40.46	11.27
Mean	1.67	3.33	2.71	0.25	24.59	0.88
St.Dev..	0.61	6.90	6.22	0.07	3.21	2.25
Average of four checks (Brasilera, Catumare, Reina y HMC 1)						
Mean	4.08	9.84	10.31	0.48	32.38	3.32

The results of an *Advanced Yield Trial* conducted at CORPOICA–La Libertad are presented in Table 2.38. Seventy genotypes (of which 5 were checks) were planted in plots of 25 plants each, with three replicates. The materials evaluated in this trial came from a *Preliminary Yield Trial* conducted the previous cycle. Excellent performance was shown by CM 6740-7 (CORPOICA-Reina), who occupied the fifth place, based on the selection index. The first and third clones belong to the same family: CM 8748 (derived from the cross between SM 494-2 and CM 2952-2). Having two sister clones occupying such a relevant position among 70 genotypes provides strong evidence that there is a good genetic material behind them. For a diversity of reasons, many of which are not clear, the general performance of this trial was poorer that those observed in other trials.

Table 2.38. Results from the *Advanced Yield Trial* conducted at CORPOICA – La Libertad (Villavicencio, Meta Department). The trial involved 70 genotypes grown in 25-plant plots and three replications.

Clone or parameter	Plant type (1 - 5)	Root type (1 - 5)	Harvest index (0 - 1)	Dry matter (%)	Fresh root yield (t/ha)	Dry matter yield (t/ha)
CM 8748-4	3.33	2.00	0.52	34.35	23.33	8.03
SM 2375-13	1.67	2.00	0.54	35.08	18.44	6.59
CM 8748-2	3.00	2.00	0.46	28.58	22.89	6.89
SM 2425-3	3.33	2.33	0.55	30.18	21.44	6.46
Reina	***2.33***	***2.33***	***0.49***	***35.83***	***17.56***	***6.30***
SM 2452-3	3.00	2.33	0.50	32.42	19.26	6.27
SM 1807- 1	2.67	2.67	0.50	36.52	16.44	6.06
SM 1773- 2	1.33	2.67	0.41	38.28	13.19	5.11
SM 2456-3	2.00	2.67	0.49	31.72	15.33	4.90
SM 1812-69	2.67	3.00	0.56	33.28	15.63	5.46
Statistics of the best 20 clones selected						
Maximum	3.33	3.67	0.56	38.28	23.33	8.03
Minimum	1.33	2.00	0.41	28.58	12.52	4.35
Mean	2.47	2.70	0.48	34.50	16.55	5.73
St.Dev.	0.67	0.52	0.04	2.59	3.10	0.91
Statistics of the 70 clones evaluated						
Maximum	4.67	4.33	0.61	42.05	23.33	8.03
Minimum	1.33	2.00	0.21	27.08	2.22	0.75
Mean	2.95	3.12	0.44	33.53	12.48	4.24
St.Dev.	0.76	0.57	0.09	2.56	4.13	1.41

Finally in Table 2.39 the results of the first of the four *Regional Trials* that have been harvested and analyzed (one remains to be harvested). CM 6740-7 (CORPOICA – Reina) and CM 4574-7 showed good performances at CORPOICA – La Libertad, but not in the remaining locations. On the other hand CM 523-7 (ICA- Catumare) had a much better adaptation to the first three locations (Cumaral, Barranca de Upía and Santa Cruz) characterized by strong edaphic limitations than at CORPOICA – La Libertad, which has milder problems of soil acidity.

As in the case of the sub-humid environment, the *Preliminary Yield Trials* planted this year will be used also in the acid-soil savannas to compare three criteria of selection: selection index, fresh root productivity and harvest index. Therefore, the *Preliminary Yield Trials* already planted and to be harvested in May 2003, have the following characteristics. Each trial has 64 genotypes, four of them are checks and the remaining 60 are experimental clones. Since there are three experiments, in total 180 experimental clones are under evaluation. Out of these 180 clones 172 had been selected as mentioned in Table 2.27. The remaining eight clones (180-172=8) have been included to carry out this comparison.

Table 2.39 Results from the *Regional Trials* conducted at four locations in the acid soil savannas (Meta Departament). The 32 genotypes are ranked according to their respctive selection index.

Clone	Plant type	Harvest index	Dry matter	Fresh root	Dry matter	RANKINGS			
	(1-5)	(0-1)	(%)	(t/ha)	(t/ha)	Cumaral	Bca.Upia	Sta.Cruz	CORPOICA
SM 2219-11	2.17	0.65	26.58	35.76	12.65	8	5	1	9
CM 6921- 3	2.00	0.51	30.80	32.00	12.92	1	4	8	13
SM 1363-11	2.50	0.56	28.54	31.71	12.88	15	6	11	2
SM 1143-18	2.09	0.57	27.75	34.13	12.49	2	14	15	5
SM 667-1	2.08	0.55	25.21	37.46	11.92	7	9	6	15
SM 1405-5	2.33	0.53	29.75	23.88	9.50	17	7	3	20
BRASILERA	2.75	0.56	26.87	32.85	12.41	3	8	24	14
CM 6975-14	2.75	0.52	26.63	36.07	12.82	22	2	21	6
MBRA 502	2.83	0.53	26.86	33.89	12.23	13	10	7	23
SM 1864-10	2.08	0.56	27.04	29.82	10.65	4	22	20	8
CM 523- 7	2.50	0.49	27.30	23.83	8.92	14	1	10	29
SM 1353-3	2.92	0.60	26.99	33.06	12.18	10	30	12	3
CM 5306- 8	2.42	0.53	28.41	27.99	10.55	18	12	2	24
SM 1152-13	2.92	0.56	29.13	33.59	12.63	5	28	22	1
SM 1694-2	2.50	0.49	27.72	23.35	9.39	24	3	5	25
SM 1699-26	2.33	0.54	27.38	25.90	9.66	16	16	4	22
SM 1862-25	2.59	0.52	28.28	27.53	10.15	11	15	16	19
CM 4574-7	2.25	0.55	24.12	32.74	10.84	23	18	18	4
CM 6740-7	2.92	0.54	26.23	33.15	11.91	28	13	17	7
SM 1794-18	3.25	0.53	28.36	25.67	10.13	21	11	9	27
CM 6438-14	2.75	0.53	27.05	28.64	10.53	9	26	13	21
SM 1859-26	3.00	0.52	26.31	33.52	11.99	6	17	29	17
SM 1810-6	2.75	0.54	27.81	23.64	9.42	20	21	19	11
CM 7052- 3	2.34	0.50	26.92	22.04	7.78	12	29	26	18
CM 6055-3	3.00	0.58	24.47	26.52	9.46	26	24	25	12
SM 1241-12	3.00	0.59	24.00	26.72	8.40	27	31	14	16
SM 1854-23	3.17	0.58	26.04	24.68	8.68	19	23	23	26
SM 1697-1	3.58	0.56	23.21	29.63	9.93	30	27	31	10
SM 1565-15	3.42	0.47	26.58	20.32	7.67	25	19	28	30
SM 1483-1	2.58	0.42	21.99	11.85	3.76	31	20	27	31
CM 2177- 2	3.17	0.46	25.68	18.12	6.17	29	25	30	28
SM 1872-9	3.33	0.44	17.48	7.71	1.82	32	32	32	32
Parameters						**Dry matter yield statistics for each location**			
Maximum	3.58	0.65	30.80	37.46	12.92	24.12	18.30	8.79	16.39
Minimum	2.00	0.42	21.99	11.85	3.76	2.78	2.41	1.04	1.07
Mean	2.68	0.54	26.77	28.39	10.34	14.84	11.48	4.93	9.05
St. Dev.	0.42	0.04	1.88	5.86	2.16	5.12	3.73	2.14	3.89

Each criteria of selection will be represented by the best 20 clones (from the *Clonal Evaluation Trial* harvested this year) for Harvest Index, fresh root yield, and selection index. Because the selection criteria for the breeding project is the selection index, obviously, the 20

best clones for this criteria were included among the 172 clones. Also, many but not all of the best 20 clones for high yield and harvest index were among the 172 selected. Only eight were among the best 20 for harvest index or fresh root yield, but had not been selected for breeding purposes. They were included in the *Preliminary Yield Trial*, however, to carry out the comparison mentioned above. Table 2.40 describes the main characteristics of each of the three groups. Obviously, some clones participate in more than one of those three groups.

Table 2.40 Statistics of the three groups of 20 clones (some clones shared by more than one group) planted to compare three selection criteria.

Parameters	Plant type (1 - 5)	Fresh root yield (t/ha)	Harvest index (0 - 1)	Dry matter (t/ha)	Dry matter (%)	Selection index
Best 20 clones for Harvest Index						
Maximum	5.00	32.57	0.77	11.11	37.63	66.28
Minimum	1.00	5.71	0.57	1.78	27.12	3.20
Mean	3.40	18.61	0.61	5.86	31.36	29.35
St.Dev.	1.14	6.77	0.05	2.32	3.21	18.10
Best 20 clones for Fresh Root Yield						
Maximum	4.00	36.14	0.58	12.59	35.67	77.85
Minimum	1.00	27.43	0.35	7.87	26.37	31.53
Mean	2.37	30.66	0.50	9.60	31.33	50.54
St.Dev.	0.90	2.65	0.05	1.14	2.47	11.86
Best 20 clones for selection index						
Maximum	3.00	35.71	0.63	11.11	36.68	69.10
Minimum	1.00	17.14	0.42	6.13	28.41	48.62
Mean	1.63	27.18	0.50	8.96	33.20	55.51
St.Dev.	0.60	5.18	0.05	1.41	2.11	6.27

2.4.3. Selections for the Mid-altitude valleys

As for other eco-regions, the most relevant experiments conducted in the Valle del Cauca will be listed first (Table 2.41) followed by results specific to each type of evaluation. As for the other regions already discussed, many improvement activities developed here also benefited other areas. For the mid-altitude valleys the selection index utilized was as follows:

Selection Index = [Fresh root yield ∗ 10] + [Dry matter content ∗ 8] - [Plant type ∗ 5] +
+ [Harvest Index ∗ 5]

This selection Index is identical to the one used for the sub-humid environment in the northern coast.

Table 2.41. Trials conducted in the Department of Valle del Cauca, Colombia, during 2000-2001.

Trial	Site	N° of genotypes	N° of reps	**Observations**
F1	Cenicaña	1500	1	In the new selection scheme the plants are left growing in the field for 10 months.
Clonal Evaluation	Palmira	880 (7)	1	See Table 2.42 to 2.44
Diallel study	Jamundi			See Table 2.45 and 2.46
	Palmira			See Table 2.47 and 2.48
Preliminary Yield Trial	Palmira	110 (10)	3	See Table 2.51
Regional Trials	Buga	34 (25)	3	See Table 2.52
	Jamundí	34 (25)	3	See Table 2.52
	S.Quilichao	34 (25)	3	See Table 2.52
	Bocas Palo	34 (25)	3	See Table 2.52
	Vijes	34 (25)	3	See Table 2.52
	Morales	34 (25)	3	See Table 2.53
	La Cumbre	33 (25)	3	See Table 2.54

¶ Values in parentheses refer to the number of plants per plot. § Genotypes involved in the diallel experiment.

The problems of frogskin disease and whitefly

Most problems with frogskin disease are related to sources of inoculum and transmission by vector insect(s) from infected to healthy plants. Strategies for reducing problems aim to reduce sources of inoculum, on the one hand, and vector populations, on the other. Measures taken to control the disease are summarized below. Two years ago, CIAT initiated a process of *indexation* to confirm that the materials it held were free of viral diseases. For frog skin disease, indexation is carried out by grafting a bud of the hypersensitive variety *'Secondina'* on to the variety to be indexed. *Secondina* is highly sensitive to the presence of the disease's causal agent, and the graft will detect any contaminated material. However, this technique is slow, requiring up to three months for final diagnosis, and is labor intensive. Even so, a very large proportion of the germplasm bank has already been indexed, together with the major varieties planted. The materials confirmed free of frogskin disease (and other viral diseases) were grown in isolated environments where only "clean" germplasm had been planted. Careful management for whitefly was carried out to prevent this vector introducing viral diseases. Fields were located where no commercial plantings of cassava were nearby.

Even if only indexed materials are planted at CIAT and careful management for whitefly populations is carried out, insects carrying disease may eventually arrive from nearby areas.

The decision has therefore been made not to extract vegetative seed from cassava without previously inspecting the roots to confirm that the plant is indeed free of symptoms. This will help eliminate any plant that may have been infected during growth at CIAT (except those cases where infection occurred late in the plant's development and symptoms have not had time to be expressed). This method has been confirmed as helping in reducing disease incidence to a certain degree.

The results from the *Clonal Evaluation Trial* harvested in June are presented in Table 2.42. The trials included as many as 880 genotypes represented by seven plants each. The trial was planted in CIAT Experimental Station in Palmira. At harvest time, 39 clones showed suspicious symptoms for frog skin disease, and were discarded as a preventive measure. This level of contamination represents about 4% of incidence, a much lower level than that found in previous years. One hundred and forty clones were selected from this trial. Average fresh root yield for the whole trial was 28.9 t/ha and for the selected fraction the average was an impressive 48.15 t/ha. Dry matter productivity for all the clones evaluated averaged11.07 t/ha, whereas for the selected fraction it was 19.24 t/ha.

Table 2.42. The most relevant results from *Clonal Evaluation Trial* evaluated at CIAT-Palmira. Department of Valle del Cauca, Colombia, during August 2001 to June 2002.

Clone or parameter	Plant type (1 - 5)	Dry matter (%)	Fresh roots (t/ha)	Fresh foliage (t/ha)	Harvest Index (0 - 1)	Dry matter (t/ha)
GM 265-82	2	42.18	81.25	59.58	0.58	34.27
CM 9901-112	1	41.29	63.33	30.00	0.68	26.15
GM 311-42	2	41.55	79.58	69.79	0.53	33.06
GM 311-55	4	40.14	93.13	62.92	0.60	37.38
GM 260-32	2	40.90	66.67	38.54	0.63	27.27
GM 284-58	3	40.16	76.04	42.71	0.64	30.54
GM 292-46	1	39.91	58.96	30.42	0.66	23.53
GM 271-43	3	41.50	65.42	29.17	0.69	27.15
GM 234-119	1	39.09	66.67	50.83	0.57	26.06
GM 268-35	1	41.92	47.92	27.29	0.64	20.09
GM 312-65	1	38.05	68.54	52.71	0.57	26.08
GM 309-67	1	42.24	51.04	43.13	0.54	21.56
Statistics from the best 140 clones						
Maximum	5.00	45.50	93.13	101.25	0.80	37.38
Minimum	1.00	34.50	22.29	8.33	0.42	9.36
Mean	2.60	40.14	48.15	29.54	0.64	19.24
St. Deviation	0.92	1.85	13.75	17.21	0.07	5.28
Statistics from the 880 clones evaluated						
Maximum	5.00	45.53	93.13	157.08	0.83	37.38
Minimum	1.00	22.39	0.19	1.23	0.07	0.07
Mean	3.33	37.97	28.91	24.24	0.56	11.07
St. Deviation	0.98	2.94	16.39	19.18	0.13	6.40

Table 2.43 Averages of the families that participated in the *Clonal Evaluation Trial* conducted at CIAT – Palmira and harvested in June, 2002. The trial had 880 genotypes.

Family	# clones	Selection Index	Select. clones (%)	Plant type (1 - 5)	Fresh roots (t/ha)	Dry matter (%)	Harvest Index (0 - 1)	Frog skin (%)
CM 9733	26	-8.94	7.7	3.31	28.46	34.81	0.55	0.0
CM 9901	33	11.56	33.3	2.88	31.27	39.02	0.68	0.0
CM 9903	24	9.76	37.5	2.58	28.68	38.34	0.68	8.3
CM 9945	15	-0.42	6.7	3.60	34.13	37.59	0.52	13.3
CM 9946	29	-13.22	0.0	3.48	4.14	39.70	0.51	10.3
CM 9949	17	-18.58	0.0	3.44	3.97	37.66	0.51	0.0
CM 9953	20	2.75	0.0	3.30	23.99	38.03	0.70	5.0
GM 228	39	3.21	12.8	2.92	23.74	38.79	0.61	0.0
GM 230	36	6.92	16.7	3.29	30.56	39.06	0.62	0.0
GM 231	28	0.62	17.9	3.36	27.43	37.77	0.61	0.0
GM 234	41	8.54	19.5	2.83	35.06	38.14	0.60	0.0
GM 235	24	8.29	33.3	2.92	30.45	38.68	0.64	0.0
GM 254	25	11.33	28.0	3.17	28.71	40.09	0.68	0.0
GM 257	25	12.86	40.0	3.44	30.04	41.28	0.65	0.0
GM 260	16	-0.44	18.8	3.38	23.46	38.84	0.58	0.0
GM 264	23	5.82	17.4	3.30	30.98	38.27	0.65	4.3
GM 265	36	1.00	8.3	3.33	27.90	37.98	0.60	5.6
GM 268	17	3.54	29.4	3.38	26.84	38.62	0.64	5.9
GM 269	8	8.01	12.5	2.88	30.23	37.80	0.69	25.0
GM 271	14	2.50	28.6	3.64	34.32	36.92	0.65	7.1
GM 283	8	-1.31	12.5	3.75	25.23	39.33	0.54	0.0
GM 284	41	8.44	36.6	3.37	37.98	38.97	0.56	12.2
GM 292	17	5.31	17.6	3.41	32.48	38.43	0.61	5.9
GM 293	11	0.57	9.1	3.55	30.63	38.30	0.55	9.1
GM 294	10	-9.79	10.0	3.67	39.05	34.70	0.42	0.0
GM 296	18	-3.77	11.1	3.28	23.45	37.40	0.58	5.6
GM 297	8	-4.80	0.0	3.13	28.98	34.88	0.62	12.5
GM 298	35	-23.68	0.0	3.00	3.08	35.88	0.46	20.0
GM 306	9	-17.44	0.0	3.11	35.76	32.56	0.35	0.0
GM 308	21	-12.20	4.8	3.24	30.29	35.53	0.38	4.8
GM 309	41	-1.04	12.2	3.40	39.89	36.49	0.47	0.0
GM 310	36	-5.12	11.1	3.34	29.53	37.70	0.43	0.0
GM 311	32	-2.61	12.5	4.22	37.21	38.54	0.44	0.0
GM 312	42	-4.18	9.5	3.89	33.68	38.31	0.42	2.4
GM 313	37	-3.58	18.9	3.57	34.56	37.37	0.45	5.4
GM 314	18	-4.89	0.0	4.00	36.99	37.09	0.45	22.2
Total	880	-.-	-.-	-.-	-.-	-.-	-.-	39
Mean	24	0.0	0.16	3.34	28.70	37.75	0.56	0.04

The 140 clones selected from the *Clonal Evaluation Trial* will be planted in three different experiments, in this case with 49 clones each. The total number of clones to participate in these experiments, therefore, will be 147 (49 x 3). The difference between the 140 clones selected and the 147 clones that will make up the next phase of evaluation gives the possibility of incorporating seven checks. The number 49 allows for a square lattice design, which will be used in all the evaluations at the *Preliminary Yield Trial* level.

The *Clonal Evaluation Trial* is not only the source of promising clones for the next stage of evaluation. The information from the trials is used to determine the how good the progenitors used to generate new clones are. Therefore, the data from the trial has been condensed to produce the information presented in Table 2.43. In this table, the average of each family for the most relevant traits are provided.

Families CM 9945, GM 269, GM 284, GM 297, GM 298 and GM 314 presented an unquestionable incidence of frog skin disease. It is assumed (and there are good justifications for this assumption) that frog skin disease is not transmitted through the botanical seed. The stakes for this trial come from plants grown the previous cycle at CENICAÑA, in a relatively isolated field, surrounded by sugar cane. At the F1 stage the F1-plants from the same family are planted together one after the other in the same row. For logistic reasons, the clones from the same family at the *Clonal Evaluation Trial* are also planted one after the other. In this case, however, there were seven plants representing each clone (not one as in the F1 stage). Therefore, the seven plants of each clone were planted together in 1-row plot, and in the following plot there will be the second clone from the same family and so forth. This information is relevant to understand what may have happened with frog skin disease. A quick review of the levels of incidence for each family, would suggest that there were three or four foci where the disease was probably introduced. It is not possible, however, to determine if the infection took place at the F1 or at the *Clonal Evaluation* stages, or in both instances. This situation is another justification for the decision taken to split each family in three groups planted scattered through the *Clonal Evaluation Trial*. In this way, at least for the familiy unit, there will be the equivalent of three replications. Had we done this a year before we could have circumstantial evidence that the infection occurred at the F1 stage, for instance.

Few families had an outstanding performance, based on the proportion of their clones that had been selected (Table 2.43). CM 9901, CM9903, GM 235, GM 257, and GM 284 had the highest proportion of selected clones (> 30%) and the highest averages for selection index (> 8.0). In contrast, families CM 9946, CM 9949, CM 9953, GM 297, GM 306, and GM 314 had not a single clone selected from them which, with one exception, was associated with negative selection indexes.

The highest productivity was observed in family GM 284 with an average yield of almost 38 t/ha of fresh roots, and optimum level of dry matter content (38.97%). However, plant type may not be a strength for this germplasm (average score slightly worse than the average of the population). Family GM 257 had poor plant architecture (average score = 3.44) but was excellent for its dry matter content (41.28%). Although fresh root productivity in this family was not the highest, it presents the highest proportion of selected clones. Families CM 9901,

CM 9903, and GM 235 had excellent yields and good dry matter contents along with good plant type (average scores < 3.0).

All the families that failed to have at least one clone selected where characterized by their poor plant type (except for family GM 298). Yield productivity of CM 9946, CM 9949, CM 9953 and GM 298 was very low and can explain their failure in having some of their clones selected. GM 297 and GM 306 had much higher yields, but their dry matter content were too low (< 35%), and therefore, the selection index correctly rejected them. GM 314 presented good yields and high dry matter contents in the roots, but it had very poor plant type (average score = 4.0) and low harvest index (0.45). This family was also severely affected by frog skin disease.

The data from the *Clonal Evaluation Trial* can be further condensed by looking at the averages of all the progenies derived from a common progenitor (Table 2.44). Clones CM 6740-7 (CORPOICA-Reina), SM 1636-24, SM 1741-1 and, surprisingly, MTAI 8 are outstanding based on the proportion of their progenies being selected (> 20%).

Table 2.44. Averages for the progenies derived from a common parent. The information comes from the *Clonal Evaluation Trial* harvested in CIAT-Palmira in June 2002. A total of 880 had been evaluated.

Progenitor	Families (#)	Progeny size (#)	Select. clones %	Plant type (1 - 5)	Fresh roots (t/ha)	Dry matter (%)	Harvest Index (0 - 1)	Frog Skin (%)	Selection Index.
CM 6740-7	8	246	21.54	3.00	29.75	38.30	0.61	1.22	5.29
CM 6754-8	1	15	6.67	3.60	34.13	37.59	0.52	13.33	-0.42
SM 805-15	3	61	1.64	3.50	11.47	38.61	0.51	8.20	-11.57
SM 1219-9	8	219	19.63	3.27	30.63	38.57	0.61	1.83	5.30
SM 1278-2	6	139	18.71	3.20	27.95	38.48	0.59	2.88	2.76
SM 1411-5	1	29	0.00	3.48	4.14	39.70	0.51	10.34	-13.22
SM 1565-17	1	17	0.00	3.44	3.97	37.66	0.51	0.00	-18.58
SM 1636-24	5	142	25.35	3.57	33.81	39.32	0.56	3.52	5.80
SM 1673-10	8	149	15.44	3.57	30.17	38.13	0.54	2.68	-0.78
SM 1741-1	8	173	21.39	3.25	31.51	37.97	0.59	8.67	3.19
SM 2058-2	1	35	0.00	3.00	3.08	35.88	0.46	20.00	-23.68
SM 2219-11	1	35	0.00	3.00	3.08	35.88	0.46	20.00	-23.68
HMC 1	6	137	12.41	3.27	31.49	37.31	0.57	5.11	0.75
MECU 72	8	236	10.59	3.64	34.77	37.22	0.43	3.39	-4.74
MPER 183	6	103	9.71	3.37	30.77	36.00	0.56	3.88	-4.42
MTAI 8	1	24	33.33	2.92	30.45	38.68	0.64	0.00	8.29

In the case of MTAI 8 few clones were representing the parental properties of this clone, so the results should be taken with some caution. However, this result is another evidence of the advantage of making crosses among clones adapted to different eco-regions. That was the case from SM 1411-4 which, being adapted to the northern coast, produced good progenies for the acid soil savannas. As a matter of fact CM 6740-7 (released for the acid soil savannas) is another example of a clone from adapted to one eco-region producing good progenies adapted to a different environment.

The progenies from SM 1636-24 had the highest selection index average (5.80), except for MTAI 8 that had too few clones representing it. The average productivity of the progeny from this clone was very high (33.81 t/ha of fresh roots), second only to those from CM 6754-8 (34.13 t/ha), but with much higher dry matter content (39.32 versus 37.59%). In any case, CM 6754-8 was represented by only 15 clones. It is obvious that the major limiting factor for the progenies derived from SM 1636-24, is the plant architecture, which is also related to a relatively low harvest index.

It is interesting to note the poor performance of the progenies from MPER 183. This clone, per se, has excellent properties. However, it proved to be a very poor progenitor both, for the acid soil savannas and the mid-altitude valleys. SM 805-15 is another case of a good clone that is not a good progenitor. It should be remembered that the progeny from this clone was very mediocre when evaluated in the sub-humid conditions from the northern coast (Table 2.17). Both clones are going to be eliminated from the crossing blocks based on this consistent information.

In general, there is no clear trend regarding frog skin disease, emerging from Table 2.44. Only two progenitors (MTAI-8 and SM 1565-17) produced symptoms-free progenies, but they were small progenies and represented only one family in each case. The opposite happened with the cross between SM 2058-2 x SM 2219-11 which resulted in the highest frog skin incidence (20%). Having been represented by a single family of clones located in one part of the field, it is not justifiable to conclude that this family is particularly susceptible to frog skin. It may have been just the position where it was planted, rather than a higher tendency to get infected.

As was the case for the sub-humid and acid-soil savannas environments, a dialed study was also conducted for the mid-altitude valleys. A set of nine parents was used. As in the other diallels, 30 clones represented each F1 cross. Two locations with three replications in each were used to obtain the data. Results from the evaluation at CIAT-Palmira are presented in Tables 2.45 and 2.46, and those from AGROVELEZ-JAMUNDI are in Tables 2.47 and 2.48. The same variables are presented for the diallel studies at the two locations, with the exception of scoring for mites at CIAT-PALMIRA and for white flies at AGROVELEZ-JAMUNDI. The fact that no reliable data for white flies could be taken at CIAT-PALMIRA reflects the success of the measures taken to control this problem. In effect, white flies pressure at CIAT's experimental station in Palmira was very low during the reported period because of the interruption of cassava planting for one month every year. This measure disrupts white flies cycle and has resulted in a significant reduction of this problem in our plantings at this station.

Table 2.45 Average for the crosses (based on 30 clones) from a 9-parent diallel conducted at CIAT-PALMIRA.

Cross	Mites (1 to 5)	Plant Type (1 to 5)	Harvest Index (0 to 1)	Dry matter (%)	Fresh roots (t/ha)
1x2	3.34	3.15	0.55	35.29	50.88
1x3	3.07	3.18	0.50	35.92	36.17
1x4	3.09	3.22	0.47	36.15	46.15
1x5	3.83	3.59	0.54	36.11	36.63
1x6	3.13	2.94	0.54	36.03	46.65
1x7	3.85	3.11	0.54	34.25	41.02
1x8	2.63	2.39	0.44	36.19	56.16
1x9	3.70	3.24	0.46	37.17	34.81
2x3	3.90	3.45	0.55	35.55	40.58
2x4	3.69	3.26	0.54	33.80	37.84
2x5	3.56	3.19	0.58	36.35	45.41
2x6	3.92	3.15	0.54	35.67	43.28
2x7	4.17	3.32	0.55	35.46	44.64
2x8	2.69	2.61	0.52	34.32	61.72
2x9	3.71	2.91	0.53	34.74	64.74
3x4	4.36	3.23	0.49	34.38	41.66
3x5	3.75	3.35	0.52	36.11	31.39
3x6	3.80	3.24	0.59	35.39	41.01
3x7	4.20	3.52	0.52	34.24	34.04
3x8	3.24	3.09	0.46	34.97	45.12
3x9	4.04	2.99	0.49	34.05	48.98
4x5	3.95	3.52	0.50	36.44	36.06
4x6	3.79	2.87	0.50	36.34	44.74
4x7	4.15	4.11	0.48	33.34	29.85
4x8	2.98	2.92	0.43	35.72	49.00
4x9	3.90	3.08	0.52	34.70	61.58
5x6	3.86	3.29	0.62	37.46	51.56
5x7	4.27	3.66	0.52	34.96	37.10
5x8	2.75	3.08	0.46	35.66	50.22
5x9	4.06	3.43	0.50	33.89	46.20
6x7	4.01	3.30	0.57	35.68	42.99
6x8	2.66	2.84	0.52	35.00	44.47
6x9	3.71	2.69	0.58	35.19	57.94
7x8	3.67	3.08	0.47	34.04	47.64
7x9	4.23	3.11	0.54	33.97	47.63
8x9	2.59	2.76	0.43	33.40	52.79
Maximum	4.36	4.11	0.62	37.46	64.74
Minimum	2.59	2.39	0.43	33.34	29.85
Mean	3.62	3.16	0.52	35.22	45.24
St.Dev.	0.52	0.32	0.05	1.03	8.45

Table 2.45 shows the averages for each F1 cross in the diallel at Palmira. The average fresh root yield was 45 t/ha is excellent, considering that it involves 1080 new genotypes. Averages for F1 families ranged from 29.85 to 64.74 t/ha. Best yields were observed for crosses 2x9, 2x8, and 4x9, with mean yields of 64.74, 61.72, and 61.58 t/ha, respectively. Similarly, these crosses presented the highest dry matter yields exceeding 21 t/ha. High dry matter content in the roots was observed from crosses involving parents 5 (SM 1673-10) and 6 (SM 1741-1).

Results from the diallel at Palmira were consolidated to obtain the averages for the progenies of each progenitor (Table 2.46). The best two parents for fresh root yield were MPER 183 and MECU 72 with average yields above 50 t/ha. This reveals the advantages of having the access to materials from the germplasm bank (both progenitors are landraces from Peru and Ecuador, respectively). In addition, MECU 72, is not only a valuable source of resistance to white flies, but also posses good levels of resistance to mites. SM 1278-2 and HMC-1 were the worse progenitors based on the average root productivity of their progenies.

Table 2.46. Averages of all the progenies from each of the parents included in the diallel study conducted at CIAT-PALMIRA.

Progenitor	Mites (1 to 5)	Plant Type (1 to 5)	Harvest Index (0 to 1)	Dry matter (%)	Fresh roots (t/ha)
1= CM 6740-7	3.33	3.10	0.51	35.89	43.56
2 = SM 1219-9	3.62	3.13	0.55	35.15	48.63
3 = SM 1278-2	3.80	3.26	0.52	35.08	39.87
4 = SM 1636-24	3.74	3.28	0.49	35.11	43.36
5 = SM 1673-10	3.75	3.39	0.53	35.87	41.82
6 = SM 1741-1	3.61	3.04	0.56	35.84	46.58
7 = HMC 1	4.07	3.40	0.52	34.49	40.62
8 = MECU 72	2.90	2.85	0.47	34.91	50.89
9 = MPER 183	3.74	3.02	0.51	34.64	51.83
Maximum	4.07	3.40	0.56	35.89	51.83
Minimum	2.90	2.85	0.47	34.49	39.87
Average	3.62	3.16	0.52	35.22	45.24

SM 1673-10, CM 6740-7, and SM 1741-1 produced progenies with higher dry matter content based on the results from Palmira, whereas MPER 183, MECU 72, and HMC-1 generated progenies with low dry matter in their roots. HMC-1 also was characterized by progenies with higher susceptibility to mites (Table 2.46). The results so far analyzed from the diallel study illustrate, once amore, the difficulties in combining in one genotype desirable traits. For instance, MPER 183 has excellent levels of root productivity but very low dry matter contents (explaining the results from the *Clonal Evaluation Trial*). On the other hand, CM 6740-7 has high dry matter content, but its productivity was not as outstanding. HMC-1 also has high dry matter content, but low root productivity and clear susceptibility to mites.

The best crosses for dry-matter yield were 2x9 (22.49 t/ha), 4x9 (21.37 t/ha), 6x9 (20.39 t/ha), and 1x8 and 2x8 (both with 20.32 t/ha). Parent 9 is in three of these five crosses.

Table 2.47. Average for the crosses (based on 30 clones) from a 9-parent diallel conducted at AGROVELEZ-JAMUNDI.

Cross	White flies (1 to 5)	Plant Type (1 to 5)	Harvest Index (0 to 1)	Dry matter (%)	Fresh roots (t/ha)
1x2	3.07	3.54	0.40	29.95	50.43
1x3	2.56	3.31	0.42	35.02	49.12
1x4	2.71	2.89	0.42	31.60	48.35
1x5	2.94	3.08	0.40	32.93	49.29
1x6	3.09	3.06	0.45	33.30	53.45
1x7	3.18	3.21	0.47	32.62	55.94
1x8	1.73	3.19	0.38	30.34	50.71
1x9	2.97	2.92	0.38	33.69	41.26
2x3	2.87	3.18	0.50	33.50	56.47
2x4	3.38	3.34	0.35	27.95	35.46
2x5	2.65	3.23	0.46	32.38	52.17
2x6	3.83	2.99	0.46	34.15	46.20
2x7	2.99	3.12	0.41	31.00	44.95
2x8	1.61	3.48	0.41	28.61	59.26
2x9	2.67	2.69	0.42	31.27	60.18
3x4	4.13	3.04	0.44	32.81	42.96
3x5	3.37	3.08	0.42	33.85	40.26
3x6	3.75	3.29	0.41	34.51	37.60
3x7	3.46	3.15	0.46	34.00	39.27
3x8	2.06	2.97	0.39	32.89	46.92
3x9	3.11	3.15	0.39	32.48	49.91
4x5	3.00	3.08	0.37	32.49	41.54
4x6	3.60	3.22	0.38	32.92	43.76
4x7	3.47	3.26	0.38	29.74	31.38
4x8	2.00	3.12	0.35	31.20	50.07
4x9	3.67	2.84	0.43	31.04	57.41
5x6	3.48	3.13	0.52	35.15	56.92
5x7	3.21	3.05	0.44	32.66	43.09
5x8	1.69	3.18	0.36	30.44	42.48
5x9	3.24	3.08	0.37	30.30	42.58
6x7	3.57	3.23	0.48	33.55	47.80
6x8	3.02	3.34	0.37	30.28	38.42
6x9	3.73	2.81	0.44	32.41	56.67
7x8	2.05	3.35	0.41	30.88	52.76
7x9	3.45	2.84	0.46	31.44	64.42
8x9	1.82	2.88	0.34	28.89	46.87
Maximum	4.13	3.54	0.52	35.15	64.42
Minimum	1.61	2.69	0.34	27.95	31.38
Average	2.98	3.12	0.41	32.01	47.95
St. Dev.	0.66	0.19	0.04	1.80	7.59

Results from the diallel at Jamundí are presented in Tables 2.47 and 2.48. Although there was severe pressure from white flies, average fresh root yield were higher than at Palmira (47.95 versus 45.24 t/ha). Root dry-matter content in Jamundí, however, was lower than at Palmira (32.01 versus 35.22 %). Best crosses for fresh root production at Jamundí were 7x9, 2x9, and 2x8.with 64.4, 60.2, and 59.3 t/ha, respectively. Crosses 2x9 and 2x8 also had been among the highest yielding F1-cross families at Palmira.

Table 2.48. Averages of all the progenies from each of the parents included in the diallel study conducted at AGROVELEZ-JAMUNDI.

Progenitor	White flies (1 to 5)	Plant Type (1 to 5)	Harvest Index (0 to 1)	Dry matter (%)	Fresh roots (t/ha)
CM 6740-7	2.78	3.15	0.41	32.43	49.82
SM 1219-9	2.88	3.20	0.42	31.10	50.64
SM 1278-2	3.16	3.15	0.43	33.63	45.31
SM 1636-24	3.24	3.10	0.39	31.22	43.87
SM 1673-10	2.95	3.11	0.42	32.52	46.04
SM 1741-1	3.51	3.13	0.44	33.28	47.60
HMC 1	3.17	3.15	0.44	31.99	47.45
MECU 72	2.00	3.19	0.38	30.44	48.44
MPER 183	3.08	2.90	0.40	31.44	52.41
Maximum	3.51	3.20	0.44	33.63	52.41
Minimum	2.00	2.90	0.38	30.44	43.87
Average	2.98	3.12	0.41	32.01	47.95

Data from Table 2.48 suggest again a good performance of the progenies from MPER 183 with the highest levels of average fresh root production (52.41 t/ha), followed by SM 1219-9 (50,64 t/ha) and CM 6740-7 (49.82 t/ha). In relation to dry-matter contents, the progenies from SM 1278-2 and SM 1741-1 were the only to average above 33 %. As was observed in Palmira, the progenies from MPER 183 and MECU 72 had low dry matter contents (31.44 and 30.44 %, respectively).

SM 1741-1 proved to be susceptible to white flies (average score 3.51) and as expected, MECU 72 produced progenies with excellent reaction to this insect (average score 2.00). The progenies from CM 6740-7 and SM 1219-9 showed good levels of resistance to white flies (average scores < 3.00).

Table 2.49. Correlations for measurements taken at CIAT-PALMIRA and AGROVELEZ-JAMUNDI based on the F1-cross family averages.

Plant type 1-5	Root type 1-5	Root color 1-5	Pulp color 1-9	Commercial roots (No.)	Fresh foliage (kg/pl)	Dry matter (%)	Harvest index (0-1)	Fresh root Yield (t/ha)
0.05	0.53	0.97	0.91	0.28	0.81	0.57	0.69	0.68

The highest dry-matter yields observed at Jamundí were from crosses 7x9 (20.25 t/ha), 5x6 (20.01 t/ha), 2x3 (18.92 t/ha), 2x9 (18.82 t/ha), and 6x9 (18.37 t/ha). Two of these five families of crosses (2x9 and 6x9), also were among the highest yielding materials at Palmira.

The problem of combining different desirable traits into one genotype is one of the difficulties frequently encountered by plant breeders. A second other limitation occurs when clones with outstanding performance in one location have a poor one in a second location, resulting in high genotype by environment interactions. Table 2.49 shows the correlations for several variables measured at Palmira and Jamundí. Correlations are based on the average for each F1 cross (across three replications of each location). Fresh root at both locations showed a good correlation of 0. 68. In general all correlations were high (> 0.50) with the exception of plant type ($\rho = 0.05$) and number of commercial roots ($\rho = 0.28$). It is possible that the low correlation for plant type is a result of the two different insect pests (mites in Palmira and white flies in Jamundí) affecting the trials. The reaction to these pests has a strong effect on the plant aspect variable, as well.

A last result of the diallel study is presented in Table 2.50, where phenotypic correlations among variables at each location are summarized.

Table 2.50 Phenotypic correlations among variables measured in the diallel studies at AGROVELEZ-JAMUNDI (above diagonal) and CIAT-PALMIRA (below diagonal), using the averages of the 36 F1 families.

	Mites Palmira	Plant type	Root type	Root Color	Pulp Color	Commer. roots	Foliage (kg/pl)	Dry matter %	Harvest index	Fresh root Yield
White flies	-.-	-0.15	-0.04	0.56	0.06	-0.13	-0.59	0.43	0.46	-0.20
Plant type	0.65	-.-	0.50	-0.05	-0.14	-0.32	-0.29	-0.18	-0.11	-0.27
Root type	0.13	0.51	-.-	-0.25	0.25	-0.81	-0.31	-0.26	-0.61	-0.80
Root color	0.63	0.39	0.10	-.-	-0.50	0.17	-0.30	0.10	0.43	0.10
Pulp color	-0.01	0.02	-0.24	-0.48	-.-	-0.13	-0.13	0.09	-0.17	-0.28
Comm. Roots	-0.37	-0.81	-0.57	-0.09	-0.26	-.-	0.36	0.24	0.57	0.85
Foliage kg/pta	-0.61	-0.71	-0.23	-0.49	-0.02	0.65	-.-	-0.35	-0.35	0.56
Dry matter	-0.14	-0.05	-0.27	-0.19	0.38	-0.08	-0.17	-.-	0.62	0.05
Harvest index	0.41	0.17	-0.33	0.61	-0.17	0.08	-0.63	0.20	-.-	0.48
FR Yield.	-0.39	-0.74	-0.51	-0.07	-0.22	0.92	0.74	-0.10	0.03	-.-

At Palmira yield and reaction to mites had a correlation = -0.39, whereas at Jamundí the correlation between white flies and fresh root yield was –0.20. These values were negative because a small insect damage is scored as 1, and a severed damage with a score of 5. The correlation between yield and plant type was much higher at Palmira (ρ = -0.74) than at Jamundí (ρ = -0.27). Plant type at Jamundí was difficult to score because of the high soil fertility resulted in frequent lodging in several families. Also worth mentioning is the contrast in the correlations between harvest index and fresh root yield at Palmira (ρ = -0.03) and (ρ = 0.48).

It was not possible to establish a clear relationship between fresh root yield and dry matter content in the roots. Therefore, it should be possible to eventually generate high yielding clones with high dry-matter content in their roots. The fact that correlations are not necessarily evidence of a cause – effect relationship is supported by the meaningless correlations between root color and harvest index (ρ = 0.63 and 0.43) or between root color a reaction to insects (ρ = 0.56 and 0.63).

In Table 2.51, the most relevant results of the *Preliminary Yield Trial* are presented. This trial included 110 genotypes, planted in two, 5-plant row plots and with three replication at CIAT-Palmira. The clones and stakes for this trial came from a *Clonal Evaluation Trial* conducted the previous year at CEUNP about 15 km from CIAT headquarters, where any clone that had just one plant with even weak symptoms of frog skin was eliminated. Still the *Preliminary Yield Trial* resulted with a very high disease incidence. As much as, 60% of the clones showed symptoms of the disease. It is not clear what happened but it is also certain that for some reason the planting at CEUNP, resulted in high degree of frog skin incidence. This should be considered as a defeat imposed by this elusive disease. All the materials planted at CEUNP had been indexed to be frog-skin free. One mistake was committed: to allow sequential plantings, and therefore, there were 6-months old plants nearby other materials just planted. It was not surprising to see that the late plantings at CEUNP were the most severely affected by frog skin. We have learned from this experience: it is not allowed to plant sequentially in the same station for periods longer than 1-2 months. For instance, this year, all the plantings at CIAT – Palmira were done between August 15 and September 20.

In spite of this problem, the general results of the *Preliminary Yield Trial* was very encouraging (Table 2.51). The 25 selected clones have been moved out of CIAT-Palmira station because, even if they did not presented any symptoms of frog skin they could still be late-infected. It has been decided that only materials certified to be disease-free and that maintain that condition will be allowed to be grown at CIAT station. The 25 selected clones, therefore, were planted at Santander de Quilichao (an area where frog skin is endemic, and therefore is not going to create a new problem). Once we have the facilities in working conditions, these clones will be subjected to meristem culture to be cleaned from the disease, and re-enter the evaluation process. This may take as much as two years, and illustrates the complications that breeding cassava at CIAT faces if the pathogen (or pathogens?) involved in frog skin disease are not soon identified

Table 2.51. Results from the *Preliminary Yield Trial* conducted at CIAT-Palmira with 110 clones evaluated in 10-plant plots with three replications.

Clone or parameter	Fresh roots (t/ha)	Plant type (1 - 5)	Harvest index (0 - 1)	Dry matter (%)	Foliar retention (1 - 5)
SM 2580-24	64.1	4.00	0.67	37.8	1.67
SM 2795-15	47.5	2.67	0.69	38.7	2.33
CM 9504-1	41.3	3.00	0.60	41.0	2.00
SM 2652-11	40.1	1.33	0.59	38.7	2.00
SM 2588-14	46.0	2.67	0.60	38.7	2.00
SM 2659-3	34.9	2.67	0.55	40.4	1.67
SM 2799-17	22.0	1.67	0.60	43.4	2.33
SM 2795-13	34.0	2.33	0.61	40.2	2.33
SM 2800-3	31.9	1.67	0.65	37.8	2.33
SM 2580-29	36.4	2.00	0.62	37.8	2.67
Statistics of the 25 clones selected					
Maximum	64.08	4.00	0.69	43.36	3.33
Minimum	21.96	1.00	0.55	34.99	1.67
Mean	36.42	2.61	0.62	38.84	2.31
St. Deviation	8.31	0.80	0.04	1.68	0.44
Statistics of the 110 clones evaluated					
Maximum	64.08	5.00	0.75	43.36	3.67
Minimum	6.17	1.00	0.18	30.22	1.67
Mean	26.10	3.12	0.55	36.67	2.50
St. Deviation	9.73	0.91	0.10	2.40	0.48

Fresh root productivity for the selected fraction averaged 36.42 t/ha, compared with the population mean of 26.10 t/ha (Table 2.51). Dry matter content was excellent with 38.84% for the selected fraction and 36.67% for all the clones evaluated. Leaf retention was scored when this trial was about five-month of age. The results of the score are presented in the right column of Table 2.51. As it is usually the case the scale used was 1= excellent and 5= very poor.

Because of the availability of this variable the selection index for this trial was as follows:

Selection Index = [Fresh root yield ∗ 10] + [Dry matter content ∗ 8] - [Plant type ∗ 5] +
+ [Harvest Index ∗ 3] – {Foliar retention ∗ 3]

As was the case in the northern coast, it was possible to detect a clear relationship between leaf retention at five-months of age and root productivity at ten- or eleven-months after planting (the correlation coefficient was = - 0.38). Leaf retention was scored under no disease or abiotic stress (i.e. water stress). Regression analysis suggests that for each unit increase for the score in foliar retention there will be a reduction in as much as six t/ha in root productivity (Figure 2.3)

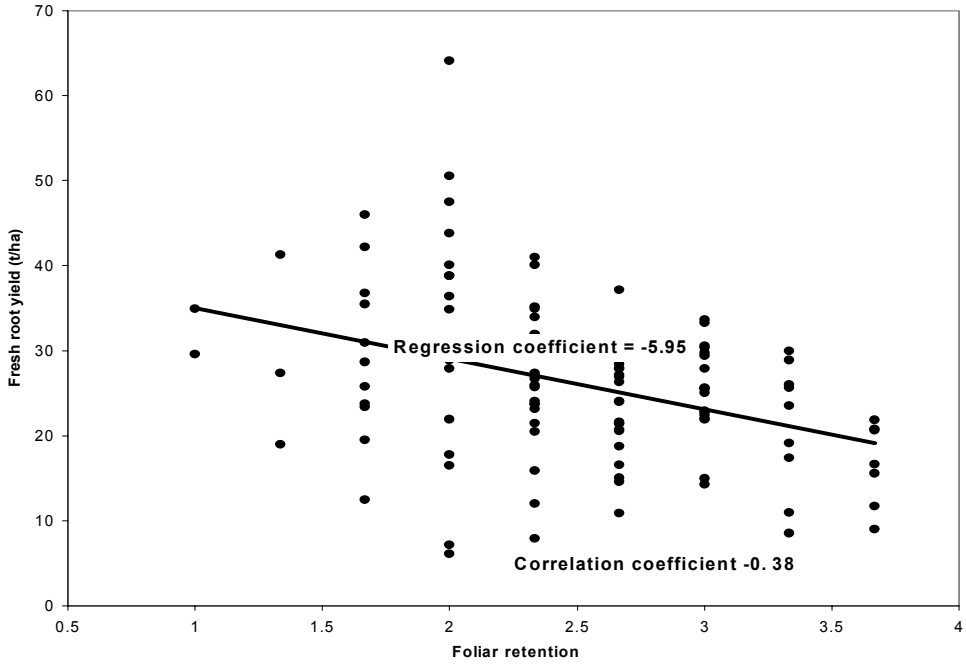


Figure 2.3. Relationship between foliar retention at five months and fresh root yield at 10 months after planting. Results from 110 genotypes evaluated at CIAT-Palmira in a trial with three replications.

Another interesting result from this trial was the possibility of determining the effect of frog skin infection on foliage productivity. Because there were cases were plants from a given clone were clean of symptoms in one or two replication and showing symptoms in the remaining replication(s) it was possible to measure the effects of frog skin in a few variables. For instance, on average plants with symptoms yielded about 20.15 t/ha of fresh foliage, whereas plants with no symptoms produced only 15.07 t/ha. In a way, this is not a surprise because frog skin prevents the translocation of starches from the leaves to the storage roots. Having more nutrients available, the above ground tissue develops more vigorously in the presence of the disease. Foliar retention was also affected by frog skin The average foliar retention score of clones that showed symptoms in the roots had been 2.48, whereas those clean of the disease had had a considerably worse score (3.32).

Table 2.52 presents the results of the *Regional Trials* conducted for the mid-altitude valleys environment. These trials were planted in five representative locations (Cauca and Valle del Cauca Departments), and included thirty genotypes, including two checks. Experimental plots had 25 plants and three replications per trial were used at each location.

The highest yields were obtained at Jamundí and Bocas de Palo, Buga and Vijes showed intermediate productivity, and S. de Quilichao had the lowest yields. The latter environment

is characterized by acid soils and high white flies pressure. The highest dry matter content was obtained at Vijes (37.67%).

Table 2.52 Relevant results from the *Regional Trials* conducted in Cauca and Valle del Cauca Departments for the mid-altitude valleys environment. At the bottom of each location their respective means for fresh root yield and dry matter content are provided. Highlighted in boldface are the two checks.

	Fresh root	Dry matter	Cooking quality	HCN	**Ranking at each location**				
Clone	(t/ha)	(%)	(1 - 5)	(1 - 9)	Boca Palo	Jamundí	Sder. Quilichao	Buga	Vijes
SM 1965-1	25.61	36.75	3.15	4.75	4	6	1	1	15
SM 2141-1	25.03	36.67	2.85	6.00	7	3	2	8	4
SM 1642-22	28.06	34.46	4.00	6.00	9	12	3	5	1
CM 8370-11	25.57	35.06	1.35	5.75	2	2	11	3	6
SM 1855-15	24.20	35.38	1.00	4.25	1	10	4	14	14
SM 2211-3	24.15	35.10	3.00	7.00	8	17	9	2	7
SM 2052-4	25.12	33.48	2.50	7.00	3	7	8	6	19
SM 2160-2	21.73	34.79	3.65	5.50	14	5	23	10	3
SM 1520-16	22.64	33.54	1.00	6.50	5	1	24	19	10
CM 8370-10	20.83	35.41	1.35	6.00	22	4	10	22	2
SM 2073-1	20.77	35.33	1.00	5.00	11	22	25	4	5
SM 1520-18	19.80	34.52	1.35	5.25	10	13	21	12	13
CM 6660-21	20.26	34.82	3.00	7.00	23	8	16	20	8
SM 1871-33	19.47	35.59	1.00	4.50	20	19	6	7	22
M TAI 8	18.50	35.08	4.15	7.50	19	14	7	24	12
SM 1779-7	21.31	34.13	1.65	4.75	18	26	5	23	11
SM 2058-2	20.86	33.43	4.00	7.25	15	11	18	18	21
SM 1660-4	21.32	32.58	3.00	5.75	21	9	19	25	17
SM 2085- 7	20.92	33.60	3.00	6.50	12	18	15	15	26
CM 523-7	***15.84***	***35.69***	***2.50***	***7.25***	***27***	***20***	***12***	***21***	***9***
SM 2198-4	17.37	34.85	3.50	8.00	16	16	28	17	20
SM 2119-1	15.57	35.77	2.00	5.50	26	21	22	13	16
SM 1788-11	16.62	34.96	3.50	5.00	24	28	14	9	24
CM 8759-14	19.98	32.52	2.85	6.25	17	23	26	26	18
CM 7463-2	16.68	33.13	2.15	3.00	13	25	29	16	23
SM 2030-5	13.93	34.56	4.00	6.25	6	30	17	28	30
SM 2052-3	13.49	33.76	2.15	3.25	25	15	30	29	25
MPER 183	***19.16***	***30.84***	***1.35***	***4.25***	***30***	***29***	***20***	***11***	***27***
SM 1788-13	18.21	31.74	3.85	4.75	28	27	13	27	28
SM 1959-1	13.52	31.05	2.35	5.50	29	24	27	30	29
Maximum	28.06	36.75	4.15	8.00	**Fresh root yield and dry matter content.**				
Minimum	13.49	31.05	1.00	3.99	24.09	25.58	13.77	17.19	20.45
Mean	20.22	34.29	2.54	5.71	33.97	35.59	31.04	33.17	37.67

¶ **HCN**: Cyanogenic potential (9=bitter, 1= sweet). **Cooking quality**: 1= excellent, 5= very poor.

Clones SM 1965-1, SM 2141-1, SM 1642-22, CM 8370-11 and SM 1855-15 had a consistently good performance across the environments where the trials had been conducted (Table 2.52). A rapid multiplication process will be started for these clones, as well as a meristem culture to produce frog-skin free vitroplant versions of them. The remaining clones had an erratic behavior. The clones used as checks (CM 523-7 and MPER 183) had a relatively poor performance, particularly for MPER 183.

Finally in Tables 2.53 and 2.54 the results of two *Regional Trials* for the high-altitude eco-region (> 1400 m.a.s.l.) are presented. Because of lack of sufficient planting material, not all the entries were planted in the two trials (only 17 of the clones can be found in the two trials). Yield of fresh roots was much higher at Morales (average 30.46 t/ha) that at La Cumbre (Average 11.32 t/ha). Clone 1058-13 had an excellent performance at Morales (Table 2.53, first place) and at La Cumbre (Table 2.54, third place). Clone SM 1053-23 had a good ranking from Morales (6th place), and also had an excellent performance at La Cumbre, but its ranking is irrelevant because at that location it was used as a check.

There were quite a few remarkable examples of genotype by environment interactions among the materials included in the two highland trials. Clone SM 1937-1 was fourth at Morales and second before the last in La Cumbre. MCOL 2261 showed a contrasting preference, it was 32nd at Morales and 10th at La Cumbre. SM 1933-5 was fifth at La Cumbre and 26th at Morales. A few clones, had a poor performance at both locations (SM 1940-3 and 1833-21).

2.4.4. Selections for the Middle Magdalena Region

CIAT recently began evaluating cassava elite materials in this region. Working in the mid-Magdalena River region is important because of the social relevance of cassava and because it combines characteristics of the sub-humid and the acid-soil savannas. One of the objectives for these evaluations was to determine the kind of germplasm that adapts better to this environment (south of Cesar and Bolivar Departments and Santander and Norte de Santander Departments).

Table 2.55 summarizes the results of four Regional Trials conducted in this eco-region (San Vicente, Barrancabermeja, Sabana de Torres, and Regidor). As in the previous cases, the ranking of each material was established based on a selection index. Most of the best performing clones are adapted to the sub-humid environment, although germplasm adapted to the acid-soil savannas and the mid-altitude valleys also was included. MTAI 8 was second only to SM 653-14, regarding fresh root productivity (> 30 t/ha). These two varieties showed excellent harvest indexes (> 0.70) and good dry matter content in the roots (> 35%), although they were not the best clones for this last trait.

Germplasm adapted to the acid-soil savannas or mid-altitude valleys (MPER 183, CM 523-7, HMC-1 and SM 1219-9) showed a mediocre performance in the region (Table 2.55), although CM 7951-5 performed relatively well.

Table 2.53. Results of the *Regional Trial* conducted in Morales (Cauca Departament) with materials adapted to the highland environment 1400 to1800 meters above sea level).

Clone or parameter	Fresh Roots (t/ha)	Dry matter (%)	Harvest Index (0 a 1)	Selection Index
SM 1058-13	43.73	39.03	0.61	35.02
SM 998-3	50.33	37.43	0.52	34.27
CM 8106-4	38.80	40.23	0.61	32.99
SM 1937-1	42.40	37.00	0.54	22.79
SM 2229-36	39.20	36.67	0.54	17.31
SM 1053-23	40.33	34.33	0.61	13.82
SM 1061-5	27.53	39.97	0.48	10.86
CG 402-11	35.80	33.97	0.61	6.33
CM 7438-14	34.87	35.00	0.56	6.32
SM 1703-17	31.27	38.30	0.40	5.99
SM 1495-22	30.27	35.97	0.58	4.45
CM 7138-12	29.87	38.43	0.39	4.32
SM 1946-2	32.27	35.90	0.50	3.64
SM 1835-28	29.07	37.43	0.47	3.06
SM 2227-21	23.83	37.13	0.63	2.50
SM 1944-10	27.93	37.30	0.50	2.47
CM 7190-2	29.23	37.20	0.43	0.81
SM 524-1	32.60	33.90	0.58	0.31
MCOL 2061	28.83	35.10	0.59	0.08
SM 1938-12	29.17	36.60	0.45	-0.45
SM 2226-48	27.37	34.67	0.61	-2.42
SM 1833-21	28.57	35.30	0.49	-4.09
SM 2233-11	33.30	32.87	0.50	-5.70
MCOL 1522	31.80	34.23	0.44	-5.81
SM 850-1	27.60	36.23	0.40	-6.09
SM 1933-5	27.47	35.30	0.38	-10.40
SM 1940-3	21.93	36.00	0.39	-15.16
SM 2311-3	24.53	32.53	0.45	-21.35
SM 2232-15	19.13	35.23	0.39	-21.66
MCOL 2740	28.93	31.03	0.36	-24.88
SM 2237-26	19.47	34.60	0.36	-25.01
MCOL 2261	19.30	32.70	0.45	-27.56
SM 2228-28	18.60	31.53	0.36	-36.76
Maximum	50.33	40.23	0.63	-.-
Minimum	18.60	31.03	0.36	-.-
Mean	30.46	35.73	0.49	-.-
St. Dev.	7.39	2.24	0.09	-.-

Table 2.54. Results of the *Regional Trial* conducted in La Cumbre (Valle del Cauca Departament) with materials adapted to the highland environment 1400 to1800 meters above sea level).

Clone or parameter	Mother	Father	Harvest Index (0 a 1)	Fresh roots (t/ha)	Dry matter (%)	Cooking quality (1-5)	Selection Index
SM 856-11	CG 402-11		0.55	20.22	34.7	3.0	41.41
SM 1269-6	CG 402-11		0.55	22.50	31.05	1.6	33.18
SM 1058-13	CG 402-11		0.47	15.79	33.9	1.0	25.52
CM 7438-6	CG 481-3	MCOL 2261	0.41	15.19	34.8	2.3	25.03
SM 1933-5	CG 402-11		0.33	16.06	33.95	2.3	20.61
SM 1716-1	SG 638-6		0.48	15.69	32.35	3.0	20.09
SM 1835-28	CG 481-3		0.32	15.24	32.85	3.0	14.41
SM 1707-2	CM 523-7		0.45	9.86	33.85	3.0	11.49
SM 524-1	MCOL 1522		0.41	9.26	34.15	1.6	9.64
MCOL 2261	Unknown		0.38	13.56	31.25	2.3	7.36
MCOL 2740	Unknown		0.36	14.31	30.65	2.3	6.02
CM 7595-1	MCOL 2261	CG 406-6	0.44	15.70	28.8	nd	5.61
SM 1710-3	MCOL 1522		0.43	13.40	29.7	1.0	3.42
SM 707-17	CG 402-11		0.35	10.33	31.4	1.6	-0.42
SM 709-1	CG 481-3		0.25	8.29	32.7	3.0	-4.25
SM 1002-1	MCOL 1413		0.32	15.09	28.4	3.0	-2.05
SM 850-1	MCOL 2257		0.31	10.00	30.4	3.0	-6.39
SM 1846-12	MCOL 647		0.30	10.09	29.65	3.0	-9.32
SM 1938-12	CM 723-3		0.38	6.11	30.55	3.0	-11.55
SM 1946-4	MCOL 2060		0.28	7.73	30.7	2.3	-11.51
SM 1495-22	CG 402-11		0.36	5.28	31.1	2.3	-12.20
SM 1061-5	CG 481-3		0.23	5.19	32.3	3.0	-13.33
SM 929-3	CG 358-3		0.24	11.50	28.6	3.0	-12.47
SM 1944-17	MCOL 717		0.24	6.57	30.55	3.0	-16.23
SM 1833-21	CG 401-6		0.24	7.36	29.85	2.3	-17.03
SM 1940-3	CM 4488-4		0.20	6.02	30.95	3.0	-17.62
SM 853-21	CG 358-3		0.28	9.65	27.95	5.0	-17.26
SM 1703-17	CG 501-2		0.24	10.65	27.15	1.0	-19.59
SM 1937-1	CG 1231-3		0.23	5.32	28.6	2.3	-26.45
SM 1946-2	MCOL 2060		0.24	7.69	27.15	1.0	-26.10
CG 402-11			0.47	22.10	na	na	28.87
SM 1053-23			0.52	19.30	na	na	24.75
SM 1944-10			0.45	19.03	na	na	21.31
Maximum			0.55	22.50	34.80	5.00	41.41
Minimum			0.20	5.19	27.15	1.00	-26.45
Mean			0.34	11.32	31.00	2.46	0.00
St. Dev.			0.10	4.55	2.21	0.87	17.92

na = not available

The first eight clones showed a more or less uniform performance with relatively consistent rankings at each of the four locations. The first clone showing important signs of genotype by environment interaction was SM 1557-17, which was 17th at San Vicente, but it was 3rd in Sabana de Torres. SM 1433-4 also showed notable changes in its ranking at different locations: it was the best clone at Sabana de Torres, but had mediocre performances in the other three locations. In spite of these two cases, results from the four locations were generally consistent suggesting that they offered relatively uniform environmental conditions for cassava growth.

Table 2.55. Results from four *Regional Trials* conducted in the Middle Magdalena River region.

Clone	Fresh root yield (t/ha)	Fresh foliage yield (t/ha)	Harvest index (0 - 1)	Dry matter (%)	Ranking at each location			
					San Vicente	B/meja	Sabana Torres	Regidor
SM 653-14	31.66	14.32	0.71	35.96	1	2	10	3
MTAI 8	31.25	12.58	0.72	35.40	7	6	2	2
CM 3306-4	26.42	14.33	0.66	36.69	2	7	16	1
CM 4843-1	32.08	17.30	0.64	34.30	5	4	7	11
CM 7514-8	22.98	17.73	0.56	38.61	13	5	6	5
CM 7951-5	23.58	10.65	0.69	36.41	3	9	5	9
CM 6119-5	25.67	14.28	0.64	36.12	6	3	11	6
SM 1741-1	26.22	14.94	0.64	35.17	8	11	8	4
SM 1557-17	29.03	14.07	0.67	33.08	17	10	3	10
CG 1141-1	23.40	13.66	0.62	35.70	18	1	12	8
MVEN 25	26.52	19.25	0.58	34.64	9	8	15	7
MBRA 383	25.78	18.02	0.59	34.57	10	12	9	12
SM 1219-9	24.91	12.41	0.66	33.31	11	13	4	16
SM 1433-4	17.88	16.28	0.52	38.06	14	15	1	14
HMC1	19.16	10.93	0.64	35.12	12	14	13	15
CM 849-1	21.52	19.13	0.53	34.11	16	17	14	17
CM 523-7	14.84	12.97	0.55	35.77	4	16	17	13
MPER 183	14.81	11.90	0.58	31.07	15	18	18	18
Maximum	32.08	19.25	0.72	38.61				
Minimum	14.81	10.65	0.52	31.07				
Mean	24.32	14.71	0.62	35.23				

During this year, we have introduced yet another modification in the region. As was indicated in Table 2.3 botanical seed for producing stakes for a *Clonal Evaluation Trial* targeting specifically this region had been planted. In Table 2.56 a general description of the materials included in this trial is provided.

Table 2.56. Description of the families and clones included in the first *Clonal Evaluation Trial* planted in the Middle Magdalena River eco-region.

	Family	Mother	Father	Seed planted	Clones in trial
1	CM 8335	MCOL 1505	CM 2177-2	50	28
2	CM 9614	CM 6740-7	MNGA 19	50	32
3	CM 9748	CG 1141-1	SM 653-16	37	26
4	CM 9772	CM 7073-7	MNGA 19	45	32
5	CM 9903	CM 6740-7	SM 1741-1	50	35
6	CM 9916	CM 7951-5	CM 6740-7	38	27
7	CM 9928	CM 8593-13	SM 206929	35	22
8	CM 9934	CM 8602-27	SM 2069-26	51	25
9	CM 9935	SM 2075-1	CM 8602-27	42	31
10	CM 9940	SM 1219-9	SM 653-14	50	33
11	CM 9953	SM 1219-9	SM 1741-1	50	37
12	CM 9965	SM 1741-1	SM 1565-17	47	20
13	CM 9985	SM 2075-1	SM 2102-36	33	27
14	GM 70	SM 494-2	MTAI 8	55	22
15	GM 212	CM 523-7	SM 805-15	50	26
16	GM 215	SM 1565-17	CM 523-7	50	21
17	GM 235	MTAI 8	CM 6740-7	37	23
18	GM 266	SM 1219-9	MTAI 8	43	18
19	SM 1521	CM 3299-4	Unknown	50	8
20	SM 2733	SM 1210-10	Unknown	50	22
21	SM 2826	CM 4365-3	Unknown	50	23
22	SM 2830	CM 7514-8	Unknown	50	20
23	SM 2832	SM 805-15	Unknown	50	14
24	SM 2859	CM 6740-7	Unknown	45	15
25	SM 2861	SM 643-17	Unknown	50	18
26	SM 2864	SM 1210-4	Unknown	50	14
27	SM 2882	CM 3372-4	Unknown	50	16
28	SM 2963	MTAI 8	Unknown	50	18
29	SM 2965	CM 4574-7	Unknown	50	26
30	SM 2967	CM 7033-3	Unknown	50	21
	TOTAL			**1408**	**700**

2.4.5. Selections for the Tolima-Huila Departments.

This region shares characteristics of the acid-soil savannas and the mid-altitude valleys. Two trials specifically targeting the region have been planted. A *Clonal Evaluation Trial* (see Table 2.3) and a *Preliminary Yield Trial* are described in Tables 2.57 and 2.58, respectively.

At the Tolima and Huila Departments two different Advanced Yield Trials were also planted during the present period, and will be harvested in 2003. Table 2.59 lists the clones that have been included in these two trials.

Table 2.57. Description of the families and clones included in the first *Clonal Evaluation Trial* planted in the Tolima-Huila Departments eco-region.

	Family	Mother	Father	Seed planted	Clones in trial
1	CM 8035	MTAI 8	HMC 1	50	21
2	CM 9642	CM 6740-7	MPER 183	50	17
3	CM 9733	HMC 1	MPER 183	31	4
4	CM 9765	CM 6754-8	SM 653-16	41	17
5	CM 9791	SM 1433-4	MNGA 19	25	28
6	CM 9912	SM 1433-4	CM 7514-8	50	32
7	CM 9914	CM 7514-8	SM 1565-17	50	22
8	CM 9926	SM 1565-17	CM 8027-3	50	9
9	CM 9961	SM 1433-4	MTAI 8	50	12
10	CM 9962	SM 1438-2	SM 1565-17	44	22
11	CM 9966	SM 1565-17	MTAI 8	32	15
12	GM 234	CM 6740-7	HMC 1	50	21
13	GM 265	SM 1219-9	MPER 183	50	38
14	SM 1521	CM 3299-4	Unknown	50	7
15	SM 2802	SM 1219-9	Unknown	50	23
16	SM 2804	SM 1565-17	Unknown	50	16
17	SM 2805	SM 1741-1	Unknown	50	29
18	SM 2826	CM 4365-3	Unknown	50	24
19	SM 2829	CM 7395-5	Unknown	50	13
20	SM 2834	SM 1411-5	Unknown	50	32
21	SM 2836	SM 1433-4	Unknown	50	34
22	SM 2839	SM 1565-17	Unknown	50	29
23	SM 2865	SM 1219-9	Unknown	50	40
24	SM 2866	SM 1460-1	Unknown	50	25
25	SM 2870	SM 1741-1	Unknown	50	18
26	SM 2871	MBRA 12	Unknown	50	20
27	SM 2873	CM 523-7	Unknown	50	12
28	SM 2882	CM 3372-4	Unknown	50	28
	Total			**1323**	**608**

Table 2.58. List of the clones included in the first *Preliminary Yield Trial* planted in the Tolima-Huila Departments eco-region.

SM 1778-50	SM 2097-4	SM 1646-5	SM 1955-7	CM 8803-7
SM 2095-12	SM 1785-10	SM 1789-52	SB 237-8	SM 2277-2
SM 1969-18	SM 1789-20	SM 1784-15	SM 1519-2	SM 1521-10
SM 643-17	SM 1910-5	SM 1652-21	SM 2090-7	CM 8288-46
SM 1627-16	SM 1431-2	SM 1657-14	SM 2085-7	CM 8472-5
MEX 95	SM 1948-29	SM 2090-1	SM 1791-40	MTAI 8
SM 2277-4	CM 6758-3	SM 1539-2	SM 2099-4	CM 3306-4
SM 1511-14	SM 2091-6	CM 3555-6	SM 2269-8	CG 1141-1
CM 4365-3	IND 39	CT 20-2	SM 1652-16	CM 4919-1
SM 1516-7	SM 1657-12	CM 8288-43	CM 8472-4	

Table 2.59. List of the clones included in the first *Advanced Yield Trial* planted in two locations in the Tolima-Huila Departments eco-region.

Natagaima (Tolima) **VEREDA: Rincon de Anchique**	**Palermo (Huila)** **VEREDA: El Juncal**
CG 1141-1	CM 660-21
CM 523-7	CM 7453-2
CM 849-1	CM 8370-10
CM 3306-4	CM 8370-11
CM 4843-1	SM 1520-16
CM 6119-5	SM 1520-18
CM 7514-7	SM 1642-22
CM 7951-5	SM 1660-4
SM 653-14	SM 1779-7
SM 1219-9	SM 1855-15
SM 1433-4	SM 2085-7
SM 1557-17	SM 2141-1
SM 1741-1	SM 2160-2
SM 1871-33	SM 2198-4
SM 1959-1	SM 2111-3
SM 1965-1	MTAI 8
SM 2052-4	MPER 183
SM 2058-2	CM 523-7
SM 2073-1	HMC 1
MTAI 8	MBRA 383
MVEN 25	CM 7951-5
MPER 183	SM 1219-9
HMC-1	
MBRA 383	

Activity 2.5 Research on post-harvest physiological deterioration

Rationale

One of the major constraints upon cassava production as a commercial crop is the perishability of its roots. Two basic types of deterioration have been identified: a physiological deterioration (PPD) which may begin within 24 hours of harvest in susceptible varieties, and a microbial deterioration which appears later and is affected by root damage, storage environment and genotype (Jennings and Hershey, 1985). PPD consists of discoloration of the parenchyma as blue-black vascular streaks. Because of PPD, cassava roots need to be consumed shortly after harvesting (van Oirschot, et al., 2000). The short post-harvest storage life of cassava is a characteristic that limits the marketability of the roots, implies high marketing margins and risks, and restricted management flexibility for farmers and processors. At least two factors have already been identified as affecting PPD: yellow roots with higher carotene contents tend to have delayed PPD onset, and high dry matter content accelerates PPD (CIAT, 2001). Any alternative aiming at reducing the PPD problem is strategic for CIAT's research on cassava, as well as for those industries processing cassava roots.

Specific Objectives

a) To develop facilities for a more precise evaluation of PPD.
b) To identify post-harvest treatments that would allow reducing or delaying the onset of PPD.
c) To determine cooking quality of ten clones with fresh roots and after different post-harvest treatments.
d) To evaluate root quality for the production of croquettes from elite germplasm

Materials and methods

Ten clones (CM 523-7, SM1520-16, MPER183, CM7463-2, CM8370-11, SM2073-1, SM1779-7, SM1871-33, SM1855-15, and SM1959-1) from the regional trials conducted through Valle del Cauca Department (Colombia) were identified for this evaluation. The clones were chosen based on the cooking quality of their roots. Roots from these ten clones were used for this experiment and after different alternative storage conditions were evaluated for PPD and cooking quality. The treatments considered in this trial were:

- Controlled temperature at 6ºC, roots within plastic bags
- Controlled temperature at 6ºC, roots in shelves
- Without control of temperature, roots within plastic bags
- Without control of temperature, roots in shelves

Each experimental unit was made up of ten commercial size roots for each of the treatments. PPD evaluations were made on each individual root, but statistical analysis was done on the

average PPD of the ten roots of each experimental unit. Data on dry matter content (%) and cooking quality were taken on the day roots were harvested and were used as check for further analysis. Results of the treatments were evaluated at 7, 14, 21 and 28 days after harvest and measured as PPD and cooking quality.

The regional trials were conducted at different locations and harvested at different time, one after the other. Differences among the different regional trials, therefore, reflect geographical differences and environmental conditions at the time of harvest. Regional Trial 1 was harvested in the middle of a lengthy dry spell. There were some roots affected by frog skin disease, which may have influenced on the evaluation of cooking quality. Trials 2 and 3 were harvested under normal rain conditions (no droughty weather) with temperatures ranging from 25 to 35 °C. Varieties, as expected, showed preferences from one location to the other, resulting in significant genotype by environment interactions.

Results

A chamber that allows evaluation under controlled temperature and moisture conditions was built by CONGELAGRO within the CIAT campus. It is large enough to allow for relevant field studies. Temperature ranges from 5ºC to 35ºC. Air relative moisture can be maintained at 60 to 70%. This chamber was utilized to carry out this research on genetic effect on PPD and alternative methods for post-harvest handling to manage the PPD problem.

CIAT continued the initial work by Zapata (2001). The main objectives were to identify different post-harvest treatments (controlled temperature and confinement within plastic bags) that would allow to reduce or delay the onset of PPD in cassava roots. For this work the recently built chamber was used with excellent results, which are under analysis and will be published during 2003.

The cooking quality of the roots from these trials was not always satisfactory. For this trait we employed a 1 to 5 scale (1=excellent and 5= very poor). The environmental conditions in the locations were the trials were conducted were not conducive to the production of roots with excellent cooking quality. The conditions at harvest time were not favorable either. Trial 1 was harvested just before the beginning of the rainy season. Dry matter content was higher than in the other trials and the cooking quality was good. For most varieties, the good cooking quality was maintained for several days after harvest and for a longer period than for Trials 2 and 3. The regional trials 2 and 3 were harvested when the rains had begun, and cassava plants had re-initiated their growth. When this occurs there is a marked reduction in dry matter content, because of the energy used by the plant to produce new foliage. It is clear that because of the conditions these trials were harvested, that dry matter content was much lower than in the first and so was the cooking quality of their roots (which had an average score = 3). The cooking quality decreased quickly (score = 5) for those roots maintained in conditions conducive to PPD.

There are several cassava-growing regions in Colombia. It is strategic for CONGELAGRO to identify the best varieties from each of the regions that may eventually provide with row material for its operations. It is also important for CIAT to identify those clones that produce

good quality roots for the processing industry. Within this project, activities oriented to answering these questions had been included.

From the different regions, Villavicencio in the eastern savannas was selected as the first option. Therefore root samples from 13 new clones were delivered to CONGELAGRO for their processing into croquettes. The clones evaluated were:, CM5306-8, CM7052-3, SM1810-6, CM6055-3, SM1405-5, SM1864-10, CM6438-14, SM1565-15, CM6740-7, SM1859-26, CM6975-14, BRASILERA, and NN (WIGASA).

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