FINAL REPORT

LAMP

JULY 1997

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Latin American Maize Project

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In the memory of

DR. WILLIAM BROWN

Plant explorer, geneticist, scientist and

leader in Plant Genetic Resources and Industry

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ACKNOWLEDGMENTS

To Pioneer Hi-Bred International, Inc. for their help in evaluating the maize germplasm of Latin America by financing LAMP and by providing the scientific counseling services of Dr. Wilfredo Salhuana.

To the Agricultural Research Service of the U.S. Department of Agriculture for their support and help in directing this project. A special note of thanks to Drs. Quentin Jones, Henry Shands, and Steve Eberhart for their direction of various stages of this project.

To the Programa Cooperativo de Investigaciones en Maiz, Agrarian University, La Molina and to Ing. Ricardo Sevilla for his diligent work and guidance as International Coordinator.

To the Centro de Informática para la Investigación Agrícola (CIPIA) of the Department of Statistics of the Agrarian University La Molina, for their support and to Ing. Jorge Rubio for his assistance in organizing the database, developing the SIL (Sistema de Información LAMP) system, and for his help in coordinating and processing LAMP information.

To the Administrators and Principal Investigators of the participant countries, without whose collaboration a successful project would not be possible.

The Final Report of LAMP is dedicated to Dr. William Brown, in recognition of his dedication, enthusiasm, pioneering efforts and success in stimulating international collaboration for the collection, classification, and preservation of maize germplasm, for his many contributions to agriculture, and for his work as a dedicated and inspiring researcher and administrator.

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(LAMP)

Ing Ricardo Sevilla and Dr. Wilfredo Salhuana

International Coordinator and Principal Advisor of LAMP

1.0 INTRODUCTION

1.1 Objective

North America and the Southern Cone of South America utilize maize primarily for animal feeding. Mexico, Central America, and the Andean Zone use maize mainly for human consumption, processed (flours) or directly. In recent years, the demand for maize for poultry feeding has increased.

The United States is the largest maize producing country in the world. It produces annually about 253 million metric tons. Latin America maize production totals about 56 million metric tons, only 13.6 percent of the world's total production, which is up three percent from ten years ago. In recent years, annual maize production increased 3% in the Southern Cone of South America, 2.2% in the Andean Region, and 1.9% in Central America (including Mexico and Caribbean). However, as the population grows 2% to 3% per year, production and consumption decrease per capita, and the importation of this cereal increases 10 kg/yr. per capita in the Andean Zone, and 28 kg/yr. per capita in Central America.

Maize genetic variability is enormous in Latin America as there are more than 260 races, which comprise 90 percent of world's maize diversity. A lot of attention has been given to the morphological study of the races of maize. There are eleven publications, edited by Harvard University in Cambridge, Massachusetts, and by the National Research Council of the USA describing 238 races from 23 different countries. Furthermore, seven catalogs on maize germplasm from seven South American countries have been published with detailed information about the morphology of the accessions.

Almost all hybrids and improved varieties arise from very few races. This is one of the reasons that susceptibility to insect pests and diseases are increased, because of genetic uniformity, and the improved varieties and hybrids may have less adaptability to the marginal environments in Latin America.

Objectives of the breeders, demands of industry, and the changing consumer preferences determine new routes to explore in plant breeding. Undoubtedly, good new germplasm and the use of new methodologies will enhance plant breeding programs. One of the sources of maize germplasm is in Latin America countries, but the landrace collections need to be evaluated in order to select the best to be utilized in breeding programs. For this reason, eleven Latin America countries and the United States consolidated their efforts to evaluate the maize germplasm existing in these countries. The principal objective of the Latin American Maize Project (LAMP) was to obtain information from the evaluation of the maize germplasm and to facilitate the access by breeders to this information so that they can use it to create superior varieties and hybrids. Utilization of the full range of genetic diversity will greatly expand the area of adaptation of derived hybrids and varieties. Only in this way the region will fully utilize its genetic resources, currently under-utilized because of the limitations of superior cultivars which can not be adapted to the limiting environments common to the region. Improving adaptation to limiting conditions is more economical and ecologically compatible than attempting to modify agricultural conditions through great investments in agricultural technology.

1.2 Maize Breeding in Latin America

To predict the impact that the evaluation of maize germplasm in Latin America will have, it is necessary to study the history of breeding in the region. In the 40’s and 50’s, the first years of breeding in Latin America, landrace varieties were used as source materials. The majority of them were collected from farmers' fields, whose ancestors had been cultivating them through the centuries. Breeders rapidly identified extremely productive races, and heterotic patterns were identified for the formation of hybrids that are still in use. Superior hybrids were rapidly adopted, their success due to the exceptional heterosis obtained by crossing two or three high yielding races.

Wellhausen made the first attempt at a systematic identification of elite racial composites and heterosis patterns for the lowland tropics. Results with other studies (Wellhausen 1965) identified Tuxpeño and its related Caribbean and USA dents, Cuban Flint, Coastal Tropical Flint, and ETO. Each country was exploiting the hybrid vigor pattern. In Venezuela: Tuxpeño x ETO; in Colombia: Caribbean Flint, Tuxpeño and ETO; in Peru: Perla x Cuba; in Argentina: Cateto, Coastal Tropical Flint, and Cuban Flint; in Brazil: Cateto, Paulista Dent, Tuxpeño; in Mexico, the Caribbean area and Central America: Tuxpeño, ETO, Cuban Flint, and Coastal Tropical Flint (Wellhausen, 1978).

In general, the maize hybrids developed from these patterns are planted on a very low percentage of the available land for maize production in Latin America because they are tropical, adapted to good soil and environmental conditions, and respond to higher rates of fertilizer.

2.0 LAMP GEOGRAPHICAL BACKGROUND

2.1 Countries and regions

LAMP was conducted in eleven Latin American countries and the United States. Evaluation trials were run in 34 regions, which covered most regions of the Americas where maize is grown from 41º Latitude in the north to 34º Latitude in the south, and from sea level to 3,400 masl (Figure 1). The number of regions per country varied from one in Venezuela to seven in Peru. In the second stage, every trial was replicated in two locations within a region. The total number of locations planted was 70, but only 61 were harvested.

A file of "Characterization of the Location" was created based on geographical, climatic, ecological, and agronomic features. Any location in LAMP had to have at least three geographical descriptors: latitude, longitude, and altitude. The following meteorological data were to be recorded in every experiment: monthly average temperature and rainfall for the months during which the trial was run; the average monthly temperature and rainfall of the last years; and 10 different soil descriptors.

2.2 Homologous Areas

In planning LAMP (Salhuana, 1988, 1991) the varying responses to different environmental conditions were recognized (primarily altitude and latitude) and five Homologous Area (HA) were defined:

HA 1	Below 1200 m. and	$< 26^0$ N or S
HA 2	1200 to 1900 m. and	$< 26^0$ N or S
HA 3	1900 to 2600 m. and	$< 26^0$ N or S
HA 4	Above 2600 m. and	$< 26^0$ N or S
HA 5		$> 26^0$ N or S

Regions were grouped into these five HAs for germplasm interchange, testing selected accessions, and evaluating heterosis.

From the 34 regions represented in LAMP, 14 correspond to HA 1 (lowland tropics), four to HA 2, five to HA 3, three to HA 4 (highlands), and eight to HA 5 (the temperate region). In HA 1 and HA 5, heterosis may be utilized because the use of hybrids is widespread.
Although heterosis was also evaluated in HA 2, 3 and 4, emphasis was on performance per se and evaluation of special characteristics defining adaptation.

2.3 The Adaptation Test

In preparation for distribution to other countries after accessions were evaluated in their own country, an adaptation test was conducted. A sample of races from each region was sent to other regions to test adaptation. According to the plan of work, the same evaluation descriptors were to be recorded in each adaptation test, and days to flower was to be recorded in heat units in order to have comparable data.

A total of 813 accessions from 11 countries were sent to 21 different regions to test adaptation. Samples sent for the adaptation test were random samples of the country's maize races. A total of 204 races were tested in the adaptation test: 61 belonged to HA 1, 51 to HA 2, 30 to HA 3, 24 to HA 4, and 38 to HA 5. As expected, it was not possible to record all data because some accessions were very poorly adapted. However, some conclusions can be drawn from the limited data recorded. Although not included in the published LAMP data, the results deserve some comment.

As a general rule, there were no problems with adaptation of the foreign material in any location of HA 1, except for the Peruvian accessions of the Northern Coast that are not adapted to any location outside of Peru.

It was evident that the latitude of 26 degrees North or South was not an appropriate limit to determine HA 5. The accessions from the South of Brazil, the North of Argentina, and the South of Paraguay that are between 26 to 30 degrees south of latitude are not adapted to locations used in LAMP above 30 degrees of latitude in Argentina, Chile, Uruguay, and USA.

Some countries tested accessions from both the same homologous area and accessions from other homologous areas. That was the case of Uruguay, where in November 1988, 311 accessions from 4 countries of the HA 5, and 11 of the HA 1 were planted in Paysandú. Data is ready to be published in a thesis of an Uruguayan student of the Agronomy Faculty.

HA 2, 3, and 4 showed many problems with adaptation of foreign materials. In Chapingo, Mexico (HA 3), the Peruvian and Guatemalan accessions suffered from a freeze that produced a lot of damage. The Peruvian materials planted in Chapingo and Celaya were severely damaged with ear rot caused mainly by *Fusarium moniliforme*. The only races that produced some grain were: Confite Punteagudo and the Northern Coast races: Rienda, Pagaladroga, Mochero, and Alazán. The best accessions were from Confite Morocho. In Chimaltenango, Guatemala (HA 2), Chilean materials from HA 5, Peruvian accessions from HA 2, and Guatemalan accessions from HA 2 were planted in May 1988. The foreign materials were heavily attacked with rust and northern corn leaf blight (*Exserohilum turcicum).* A few accessions looked fairly good, notably those collected in the northern highlands of Peru. The Peruvian germplasm is earlier than the Guatemalan accessions.

In 1992, an experiment was planted in CIMMYT experimental stations at El Batán, Mexico, at 2,200 masl and at Tlaltizapán at 940 masl. The main objective of the experiments was to test adaptation of HA 3 and 4 accessions. The first conclusion was that Mexican and Peruvian accessions of these homologous area belong to similar groups. The Colombian and Guatemalan accessions were completely unadapted to the Mexican plateau (Mesa Central) and are very late and tall. Andean HA 4 regions belong to the same homologous area as Mexican HA 3 regions. Colombian and Guatemalan HA 3 regions are about the same, but they belong to the HA 2 Mexican region. Lack of adaptation of Peruvian accessions in Mexico is due mainly to the high susceptibility to the Mexican *Fusarium* races.

Conclusions about the adaptation test are:

a) Adaptation of foreign germplasm was not a problem in the lowland tropics (HA 1).

b) The HA 2 is the most heterogeneous area across countries. Regions located between 1000 to 1900 masl in Latin America are very different even though they are at the same altitude. Other parameters are required to group them.

c) The test in Mexico for accessions from HA3 and HA4 shows that the germplasm from Mexico and Peru are adapted, whereas Colombian and Guatemalan germplasm are not.

d) The latitude of 26 degrees North or South is not the appropriate limit to define HA 5, probably 30 degrees should be used.

3.0 LAMP CHRONOLOGY

3.1 Stages of LAMP

LAMP was planned to be carried out in five stages:

STAGE 1. Accessions belonging to a region were planted for evaluation in a 10 m^2 plot in two replications at a single location environmentally similar to that from which the landrace accessions were originally collected.

STAGE 2. The upper quintile (20%) of accessions evaluated for agronomic performance in stage 1 were planted in two locations with two replications, and the upper 5% were selected based on agronomic performance.

STAGE 3. Selected accessions were interchanged among regions belonging to the same Homologous Area. They were tested in two locations with two replications in each region. In an isolated field within each region, the selected accessions from the same homologous area were crossed with the best tester of the region.

STAGE 4. With two or more replications in two locations within each region, experiments to test the combining ability of the selected accessions with the local tester were carried out.

STAGE 5. The elite germplasm was integrated into breeding programs.

In most of the cases, work was completed as planned. In the highlands (HA 2, 3, and 4), there were some problems to get seed of the testcrosses (accession x tester). The differences in planting date and the necessity to repeat the crossing work delayed stages 3 and 4 in these HAs.

4.0 THE DIVERSITY TESTED IN LAMP

4.1 Races of Maize

Accessions tested in LAMP represent most of the races of maize in Latin America. Unfortunately, not all accessions tested in LAMP were properly classified, and many of them were never classified. However, this descriptor, although incomplete, is useful in terms of measuring maize diversity evaluated in LAMP.

Table 1 shows the number of races evaluated in stage 1 in each region and races selected and tested in stage 2. Discarding duplicates (for instance, Tuxpeño which was tested in four countries), the number of races tested was 307 and the number represented by selected accessions was 74 (about 25%).

5.0 METHODOLOGY

5.1 Experimental methodology

In stages 1 and 2, a randomized complete block design with two replications was used to evaluate the accessions. To avoid inter-plot competition, randomization was made in defined groups by races or by maturity. Plots were of 10 m^2 each. Beginning with stage 2, each experiment was repeated at two locations in each country to evaluate the genotype by environmental interaction.

5.2 Descriptors used in evaluating accessions

Germination percent: Plant count prior to thinning divided by number of seeds planted, and multiplied by a hundred.

Number of days to tassel: Days from planting to 50 percent pollen shed.

Number of days to silk: Days from planting to 50 percent silk emergence.

Plant height: Height of the plant in centimeters, based on the average of the measurements for 10 plants from ground level to top of the tassel.

Ear height: Measurement taken from ground level to the vertex of the angle of insertion of the uppermost ear.

Number of plants: Plants counted at harvest in each plot.

Percent broken stalks: Stalks in each plot that are broken below the ear before harvest (reported as percent).

Percent root-lodged plants: Plants leaning 30 degrees or more in the first 60 centimeters from the ground (reported as percent).

Degree of tillering: Code indicates the degree of tillering: 1 = none; 9 = high.

Ears per plant: Ears counted at harvest in each plot (reported as number of ears per plant).

Ear quality: Code indicates the ear quality: 1 = very poor; 9 = excellent.

Yield: Scales were read to the nearest tenth of a kilogram (reported as kilograms per hectare adjusted to 15% moisture).

Moisture percent: Moisture samples measured on grain taken by shelling two rows from each of 10 ears and reported as percent.

Shelling percent: Grain/Ear weight ratio x 100.

Kernel type: Code indicating the type of kernel:

HR = floury	FT = flint	SW = sweet
DE = dent	SF = semiflint	HF = floury semiflint (Morocho)
SD = semident	PP = pop	

Kernel color: Code indicating the color of the kernel.

AM = yellow	RM = red mosaic	PM = purple spotted or mottled
BL = white	MA = brown	MR = brown red
NA = orange	MM = brown mosaic	MC = light brown
RO = red	MV = brown variegated	SL = salmon pink
RV = red variegated	PR = purple	RB = red with white ca90

Race name: Name of the race for the accession

5.3 Making the Testcrosses

In each region of the same homologous area, crosses to produce the testcrosses were made. Each region received 100 seeds of each of the elite HA accessions. Two or three rows of each accession were planted in isolated fields along with the tester which was planted at three times: simultaneously, earlier, and later than the accessions. Results from adaptation tests grown in some regions in stage 3 were used to select the planting dates of females (accessions) and male (tester) rows. The female rows were detasseled.

There were no nicking problems in HA 1 except in Tucuman, Argentina. In HA 5, five accessions from Brazil could not be crossed with testers from Chile, Argentina, USA, and Uruguay because they were later than most germplasm of the temperate regions. Seed of testcrosses were formed with a mixture of seed from ears harvested in a plot. There were many problems in the HA 2, 3, and 4 because lack of adaptation and differences in maturity that did not permit production of all crosses planned.

6.0 THE EVALUATION WORK

6.1 Evaluation of combining ability

The combining ability of the elite accessions was evaluated by crossing them to testers belonging to the same homologous area. In stage 4, the testcrosses (accessions x testers) were evaluated. These testcross experiments were conducted using a lattice or a randomized complete block design. Number of replications were two in all regions, except in Colombia where three replications were planted and in Mexico where four replications were used. Number of rows per plot was two. Plot area ranged from 8 m^2 to 11.9 m^2 , and the number of hills per row was 11 with two plants per hill.

In HA 1, each region evaluated the testcrosses with their local tester, and also the testcrosses with a foreign tester. In HA 5, all regions evaluated the testcrosses produced in 4 regions: Pergamino (Pampeana region), La Platina (Santiago), Paysandú, and Iowa. Sixty nine HA 5 accessions were crossed with the local tester of each region. The HA 2, 3, and 4 testcrosses were delayed because the difficulties in making the crosses. The regions, testers, and number of testcrosses areappend shown in Table 2.

The characteristics of the checks for each region are shown in Table 3.

6.2 Evaluation of special characteristics

According to LAMP protocols, evaluation for special characteristics was to be done anytime stress was homogenously present in the experiment. Methodology for evaluation was the same in each case, under natural conditions (no artificial stress and no innoculation):

Pests and diseases: Code indicating degree of susceptibility, 1 = susceptible and

9 = resistant.

Climatic and soil limiting factors: Code indicating tolerance, 1 = extreme susceptibility and

9 = extreme tolerance.

For the evaluation of special characteristics, about 30 experiments in 9 countries were conducted. The experiments for drought resistance, *Exserohilum turcicum, Spodoptera frugiperda*, *Heliothis zea, and Fusarium moniliforme* were conducted in natural conditions. Statistical inference could not be made when environmental conditions were not ideal for the study or when the incidence of the disease was not sufficient to detect tolerance for the special character in study.

However, some experiments produced results that permited the identification of good sources of resistance or tolerance. Some of the successful experiments were: evaluation for *Fusarium moniliforme* with artificial innoculation in Pairumani, Bolivia; evaluation for virus diseases monitorized with ELISA in Caraz (Peru); evaluation for acid soil adaptation in Sete Lagoas, Brazil, in 1992; evaluation for "Mal del Río Cuarto virus" in Rio Negro, Argentina; evaluation for avoidance mechanism associated with cold tolerance in Jauja, Peru; and evaluation for value-added traits by the cooperation with the Center for Crops Utilization Research of the Iowa State University, Ames, Iowa, USA. Reports of these evaluations are being published in different papers. In Chile, early material belonging to the Araucano race was identified as well as drought tolerant germplasm belonging to the Semanero race. In Brazil, evaluation in acid soils detected some accessions that yielded better than the Brazilian tolerant hybrids: BOZM-468, CMS-0508 III, Se-33, and PAZM-08063. In Paraguay where *Spodoptera frugiperda* is a main constrain, Brazilian populations such as BR-105 were very resistant.

7.0 THE SELECTION THROUGH THE FIVE STAGES

7.1 Number of accessions evaluated and selected in stages 1 and 2

Number of accessions evaluated and selected in stages 1 and 2 in each region is shown in Table 4. In stage 1, 14,357 accessions were planted; however, only 12,113 were evaluated. Because of low germination, a number of accessions could not be evaluated properly. In the first stage 3,094 accessions were selected. In the second stage 3,066 were evaluated and 270 selected. Stage 1 and 2 results from all five Homologous Areas were published (LAMP, 1991).

7.2 Elite accessions

The 270 elite accessions that were evaluated in Stage 4 experiments in testcross combinations or as accessions per se included 100 in HA 1, 32 in HA 2, 37 in HA 3, 20 in HA 4, and 78 in HA 5. A summary of the results of the testcrosses from each country were reported and published in the Meeting V of LAMP, Fort Collings, Colorado, July 8-10, 1992. Stage 4 results from Homologous Areas 1 and 5 were published (Salhuana and Sevilla, 1995).

Results of testcrosses summarized in Figure 2 for yield show that in HA 1, 41% of entries (accession x tester) were above the check in stage 4 and 16% above the check in stage 2 (accesion perse). The percentages for HA 5 are 6% and 1%.

Lowering the plant height is a breeding objective in almost all Latin American regions. In HA 1, about 20% of the accessions were lower than the check in both stages, per se (stage 2) and in testcrosses (stage 4). In HA 5 more than 50% of the elite accessions were lower than the check in both stages. Figure 3 shows that the percentage of elite accessions being earlier (lower moisture percent) was about the same in both stages and in both homologous areas (about 50%).

As a general conclusion, there are many possible accessions to use to increase the yielding ability and decrease the plant height and grain moisture at harvest using the maize germplasm in HA 1, and HA 5.

8.0 GERMPLASM ENHANCEMENT

8.1 Heterotic patterns

According to LAMP protocols, PIs chose at least one tester to cross all the elite accessions pertaining to the same Homologous Area. Some of the accessions of HA 1 combined well with only one tester; almost all the Colombian and Venezuelan accessions and some accessions from Bolivia, Brazil, Mexico, and Peru show specific patterns.

Accessions that combined well with 4 and 5 testers (Table 5) are: Pe-11, Chis-775, Pas-14, St. Croix Gpo 3; and with 3 testers are: Se-32, Se-33, Guate Gpo 21-18A, Chis-462, St. Croix 1. Testers that appear more frequently in these selected testcrosses are: BR-105, and BR-106 from Brazil, Suwan from Bolivia, HB-83(m) from Guatemala, and H-511 from Mexico.

BR-105 and Suwan were derived from the same source, TAI Compuesto I from Thailand, which was developed by mixing a wide range of germplasm including Coastal Tropical Flint

(Sriwatanapongse et al., 1985). BR-106 is a dent tester belonging to the Dente Riograndense and Tuxpeño race. It was formed by intermating dent varieties such as Dentado Composto, Centralmex, Maya, and Tuxpeñito. HB-83(m) is the male parent of the double cross hybrid HB-83, from the CIMMYT Population 43 (43-46 x 43-68). H-511 is a single cross of Capitein 348 and SLP20, two Tuxpeño accessions.

The other two Mexican testers, V-424 and H-422, belong to the Tuxpeño race, but H-422 has some Corn Belt germplasm. One Peruvian tester, PM-701(m) is from Coastal Tropical Flint, and the other, PM-212(m) is Perla, a Peruvian landrace. Besides HB-83(m), other testers that originated from CIMMYT populations are: PM-102(m) from Population 24; Guarani V-312 from Population 27; HC 128 x HC 219 (Population 32 x Population 21), and CENIAP PB-8(h), from Tuxpeño Crema Planta Baja.

Results reconfirmed the well-known heterotic pattern of two widely used races of Latin America, Tuxpeño and Coastal Tropical Flint. Other races such as Tuson, Dente and Semi-dente Amarelo, Saint Croix, Cateto, Perola, Común, Perla, Arizona, and Costeño deserve to be considered for the full exploitation of heterosis of Latin American germplasm.

8.2 Source materials for improvement of agronomic traits

The more important agronomic traits evaluated in LAMP besides yielding ability were standability (root-lodging and broken stalks), earliness, and plant and ear height. There are very sharp and evident differences between the check varieties and the landrace accessions. In HA 1 and HA 5 experiments, almost without exception, checks showed very good standability, whereas many accessions suffered from root-lodging or broken plants. However, testcrosses were often nearly as good as the checks.

Earliness is the trait that can be improved easily with the utilization of foreign germplasm. In Colombia (HA 2), the testcross Jal 167B x ICA V-303 was very early and showed good general combining ability. Other Mexican accessions such as Chih 191 can be good sources for earliness. In Guatemala, many Mexican accessions were very early, mainly those from Durango and

Chihuahua. Tams 119 an elite HA 2 Mexican accessions from the Tuxpeño race could be good sources for the required earliness for Guatemala.

In Peru, Lbque 46 (Arizona race) from the Northern Coast was high yielding in testcrosses, and it is very early. In Pairumani Bolivia (HA 3), the Peruvian accessions performed well both per se and in crosses by Compuesto 18 and Choclero 2. The Compuesto Amarillo de Ancash and Anc 139 produced very early and high yielding hybrids when crossed to Compuesto 18. The cross Jun 164 x Choclero 2 was another testcross that was high yielding and early.

8.3 Stage 5 Pre-breeding work

Pre-breeding work started in stage 5 of LAMP. Argentina, Brazil, Uruguay, and the United States are engaged in a cooperative project to identify and select accessions with good combining ability when crossed with two testers. Four accessions, ARZM-16026, CHZM-05015, URZM-13061, and FS8-BT, were selfed in Iowa in 1992 and progeny were sent to Argentina, Brazil, and Uruguay. In Argentina the S_1 lines were planted to be crossed to a non-Stiff Stalk Synthetic (SSS) tester, Syn Mo17. The S_1 lines were evaluated per se. Topcrosses of the best 20% lines were tested in Argentina, and they were sent to other HA 5 regions for evaluation. Brazil also received progenies of the S_1 lines. They were planted in a temperate region in 1994. They showed poor germination and were attacked by a soil fungus, but 10% were selected which will be incorporated to the breeding work. Seed of 830 S_1 lines were planted in Uruguay in 1993.

In Argentina, LAMP accessions as well as other non-selected accessions are being utilized in breeding programs. Eighty Cristalino Colorado accessions, including 14 LAMP elite HA 5 accessions were crossed to 4 testers, 2 locals (HP3 and P5L2) and two universal testers (Syn B73 and Syn Mo17). Some of the testcrosses to Syn Mo17 and to Syn B73 outyielded the best check by about 25%.

In Chile, seed of two Argentinean accessions ARZM-17056 and ARZM-16026, the Uruguayan accession URZM-01089, and the Chilean CHZM-05015 were planted for selfing. Derived lines were tested in crosses with two distinct heterotic testers. The top 10% lines have been recombined to complete the first selection cycle. Selected accessions have been crossed to (B73 x B14A). F_1

progenies will be planted for selfing. In another project, about 200 accessions have been crossed by lines of INIA-160; and the F_1 will be backcrossed to the accessions as the recurrent parent to have 75% of the accession germplasm in the crosses.

As Uruguay is very interested in maize for silage, breeders will start a cooperative project (INIA and the Agronomy School of the Universidad de la República) to generate improved materials with selected accessions belonging to Dente Rugoso, Morotí, and Pisingallo races.

In the United States, in addition to the evaluation of the S_1 lines in the cooperative project, top HA 5 accessions have been crossed by two testers. Eleven crosses by B73 (SSS tester) and 10 by Mo17 (non-SSS tester) have been involved in a pedigree selection scheme by backcrossing or selfing the segregating populations. At Ames, Iowa, pedigree breeding was initiated in CHZM-05015 x Mo17, the backcrosses to Mo17, and two private breeding crosses with CHZM-05015. Selfing from S_1 to S_4 will provide material to evaluate and select for value added traits. HA 1 and 5 accessions, backcrosses and derived lines were analysed for oil quality. Pedigree breeding was started in a private breeding cross that had protein levels above 15%. Samples of breeding crosses were analyzed for oil quality, and starch was extracted for starch quality analysis.

In the U.S., an unprecedented public/private research effort to broaden the genetic diversity of U.S. corn hybrids using enhanced maize germplasm derived from selected LAMP accessions has been initiated as the Germplasm Enhancement Maize project (GEM) (Salhuana, et al., 1994). This is a unique case of collaboration in which 19 public institutions and 21 private seed companies are working together with the objective of increasing the productivity and genetic diversity of maize grown in the U.S. Contributions to this project from seed companies (includes making crosses of LAMP germplasm with their elite proprietary inbreds, exchanging complex crosses, and evaluating hybrids involving the newly derived lines) are worth millions of dollars. Breeding crosses of HA 1 and 5 LAMP accessions were developed by private companies by crossing an accession with a commercial inbred lines, either of the SSS or non-SSS heterotic pattern. Eighty breeding crosses (25% LAMP accession: 75% Corn Belt inbred lines) were developed by sending the breeding crosses to a different company to cross to an inbred line of the appropiate heterotic pattern. S_3 lines from Caribbean accessions were crossed to B73 and Mo17, and topcrossed to the oposite inbred line. The best B73 and Mo17 crosses are being developed into inbred lines for eventual release as breeding lines. The reactions to more than twenty diseases and insects are being evaluated by scientists in universities and private companies. Also grain quality and silage potential are being evaluated in different institutions.

Bolivia selected two HA 1 accessions: BOZM-0093 and Chis 775. BOZM-0093 has very good combining ability mostly with testers belonging to the Tuxpeño race, and Chis 775 has very good general combining ability with several testers. About 500 S_1 lines from two crosses, BOZM-0093 x Suwan and Chis 775 x BR-106, have been developed and evaluated. The top lines have been selected to form two synthetics which will be the pollen parent and the seed parent of a reciprocal recurrent selection project.

In Brazil, two cycles of mass selection with biparental control have been made in two elite accessions, Pas 14 and Pe 01, for improvement in prolificacy, lower plant height, and resistance to foliar diseases. Besides, the acid soil tolerant accessions have been selected to use in breeding programs. A project named NAP (Support Research Nucleous - maize) was initiated in 1995, in cooperation with private and public seed companies, to evaluate genebank accessions for resistance to corn stunt virus, rust, and other foliar diseases. Selected elite accessions will be used to form synthetics.

In the Caribbean region of Columbia, a project has been initiated using 10 Colombian accessions from HA 1 to search for populations that utilize little nitrogen but give high yields and good stability. The best accessions, Cor 320 and Val 343, have been used as parents to develop and evaluate S_1 lines derived in low nitrogen environments. Breeding is under way to form synthetics, composites or hybrids tolerant to low fertility soils. The best accessions from the Puya race have proved to be better than the Puya varieties planted in a large maize region of the country; and a newly developed composite is already being used as an improved variety.

Guatemala started a line breeding project. In 1992, seven Guatemalean elite HA 1 accessions were selfed to produce S_1 lines. In 1993, the selected S_1 lines were selfed to get S_2 lines. About 600 S_3 inbred lines are ready to be tested for combining ability to generate synthetics or hybrids for the Guatemalan lowlands.

In Mexico, very important information has been generated from the diallel cross experiments. A reciprocal recurrent selection scheme has been proposed to INIFAP using Chis 772 x Tams 525 or Chis 567 x Tams 125 as heterotic parents.

In Paraguay, the crosses BG-070422 and BG-07422 x Guaraní V-312, and Flint Composto x Guaraní V-312 have been selfed to get lines to start a breeding program.

In Peru four accessions, Pas 14, Pe 11, S.Croix Gpo 3, and Mag 388, were selfed and the progeny were tested per se. A diallel between 7 accessions and 3 Peruvian testers showed the good performance and high heterosis of Pas 14 x Pe 11. Full-sib families from the best S_1 lines were generated and testcrossed to a Cuban and a Perla tester. Based on the testcrosses performance, the best lines from Pas 14 and Pe 11 have been selected to form early hybrids for the Peruvian Coast.

Pre-breeding work in the HAs 2, 3, and 4 has also been initiated. Bolivia is using the earliness and good combining ability of the Peruvian accessions, but a strong selection for *Fusarium* resistance has to be done. In Colombia, breeders have started a selection project using superior accessions for resistance to *Phyllachora maydis*. Diallel experiments conducted in Mexico are being used to plan the breeding work for the Mexican highland maize regions. Also, in Peru, LAMP information is being used in the highlands for breeding for cold tolerance and disease resistance, mainly viruses. Many racial composites have been formed and tested, mainly in the highlands, to be used as improved varieties in order to improve the productivity while maintaining diversity.

9.0 INFORMATION

9.1 SIL (Sistema de Información de LAMP)

LAMP is a project to generate information to be useful for everybody involved in the conservation and utilization of maize genetic resources. When LAMP started in 1986, there were diverse databases, background and training in computer science, and information used among countries. Only six countries had microcomputers to be used for LAMP; the others had large computers in the institutions where the LAMP PIs worked. Most of them used 5 1/4 inches diskettes to distribute information.

The name or identifier assigned to a landrace accession by the country where the accession was collected was used as the primary identifier. Passport data of the accessions under evaluation were centralized. A file was created for storage and interchange of information about passport data. In addition, each country created a database for interchange of information about: a) Identification; b) Collection of the germplasm; c) Geographical location; d) Data of the agronomic evaluation; and e) Data of the location where the evaluation was done in each country. It was agreed to centralize data in CIPIA (Information Center for Agricultural Research) in Universidad Nacional Agraria La Molina (UNALM), Lima, Peru.

To manage and interchange information, CIPIA created the SIL (LAMP Information System). SIL has instructions for the system management: data input, data content, generation of histograms of frequencies; calculations of entry means; selection of accessions; report printing; copying; editing and elimination of files; file sorting and file directories. Besides SIL has instructions to get into the LAMP data base: descriptions and commands; information management, and descriptions of variables in each file.

In order to maintain good communication between CIPIA and the LAMP PIs, CIPIA sent back to each PI a letter (FRI = Ficha de Recepción de Información) acknowledging receipt of information, the quality of the information, and any other thing about information interchange and data to and from the files for the catalogs. From stage 2 through 5, CIPIA sent back a total of 621 FRIs to the country PIs.

9.2 Catalogs

Stage 1 and 2 results from all five Homologous Areas were published (LAMP, 1991). This catalog provides information on countries, homologous areas, regions, and localities; germplasm evaluated (number of accessions and races); stages of evaluation and selection; experimental methodology, definition of descriptors.

Data is presented on a country basis. Within a country, the complete country germplasm passport data appears first in a sequential way: characterization of the locations where the first stage evaluations were done in HA 1; first stage evaluation data in HA 1; characterization of the locations where the second stage evaluations were done in HA 1,... and so on. For the stage 1 data, descriptive statistics were calculated: number, minimum and maximum values, average, standard deviation, and coefficient of variation. For stage 2, besides those descriptive statistics, an analysis of variance across locations was done for seven descriptors: number of days to tassel, ear height, percent of broken stalks, percent of root-lodged plants, number of ears per plant, field weight, and moisture percent. Data for 12,113 accessions are in this LAMP catalog.

Stage 4 results from Homologous Areas 1 and 5 were published (Salhuana and Sevilla, 1995). This catalog contains results of elite accessions per se evaluation and testcross evaluation. It contains Stage 3 and 4 Experimental Methodologies, Testers, Testcrosses, Countries, Regions and Locations, the Elite accessions, and the check varieties. The catalog has data of 52 experiments with 14 different testers in HA 1, and 36 experiments with 4 different testers in HA 5. From the 34 regions represented in LAMP, 14 correspond to the lowland tropics (HA 1) and 8 to the temperate region (HA 5). The data of these two catalogs were digitized on a CD-ROM [along with maize genebank inventories from CIMMYT, USDA/ARS (GRIN), and Agriculture and Agri Foods Canada] and distributed. Each database is accompanied by its respective program to search for the information. Stage 4 results from Homologous Areas 2, 3, and 4 will be published in 1997 (Salhuana and Sevilla, in preparation). The catalogs and CD-ROMs are available from the Director, National Seed Storage Laboratory, 1111 South Mason Street, Fort Collins, CO 80521-4500, USA.

9.3 Reports

There have been seven LAMP meetings where the principal investigators presented data, discussed results, and planned future work. There is a report for each meeting. The LAMP meeting, data and locations were held as follows:

Meeting	Date	Location	Country
1st	May 87	Santiago	Chile
2nd	March 88	CIMMYT	Mexico
3rd	April 89	Lima	Peru
4th	July 90	Sete Lagoas	Brazil
5th	July 92	Fort Collins	USA
6th	April 94	CIMMYT	Mexico
7th	June 96	CIMMYT	Mexico

10.0 ACHIEVEMENTS OF LAMP

10.1 Seed availability

Before LAMP very few countries used their native germplasm. As a consequence, seed of maize landrace accessions remained static in germplasm banks. Prior to and during LAMP, a USDA/ARS project coordinated by North Carolina State University regenerated about 5,000 accessions from Mexico, Colombia, and Peru. CIMMYT and NSSL also preserved high quality seed of many Latin American maize accessions. However, when LAMP started, PIs planned to plant 14,889 accessions for evaluation. Although 14,357 were planted, only 12,113 were effectively evaluated. The difference was mainly due to the low number of plants in the plots because of poor or no germination.

Even though regeneration was not an objective of LAMP, it was necessary to regenerate 1,522 samples. Another accomplishment of the LAMP project was to determine the status of gene banks in Latin America: the number of the accessions, the quantity and quality of the seed for each accession, and a list of accessions that needed to be regenerated. As a result of this information, another cooperative project was developed by USAID/USDA/CIMMYT and 13 cooperating countries called "Regenerating Endangered Latin American Maize Germplasm" (Salhuana et al. 1994). About 10,000 endangered land race accessions are being regenerated. The regenerated seed will be preserved in each country's genebank, in the CIMMYT active and base collections, and in the National Seed Storage Laboratory base collection.

Seed of LAMP accessions can be obtained from the country of origin, from CIMMYT, Lisboa 27, Apdo. Postal 6-641, 06600 Mexico, D. F. Mexico, from the North-Central Plant Introduction Station, Ames, Iowa 50011, USA, or from the National Seed Storage Laboratory, 1111 South Mason Street, Fort Collins, CO 80521-4500, USA.

10.2 Developing a maize core subset

The idea of developing a core collection was proposed by Frankel (1984) and further developed by Brown (1989a,b, 1995). They suggest that "A core collection consists of a limited set of accessions derived from an existing germplasm collection, chosen to represent the genetic spectrum of the whole collection. The core should include as much as possible of its genetic diversity." The core subset is suggested to be about 10% of the crop collection, but may vary from 5% for very large collections to 50% or more for very small collections, with about 3,000 suggested as a maximum number.

Brown (1989a) recommended stratified sampling methods when establishing core collections. Grouping begins with taxonomic affinity (e.g., species, subspecies, cytological races). Accessions within each taxon can be then assigned to strata based on ecogeographic zones and genetic characteristics (e.g., ploidy level, photoperiod response, races, etc.).

Development of a useful core subset may involve the following steps: 1) assembling and reviewing passport data and other information to be used in establishing non-overlapping groups, 2) assigning accessions to appropriate groups, 3) choosing accessions for the preliminary core subset from each group, and 4) collecting data on phenotypic and genetic traits for accessions in the preliminary core and using multivariate analytical methods to construct clusters and dendrograms to elucidate systematic and statistical genetic relations for further refinement of the core subset.

Proportional sampling within each group may provide a more representative sample of the total genetic diversity in the core subset than would a completely random sampling from the crop collection. Once the number needed from each group has been determined, there is merit in choosing accessions with more desirable agronomic traits within each group.

CIMMYT staff have developed methodologies to use LAMP stage 1 and 2 data for the several traits recorded to designate a maize core subset with as much diversity as possible (Franco et al., 1997). Data from experimental trials of accessions in the CIMMYT genebank (Taba, et al., 1994; Franco et al., in press; Taba et al., in preparation) will be used to complement the LAMP data. Also, groupings of accessions with these methogologies will assist in the refinement of the race classification and assist in the identification of accession that now may have incorrect race classifications.

REFERENCES

Brown, A.H.D. 1989a. The case for core collections. p. 136-156. *In* A.H.D. Brown et al. (eds.) The use of plant genetic resources. Cambridge Univ. Press, Cambridge.

Brown, A.H.D. 1989b. Core collections: a practical approach to genetic resources management. Genome 31(2):818-824.

Brown, A.H.D. 1995. The core collection at the crossroads. p. 3-19. *In* T. Hodgkin, A.H.D. Brown, Th.J.L. van Hintum, and E.A.V. Morales (eds.) Core Collections of Plant Genetic Resources. IPGRI, Sayce Publishing, and John Wiley and Sons, Chichester.

Eberhart, S.A., W. Salhuana, R. Sevilla and S. Taba. 1995. Principles for tropical maize breeding. Maydica 40:339-355.

FAO Yearbook Production. 1988. Vol. 42:113

Franco, J. J. Crossa, J. Diaz, S. Taba, J. Villaseñor, and S.A. Eberhart. 1997. A sequential clustering strategy for classifying gene bank accessions. Crop Sci. 37:(in press).

Franco, J., J. Crossa, J. Villaseñor, S. Taba, and S.A. Eberhart. 1997. Classifying Mexican maize accessions using hierarchical and density search methods. Crop Sci. 37:972-980.

Frankel, O.H., 1984. Genetic perspectives of germplasm conservation. p. 161-170. *In* W.K. Arber, et al. (eds.) Genetic Manipulation: Impact on Man and Society. Cambridge Univ. Press, Cambridge.

LAMP. 1991. Catalogo del germplasma de maiz, Tomo 1 and 2. ARS Special Publication. Beltsville.

Salhuana, W. 1988. Seed increase and germplasm evaluation. In Recent Advances in the Conservation and utilization of Genetic Resources: Proceedings of the Global Maize Germplasm Workshop, pp 29-38. Mexico, D.F.: CIMMYT.

Salhuana, W., Q. Jones, and R. Sevilla. 1991. The Latin American Maize Project: model for rescue and use of irreplaceable germplasm. Diversity vol. 7, no. 1 and 2:40-41. Washington, DC.

Salhuana, W., L. Pollak and D. Tiffany. 1994. Public/private collaboration proposed to strengthen quality and production of U.S. corn through maize germplasm enhancement. Diversity, Vol. 9, no. 1 and Vol. 10, no.1:77-79. Washington, DC.

Salhuana, W. and R. Sevilla (eds.). 1995. Latin American Maize Project (LAMP), Stage 4 results from homologous areas 1 and 5. ARS Special Publication. Beltsville.

Sriwatanapongse, S. , C. Chutkaew, and S. Jinhnayon. 1985. Proceedings of the Fifth International Congress Society for the Advancement of Breeding Researchers in Asia and Oceania (SABRAO). Kasetsart University, Bankok, Thailand.

Taba, S. J. (ed.). 1994. The CIMMYT maize germplasm bank: Genetic resource preservation, regeneration, maintenance, and use. CIMMYT Maize Program Special Report. Mexico D.F., Mexico.

Taba, S., J. Diaz, F. Pineda E., J. Franco, and J. Crossa. (In preparation). Pattern of Phenotypic Diversity of the Caribbean Maize Accessions

Taba, S., S.E. Pineda, and J. Crossa. 1994. Forming core subsets from Tuxpeño race complex. *In* S. Taba (ed.). The CIMMYT maize germplasm bank: genetic resource preservation, regeneration, maintenance, and use. CIMMYT Maize Program Special Report. Mexico, D.F., Mexico.

Wellhausen E.J., 1978. Recent developments in maize breeding in the tropics. *In:* D. B. Walden. Maize Breeding and Genetics. Chapter 5. John Wiley & Sons, New York.

Figure 1. Countries involved in LAMP and classification of Homologous Area:

HA 1	Below 1200 m. and	< 26° N or S
HA 2	1200 to 1900 m. and	< 26° N or S
HA 3	1900 to 2600 m. and	< 26° N or S
HA 4	Above 2600 m. and	< 26° N or S
HA 5		> 26° N or S

Table 1. Races Evaluated and Selected in Lamp in Stage 4.

HA	COUNTRY	RACE TOTAL	SELECT Number	%	NAME	# ACCESSIONS
1	ARGENTINA	14	7	50%	Camelia	1
1	ARGENTINA				Canario De Formosa	1
1	ARGENTINA				Cristalino Amarillo Anaranjado	1
1	ARGENTINA				Dentado Blanco	1
5	ARGENTINA				Cristalino Colorado	14
5	ARGENTINA				Dentado Amarillo	2
5	ARGENTINA				Dentado Blanco	3
5	ARGENTINA				Dentado Blanco Rugoso	1
1	BOLIVIA	32	6	19%	Cubano Amarillo	3
1	BOLIVIA				Cubano Blanco	1
1	BOLIVIA				Perola	1
3	BOLIVIA				Aperlado	1
4	BOLIVIA				Hualtaco	2
3	BOLIVIA				Morocho	1
1	BRAZIL	20	5	25%	Cateto	1
1	BRAZIL				Dente Amarelo	8
1	BRAZIL				Dente Branco	1
1	BRAZIL				Semidente Amarelo	6
1	BRAZIL				Unclassified	1
5	BRAZIL				Dente Riograndense	5
5	CHILE	23	4	17%	Camelia	12
5	CHILE				Choclero	1
5	CHILE				Cristalino Chileno	2
5	CHILE				Diente De Caballo	1
1	COLOMBIA	23	7	30%	Comun	9
1	COLOMBIA				Costeño	8
1	COLOMBIA				Puya	1
1	COLOMBIA				Unclassified	4
2	COLOMBIA				Amagaceño	2
3	COLOMBIA				Capio	1
2	COLOMBIA				Comun	7
3	COLOMBIA				Comun	2
2	COLOMBIA				Montaña	1
3	COLOMBIA				Montaña	3
4	COLOMBIA				Montaña	4
3	COLOMBIA				Montaña- Comun	1
4	COLOMBIA				Sabanero	2
4	COLOMBIA				Sabanero-Capio	1
3	COLOMBIA				Sabanero-Montaña	1
4	COLOMBIA				Sabanero-Montaña	1
4	COLOMBIA				Unclassified	4
1	GUATEMALA	13	4	31%	Criollo	1
1	GUATEMALA				Ntamtb	1
1	GUATEMALA				Tepecintle	4

Table 1. Races Evaluated and Selected in Lamp in Stage 4 (continued).

HA	COUNTRY	RACE TOTAL	SELECT Number	%	NAME	# ACCESSIONS
1	GUATEMALA				Tuson	1
3	GUATEMALA				Oloton	2
2	GUATEMALA				Unclassiffied	3
3	GUATEMALA				Unclassiffied	1
1	MEXICO	40	17	43%	Celaya/Vandeño	1
1	MEXICO				Cubano Amarillo *	1
1	MEXICO				Dzit Bacal/Tuxpeño *	1
1	MEXICO				Elotes Occidentales	1
1	MEXICO				Olotillo/Tabloncillo	1
1	MEXICO				Olotillo/Tuxpeño *	1
1	MEXICO				Raton *	1
1	MEXICO				Raton/Tuxpeño	1
1	MEXICO				Tabloncillo	1
1	MEXICO				Tabloncillo Perla/Vandeño	1
1	MEXICO				Tabloncillo/Dulcillo	1
1	MEXICO				Tuxpeño	5
1	MEXICO				Tuxpeño/Jala *	2
1	MEXICO				Tuxpeño/Norteño *	1
1	MEXICO				Tuxpeño/Olotillo *	3
1	MEXICO				Tuxpeño/Raton *	2
1	MEXICO				Tuxpeño/Tepecintle *	2
1	MEXICO				Tuxpeño/Vandeño	1
1	MEXICO				Zapalote Grande *	1
1	MEXICO				Zapalote Grande/Tepecintle	1
1	MEXICO				Vandeño *	3
2	MEXICO				Bolita	1
2	MEXICO				Celaya	4
3	MEXICO				Chalqueño	9
3	MEXICO				Cónico	8
3	MEXICO				Cristalino De Chihuahua	2
2	MEXICO				Raton	1
2	MEXICO				Tabloncillo	2
2	MEXICO				Tuxpeno	5
2	MEXICO				Elotes Occidentales	1
3	MEXICO				Gordo	1
2	MEXICO				Onaveño	1
1	PARAGUAY	10	4	40%	Avati Moroti	1
1	PARAGUAY				Opaco	1
1	PARAGUAY				Sape Pyta	1
1	PARAGUAY				Tupi Moroti	1
1	PERU	49	14	29%	Alazan	2
1	PERU				Alazan/Arizona	1
1	PERU				Arizona	1

Table 1. Races Evaluated and Selected in Lamp in Stage 4 (continued).

HA	COUNTRY	RACE TOTAL	SELECT Number	%	NAME	# ACCESSIONS
1	PERU				Colorado/Perla	1
1	PERU				Cubano Amarillo	7
1	PERU				Perla	2
2	PERU				Ancashino	1
3	PERU				Ancashino	2
2	PERU				Capio	1
4	PERU				Cuzco	3
4	PERU				Cuzco Cristalino Amarillo	1
2	PERU				Cubano Amarillo	2
3	PERU				Huayleño	1
3	PERU				Morocho	1
4	PERU				Morocho	1
4	PERU				San Gerónimo Huancavelicano	1
1	USA-Tropical	14	5	36%	Creole(Criollo)/Argentino	1
1	USA-Tropical				Creole(Criollo)/Tuson	1
1	USA-Tropical				Saint Croix/Early Caribbean	1
1	USA-Tropical				Saint Croix/Unclassified	1
1	USA-Tropical				Tuson/Unclassified	1
1	USA-Tropical				Unclassified	1
1	USA-Tropical				Unclassified/Canilla	1
5	USA-Temperate	7	3	43%	Corn Belt Dent	4
5	USA-Temperate				Corn Belt Dent/Unclasified	1
5	USA-Temperate				Northern Flint	1
5	USA-Temperate				Southern Dent	6
5	URUGUAY	14	4	29%	Cateto Sulino	12
5	URUGUAY				Dente Branco	6
5	URUGUAY				Dente Riograndense	1
5	URUGUAY				Semidente Riograndense	6
1	VENEZUELA	19			Unclassified	5
	TOTAL	278	80	29%		284*

* 17 accessions of HA 1 were tested only in Mexico

Table 2. Number of Accessions of Each Country Crossed with Testers

HA	Country	Region	Tester	Arg	Bol	Bra	Chi	Col	Gua	Mex	Par	Per	Uru	USA	Ven	TOTAL
1	Bolivia	Santa Cruz	Suwan	4	5	7		22	7	15		7		7	5	79
	Brazil	Sete Lagoas	BR-105		5	17			7	15	2	14		7	5	72
	Brazil	Janauba	BR-106		5	17			7	15	2	14		7	5	72
	Colombia	Monteria	ICA V-156		5	21		21		15		7		7		76
	Colombia	Palmira	ICA V-258	2	2	27		9	7	11	2	6		4		70
	Guatemala	Cuyuta	Hb-83 (m)	4	7	17		22	25	15	4	13		8	5	120
	Mexico	Cotaxtla	H-422	4	5	17		20	7	30		14		7	5	109
	Mexico	Cotaxtla	V-424	4	5	17		19	7	30		9		7	5	103
	Mexico	Cotaxtla	H-511	4	5	17		20	7	30	4	13		12	5	117
	Paraguay	Itapua	Guarani V-312	4	5	17		22	7	15	4			7		81
	Peru	Piura	Pm-102 (m)	4	3	20		15		8		12		5	2	69
	Peru	La Molina	Pm-212 (m)	3	5	12		22	7			12		8	4	73
	Peru	Huanuco	Pm-701 (m)	4	5	16		22	7			12		8	4	78
	USA	Puerto Rico	HC-128 x HC-219	4	5	17		22	7	15	2	14		7	5	98
	Venezuela	Maracay	Ceniap Pb-8 (h)	4	5	17		22	7	13		14		7	5	94
5	Argentina	Pampeana	SR-76	18		5	16						25	10		74
	Chile	Santiago	B73 X B14A	18			16						25	10		69
	Uruguay	Paysandu	Del Plata 101	18			16						25	10		69
	USA	Iowa	B73 X B14A	18			16				2		25	10		71
	USA	Iowa	Oh43 X Mo17	18		5	16				2		25	10		76
2	Colombia	Medellin	ICA V-303					9	3	15		2				29
	Mexico	Celaya	B32 X B33					10	3	40		6				59
			SSE3 X SSE5					10	3	36		7				56
			Cafime							31						31
	Peru	Caraz	PMV-580		4			4		15						23
3	Bolivia	Cochabamba	Compuesto 18		2			17	3			4				26
	Colombia	Rio Negro	ICA V-453		1			8	4	2						15
	Mexico	Chapingo	H-32 (h)							28						28
			H-30 (h)							31						31
			H-129 (h)							31						31
	Peru	Carhuaz	Am. Ancash		4			5		15		9				33
4	Bolivia	Cochabamba	Choclero 2		2			18				6				26
	Colombia	Rio Negro	ICA V-508		2			9		1		6				18
	Peru	Jauja	PMS 636							13						13

Table 3. Characteristics of the Common Checks Tested in 34 Regions.

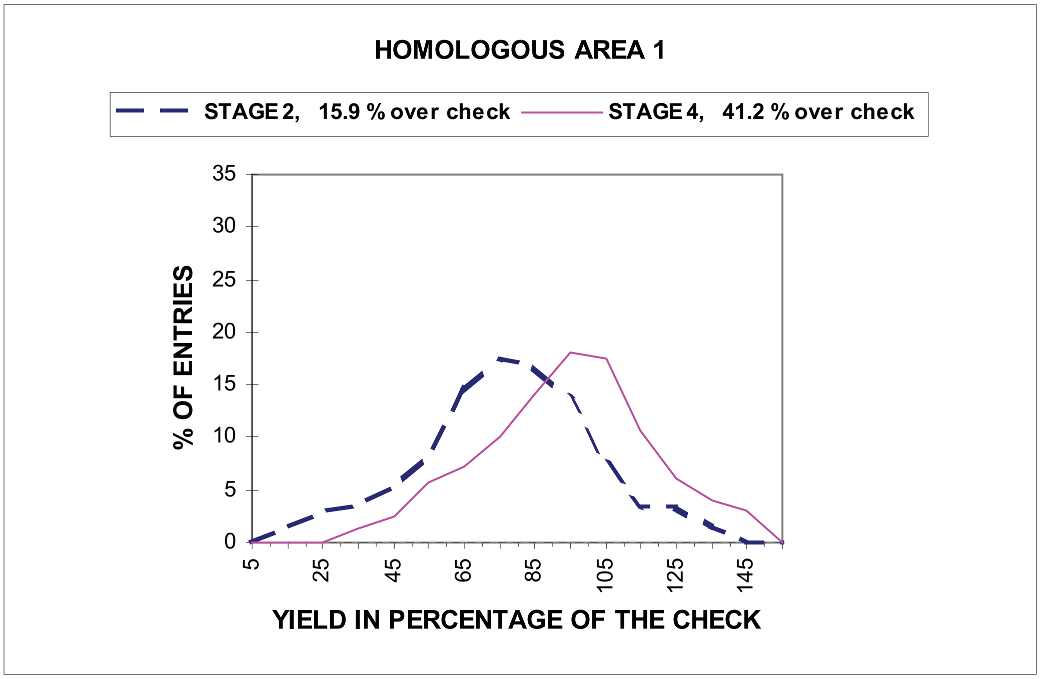
Country	Region	Check Name	Population type	Vegetative period	Grain color	Grain type
Argentina	Pampeana	DeKalb 4F-37	H	E	AM	FT
Bolivia	Cochabamba	Compuesto 13	S	L	AM	SD
	Santa Cruz	Suwan	V	M	AM	SD
Brazil	Sete Lagoas	BR-105	V	M	AM	SD
	Janauba	BR-106	V	M	AM	DT
	Pelotas	CMS-24	H	M	AM	FT
Colombia	Montería	ICA V-109	V	E	AM	FT
	Palmira	ICA H-211	H	M	AM	FT
	Medellín	ICA V-303	V	M	AM	FT
	Río Negro	ICA V-453	V	L	BL	FT
	Bogotá	ICA V-508	V	M	AM	HR
Chile	Santiago	INIA-160	H	L	AM	DT
Guatemala	Cuyuta	A-6(ICTA B-1)	V	E	AM	SD
	Chimaltenango	V-301	V	L	BL	FT
	Quezaltenango	San Marcelo Amarillo	V	L	AM	FT
Mexico	Chapingo	H-28	H	M	BL	FT
	Celaya	V-385	V	M	BL	SD
	Cotaxtla	H-507	H	M	BL	DT
Paraguay	Caacupé	GV-251	V	M	BL	SD
	Itapúa	GV-312	V	E	AM	SF
Peru	Piura	PM-102	H	E	AM	FT
	Lima	PM-212	H	L	AM	FT
	Caraz	PMV-580	V	M	BL	HR
	Carhuaz	Comp.Am.Ancash	V	E	AM	HR
	Cuzco	Blanco Urubamba	V	L	BL	HR
	Junín	PMS-636	S	E	Bl	HR
	Huánuco	PM-701	H	M	AM	FT
Uruguay	Paysandú	Del Plata 101	H	M	AM	FT
U.S.A.	Iowa	B73 X Mo17	H	M	AM	DT
	Georgia	P 3475	H	E	AM	DT
	Puerto Rico	Diente De Caballo	V	L	AM	DT
Venezuela	Maracay	CENIAP PB-8	H	M	BL	DT

(E) Early (H) Hybrid AM = Yellow FT = Flint SD = Semident
(M) Medium (V) Variety BL = White ST = Semiflint HR = Floury
(L) Late (S) Synthetic or Composite DT = Dent

Table 4. Number of Accessions Tested and Selected in Stages 1 and 2 of Lamp.

Country	HA	Region	Alt (masl)	Lat (degree)	Long (degree)	Stage 1 Eval	Stage 1 Sel	Stage 2 Eval	Stage 2 Sel
Argentina	5	12.1 Pergamino	65	34 S	60 W		330	330	20
	1	12.2 Tucuman	322	26 S	65 W		20	20	4
Bolivia	3&4	1.1 Pairumani	2580	17 S	66 W	453	63	42	4
	1	1.2 Santa Cruz	280	18 S	64 W		32	52	5
Brazil	1	2.1 Sete Lagoas	736	19 S	44 W	643	97	148	3
	1	2.2 Janauba	560	15 S	44 W	622	97	155	14
	5	2.3 Pelotas	220	32 S	52 W	311	49	49	5
Colombia	1	3.1 Turipana	15	9 N	76 W	467	139	137	12
	1	3.2 Palmira	1020	3 N	76 W	431	91	90	10
	2	3.3 Tulio Ospina	1450	6 N	65 W	384	85	85	10
	3	3.4 La Selva	2120	6 N	75 W	213	52	41	8
	4	3.5 Tibaitata	2650	5 N	74 W	209	58	58	12
Chile	5	4.1 La Platina	680	34 S	71 W	730	147	147	16
	5	4.2 Copiapo-vicuña	310	27 S	71 W				
Guatemala	1	5.1 Cuyuta	48	15 N	91 W	340	69	69	7
	2	5.2 Chimaltenango	1800	15 N	92 W	102	17	20	3
	3	5.3 Quezaltenango	2300	15 N	92 W	21	10	10	3
Mexico	3	6.1 Chapingo	2250	19 N	98 W	1251	400	300	20
	2	6.2 Celaya	1752	20 N	100 W	458	132	130	15
	1	6.3 Cotaxtla	60	18 N	96 W	1360	290	286	15
Paraguay	1	7.1 Caacupe	228	25 S	57 W	238	36	36	4
	5	7.2 Cap. Miranda	200	27 S	56 W	219	51	51	0
Peru	1	8.1 Piura	29	5 S	80 W	372	75	75	4
	1	8.2 La Molina	251	12 S	76 W	197	42	44	3
	2	8.3 Caraz	2300	9 S	77 W	80	28	26	4
	3	8.4 Carhuaz	2600	9 S	77 W	410	86	86	4
	4	8.6 Junin	3300	12 S	76 W	505	106	80	6
	1	8.7 Huanuco	1900	10 S	76 W	222	75	85	7
Uruguay	5	9.1 Paysandu	61	32 S	58 W	443	100	100	25
USA	5	10.1 Iowa	244	41 N	93 W	261	53	53	6
	5	10.2 Georgia	103	30 N	83 W	140	30	30	6
	1	10.3 Puerto Rico	420	18 N	67 W	553	112	112	7
Venezuela	1	11.1 Maracay	459	10 N	68 W	295	60	60	5
Total						12,113	3,094	3,066	267

Figure 2. Yield in percentage of the regional check variety



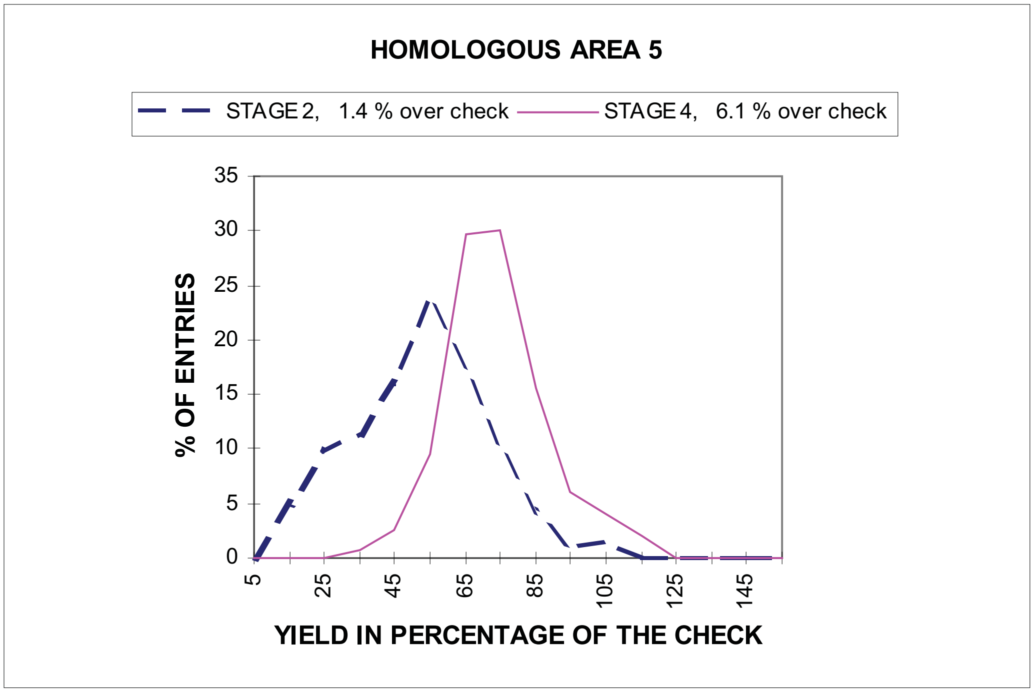
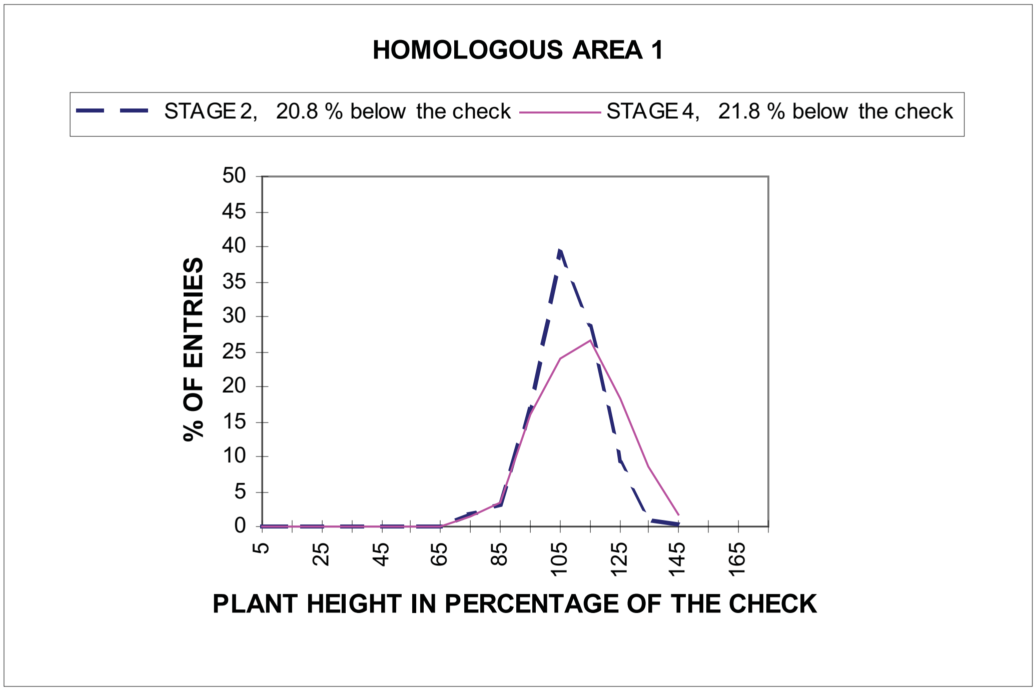


Figure 3. Plant height in percentage of the regional check variety



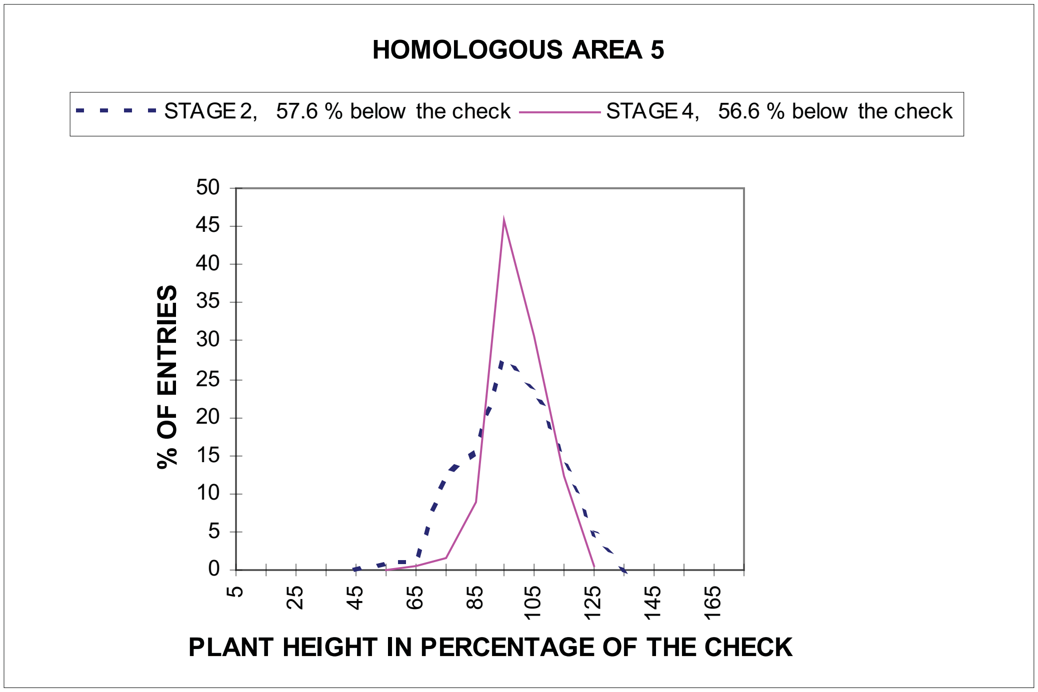
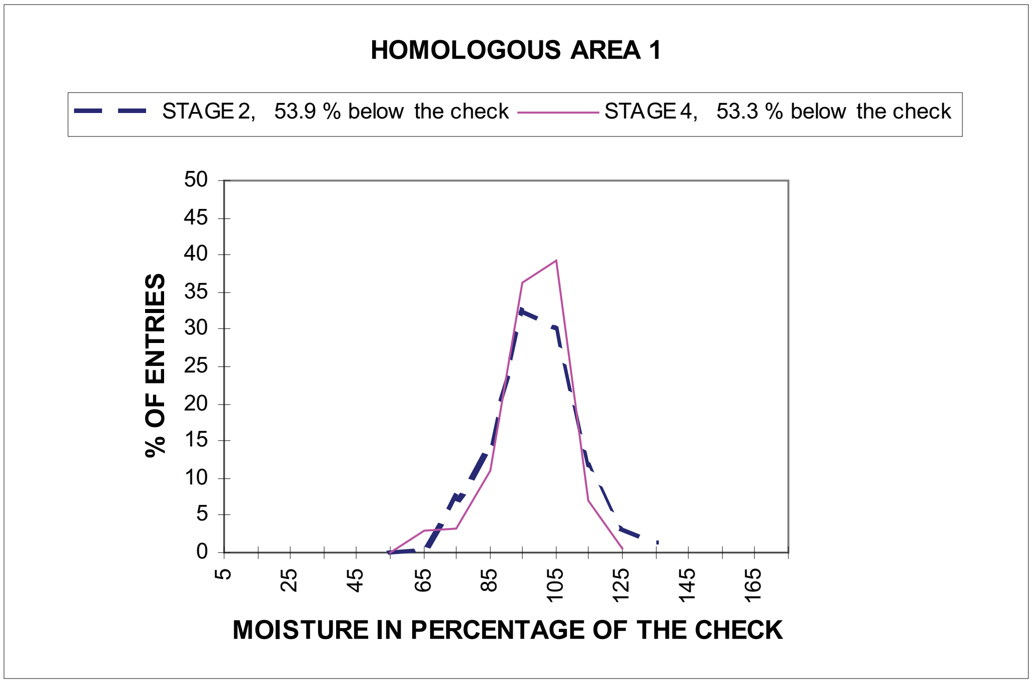


Figure 4. Moisture in percentage of the regional check variety



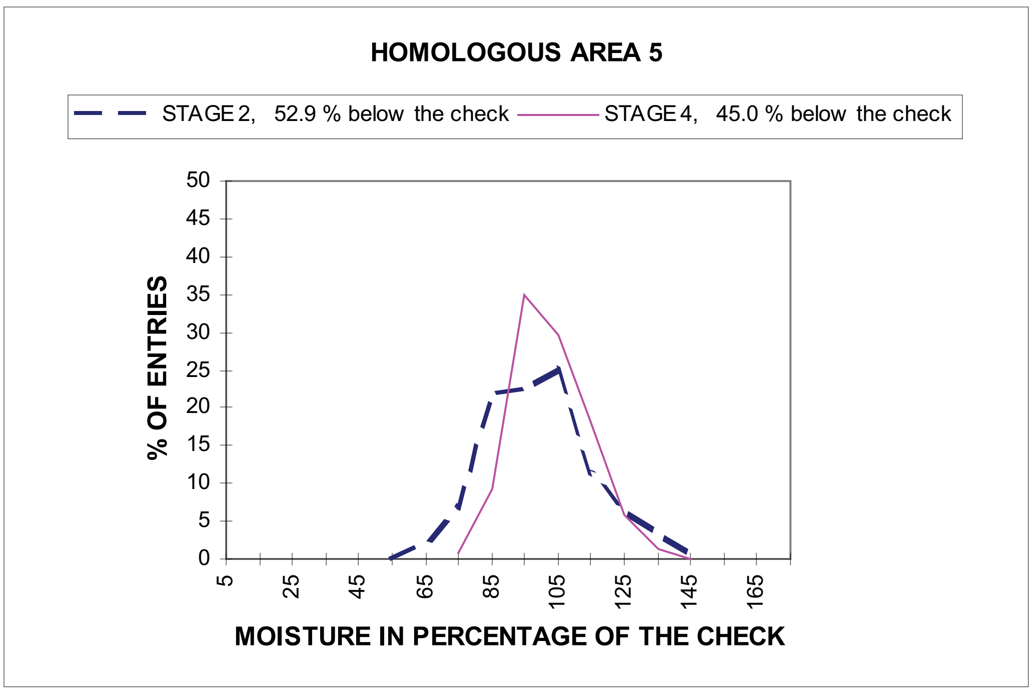


Table 5. Elite LAMP accessions with good combining ability with testers.

COUNTRY	ACCESSION	RACE	COMBINED WELL WITH TESTER
PERU	LBQUE 46	Arizona	PM701(m),
BRAZIL	Flint Comp.	Cateto	GuatV-312
BRAZIL	PE-01	Cateto	BR105, BR106,
COLOMBIA	VAL 310	Comun	PM212(m),
COLOMBIA	VAL 343	Comun	ICAV-258, PB8(h)
COLOMBIA	VAL 404	Comun	ICAV-258,
COLOMBIA	BOL 326	Costeño	PM701(m),
COLOMBIA	MAG 310	Costeño	PM212(m),
GUATEMALA	Guat Gpo21-18a	Criollo	Suwan, V-424, PB8(h),
USA-CARIBBEAN	Cuba 164	Criollo/Argentino	ICAV-258, H-511,
USA-CARIBBEAN	Barb Gpo 2	Criollo/Tuson	Suwan,
BOLIVIA	BOZM-1168	Cubano Amarillo	BR105,
BOLIVIA	BOZM-093	Cubano Amarillo	BR106, PM-102(m),
BOLIVIA	BOZM-0303	Cubano Amarillo	Suwan, BR106,
BRAZIL	C.Jaiba III	Cubano Amarillo	V-424, PM701(m), ,
MEXICO	CHIS 429	Cubano Amarillo	PB8(h),
PERU	M.DIOS 46	Cubano Amarillo	PB8(h),
PERU	PAS 14	Cubano Amarillo	BR105, H-422, PM-102(m), HC128xHC219, PB8(h),
PERU	UCAY 12	Cubano Amarillo	BR105,
BRAZIL	CMS-06	Dente Amarelo	HB-83(h), H-422,
BRAZIL	094.R2	Dente Amarelo	BR106,PM701(m),
BRAZIL	PE-11	Dente Amarelo	BR106, HB-83(h), H-422, PM-102(m), PM212(m),
BRAZIL	PE-27	Dente Amarelo	HB-83(h), HC128 x HC219,
BRAZIL	SE-33	Dente Amarelo	Suwan, HB-83(h), HC128xHC219,
BRAZIL	SE-32	Dente/Cateto	BR105, BR106, ICAV-258,
USA-CARIBBEAN	P.Rico Gpo 3	Early Caribbean	PM-102(m), PM212(m),
PERU	LIM 13	Perla	V-424,
BOLIVIA	BOZM-1155	Perola	BR106,
MEXICO	TMS 103	Raton/Tuxpeño	Suwan,
USA-CARIBBEAN	S.Croix Gpo 3	Saint Croix	Suwan, BR105, H-511, PM212(m),
USA-CARIBBEAN	S.Croix 1	Saint Croix	BR105, BR106, H-511,
BRAZIL	C.Manaus	Semidente Amarelo	BR105, ICAV-258,
BRAZIL	CMS-0508 III	Semidente Amarelo	BR106,
BRAZIL	SE-03	Semidente Amarelo	BR106,
BRAZIL	SE-28	Semidente Amarelo	HB-83(h), H-422,
GUATEMALA	Guat 209	Tuson	Suwan, BR105,
USA-CARIBBEAN	BVI 155	Tuson/Criollo	H-511, PM212(m),
BRAZIL	Tuxpeño 1	Tuxpeño	Suwan,
MEXICO	CHIS 462	Tuxpeño	H-511, H-422, V-424,
MEXICO	CHIS 644	Tuxpeño	BR105,
MEXICO	VER 147	Tuxpeño	BR106,
MEXICO	CHIS 775	Tuxpeño	Suwan, BR105, BR106, H-511,

Table 5. Elite LAMP accessions with good combining ability with testers (continued).

COUNTRY	ACCESSION	RACE	COMBINED WELL WITH TESTER
MEXICO	COAH 53	Tuxpeño/Norteno	V-424,
MEXICO	CHIS 567	Tuxpeño/Olotillo	H-511,
MEXICO	CHIS 740	Tuxpeño/Olotillo	Suwan, BR105,
COLOMBIA	HUI 305	Unclassified	PM-102(m),
COLOMBIA	TOL 403	Unclassified	Suwan,
USA-CARIBBEAN	R.Dom 150	Unclassified	HC128xHC219,
VENEZUELA	BG-70403	Unclassified	HB-83(h),
VENEZUELA	BG-070404	Unclassified	BR105, GuatV-312
VENEZUELA	BG-002	Unclassified	HB-83(h),
VENEZUELA	BG-809	Unclassified	HB-83(h), H-511,

ARGENTINA LAMP FINAL REPORT

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1. Genetic Materials Used in Argentina

Argentina has been characterized traditionally for the production of a typical variety of Cristalino Colorado race called "Maiz Plata". It is utilized mainly for animal feed. Previously, its use accounted for nearly 100% of the market of hybrids and varieties for local consumption and for exportation. Lately, the Dentado Amarillo (Yellow Dent) race has also been used in the commercial production of hybrids, due to the high heterosis of the crosses between lines from both races. At present, the contribution of the Cristalino Colorado race to the formation of the hybrids used in Argentina is 75%, and the Dentado Amarillo is 25%.

The Corn Breeding Program of INTA in Pergamino works mainly in the generation of lines and hybrids of the Cristalino Colorado race. Also it works to a limited extent with the Dentado Amarillo race and with other races for specific utilization such as Pisingallo and Cristalino Blanco.

The ears of the Cristalino Colorado race have from 12 to 20 straight grain rows with cylindrical shape. The flint endosperm is orange-yellow in color. It covers the entire germ, and has a tiny floury endosperm column, which generally does not reach to the top of the grain. The kernel has a round shape. There is no color in the pericarp and aleurone; and the cob is white. The accessions are generally of medium earliness from 65 to 85 days from planting to flowering.

The Dentado Amarillo race has thick ears, reaching a diameter of 60 mm, with cylindrical shape. The number of kernel rows varies from 10 to 28. Kernels are elongated with a dent or semident crown. Flinty yellow colored endosperm is located at the sides with variable width. There is no color in the pericarp and aleurone; and the color of the thick cob is predominantly red.

2. Elite LAMP Populations

Three hundred fifty accessions were evaluated in LAMP; and 330 were from the temperate region evaluated at Pergamino. Through the different stages of the project, 20 accessions were evaluated and selected of which 14 were from Cristalino Colorado, 3 Dentado Blanco (White dent), 2 Dentado Amarillo (yellow dent), and 1 Dentado Blanco Rugoso (wrinkled white dent).

Agronomic traits were used for the selection of the 20 elite accessions based on the results from the comparative yield trials. The main characteristics used were yielding ability, earliness, plants free of diseases and insect damage, and standability (no root lodging plants in the field), good ear quality, and ear type.

The elite materials selected in the LAMP stage II are as follows:

Accession	Race
ARZM 13035	Cristalino Colorado
ARZM 18009	Cristalino Colorado
ARZM 13026	Cristalino Colorado
ARZM 17056	Cristalino Colorado
ARZM 16035	Cristalino Colorado
ARZM 14057	Cristalino Colorado
ARZM 16021	Cristalino Colorado
ARZM 01102	Cristalino Colorado
ARZM 17026	Cristalino Colorado
ARZM 16001	Cristalino Colorado
ARZM 16053	Cristalino Colorado
ARZM 19006	Cristalino Colorado
ARZM 16026	Cristalino Colorado
ARZM 16042	Cristalino Colorado
ARZM 16062	Dentado Amarillo
ARZM 18057	Dentado Amarillo
ARZM 03054	Dentado Blanco
ARZM 03056	Dentado Blanco
ARZM 17034	Dentado Blanco
ARZM 01150	Dentado Blanco Rugoso

As reported in the 1994 LAMP Meeting, the elite LAMP accessions, mainly those from the Cristalino Colorado race along with other non-improved populations from the Germplasm Bank, were incorporated in the breeding work to get lines and commercial hybrids.

3. Activities in Stage 5

3.1 Accessions Used

According to LAMP Meeting V held in Fort Collins in July 1992, three orange flint type populations were selected: ARZM-16026, CHZM-05015 and URZM-13061. The populations were selfed in Iowa, and the S1 populations were shipped to different HA 5 countries. In March 1993, 837 S1 lines were received.

The LAMP stage 5 activities have been planned as the thesis of Ing. Agr. Luis Miguel Alvarez Mejia as part of the requirements for the postgraduate course in Plant Genetic Resources which is offered in Pergamino Experimental Station (INTA) and the Universidad Nacional de Rosario.

3.2 Present Activities

As agreed in the LAMP meeting V, the S1 lines were evaluated and crossed with the Mo17 inbred line from Ames, Iowa. The S1 lines were planted with the tester in an isolated plot in November 1993. The S1 plants were emasculated by hand to assure pollination by the tester. The S1 lines were also evaluated per se. The following descriptors were recorded: days from planting to female flowering, percent of broken plants and root lodged plants, number of tillers, number of ears per plant, and plant health. After harvest, the following ear and kernel characteristics were evaluated: shape, ear diameter, ear length, number of kernel rows, number of kernels per row, seed quality, and seed damage. These traits along with the plant characteristics were used to select the 20% S1 superior lines from each population to evaluate their top crosses in yield trials. 80 S1 lines were selected from each population. Seed of the selected top crosses were sent to other HA 5 countries to be evaluated in yield trials.

In October 1994, the selected materials were planted in yield trials in three locations at the Pampeana regions: Pergamino in two planting dates, Ferre, and Colón. Incomplete randomized blocks were used with two replications per location. Plots had two 5 meter rows, separated by 70 cm and 25 cm between plants. Besides the above cited descriptors, days to male flowering, percent of damaged plants by the Mal del Rio Cuarto, and yield corrected to 15% kernel moisture were recorded. Data were statistically analyzed by SAS, resulting in the selection of the 20% superior accessions based on their combining ability.

A synthetic will be formed using remnant seed stored in the germplasm bank of the selected S1 lines, and this synthetic will be made available to the breeders such as INTA and the LAMP members. The material will be planted in 1996 Spring. The thesis work was presented to the Examination Committee for its evaluation and will be defended at the end of June.

3.3 Future Plans

The synthetic will be incorporated into breeding programs as soon as possible by INTA breeders to get lines to be used in any breeding strategy.

3.4 Expectations for the Stage 5

The work expectations for Stage 5 have been covered. Argentina scientists have not limited their work to using only the 20 selected populations in Stage 2. Other important land races were incorporated as mentioned above.

4. Use of LAMP Populations

The utilization of the germplasm mainly from the Cristalino Colorado, Dentado Amarillo, Pisingallo, Cristalino Blanco as well as other races has been increased in the maize breeding program because of the evaluation of the accessions in LAMP. The evaluated materials and the information recorded were used applying different strategies in the formation of heterotic groups with Cristalino Colorado populations, the evaluation of Mal del Rio Cuarto tolerance as well as other maize breeding program activities.

5. The Importance of LAMP in Argentina

Because of LAMP, “the germplasm banks were opened” permitting breeders the discovery of genetic materials with great possibilities of successful use. LAMP enhanced the utilization of the non-improved populations incorporating major genetic variability to the working collection.

As mentioned above, the INTA maize breeding program is applying different work strategies to generate lines and hybrids with special agronomic characteristics such as insect and disease resistance, adaptation to several climatic stresses such as drought tolerance, germination at low temperature, etc. Besides, INTA is working in the evaluation of biochemical characteristics (oil, starch, and protein content) of germplasm bank accessions as well as the breeder’s working collections using electrophoresis and high performance liquid chromatography (HPLC).

BOLIVIA LAMP FINAL REPORT

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1. Genetic Material Used in Bolivia

About 50 percent of the maize areas in the Bolivian tropics are planted with a tropical semident yellow kernel race. Cuban Yellow and Suwan are the most representative varieties. The improved varieties for the highlands were generated in the Pairumani Center in Cochabamba.

Compuesto 10 was formed by Rocamex V-7, Tuxpeño, and Perla from Bolivia; Compuesto 13 from North American Corn Belt Dent, Huilcaparu, and Kellu from Bolivia. Compuesto 18 was formed with Ancho from Mexico, Corn Belt Dent, Morocho, and Kellu. Choclero 2 was formed by crossing Hualtaco from Bolivia, Cuzco Peruano and Corn Belt Dents. Choclero 3 came from Choclero 2, Ancho and Tuxpeño.

The Aycha Sara variety is homozygous opaque-2. The more widely used variety is Aycha Sara 5 which was formed by crossing Amarillo Calca from Peru, Ancho from Mexico, Aycha Sara 2, and Hualtaco from Bolivia.

2. Elite LAMP Populations

Five accessions were selected in the HA 1: BOZM-0303, BOZM-0082, BOZM-1168, BOZM-1155, and BOZM-0093; two accessions were selected in the HA 3: BOZM-1218 and BOZM-1224; and two in the HA 4: BOZM-0978 and BOZM-0862.

3. Activities in Stage 5

3.1 Accessions Used

Results both in Bolivia and Brazil showed that BOZM-0093, a Bolivian accession belonging to the Cubano race, had excellent combining ability when it was crossed with testers of the Tuxpeño race. The accession Chis-775 from the Tuxpeño race showed very high productivity in Bolivia, Brazil, Peru, and Paraguay when it was crossed by Suwan and by BR-105 (Suwan) from Brazil.

3.2 Present Activities and Use of Lamp Populations

Based on these results, it was decided to form two synthetic varieties from these accessions. However, they presented two negative characteristics: very tall plants and ears and many root lodged plants. Because of that, instead of using the accessions per se, it was decided to start with the crosses: BOZM-0093 x Suwan, and Chis-775 x BR-106 (a Tuxpeño Improved Synthetic).

In 1993, the crosses were recombined with selection against the taller plants with high ear placement. In 1994/95, about 200 to 250 plants were self pollinated in both populations to generate S1 and S2 lines. In 1995/96, the S2 superior lines were recombined, and two synthetic varieties were formed. Both varieties are showing short plants with medium ears heights and with reduced root lodging. The synthetic variety derived from BOZM-0093 x Suwan was named Pairumani Sint. 103, and the one derived from Chis-775 x BR-106 was named Pairumani Sint. 104.

In the winter 1996, the following crosses were made:

S2 lines of BOZM-0093 x Suwan by Sint. 104

S2 lines of Chis-775 x BR-106 by Sint. 103

Sint. 103 x Sint. 104

In HA 3 and HA 4, good interesting foreign materials were identified, mainly because of their tolerance to *Fusarium* that causes ear rot and their earliness. However, these foreign materials can not be utilized directly because the Andean people are very specific in their preference about the taste, size, texture, and color of the grain. To keep those characteristics in the future improved variety, the elite accessions will not be used directly but in crosses by Compuesto 18 and Ancho.

Apparently there is some relationship between the size of the grain and the susceptibility to ear rot caused by *Fusarium*, which will make the transfer of disease resistance to the native varieties difficult.

3.3 Future Plans

In summer 1996/97, a trial will be planted in two or three locations with the elite accessions, the synthetics 103 and 104, and the parents (BOZM-0093, Chis-775, Suwan, and BR-106) in order to evaluate the performance of the synthetics, their combining ability, and the combining ability of the lines extracted from them. Also in the same season more than 10 yield trials in different locations have been planned to test these new synthetic varieties with open pollinated varieties or hybrids from the national programs.

The synthetics will be backcrossed using the parental accessions as the recurrent parent. Then there will be strong selection for shorter plants and lower ear height.

BRAZIL LAMP FINAL REPORT

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1. Breeding Materials Used in Brazil

Brazil is a large country, and we have different situations because there are public and private breeding programs. There are more than 22 private enterprises that produce hybrid seeds and we do not know the basic materials that they used for breeding. There are also many public programs that produce varieties and hybrids including, in this case, the National Maize and Sorghum Research Center/EMBRAPA (CNPMS). We will answer for only CNPMS in this report.

Before LAMP, we were already working with intrapopulation and interpopulation breeding programs. There were many populations and inbred lines. Basically all materials are of tropical origin, and in most cases they came from other countries and from CIMMYT. The breeding program was started in 1976 with plant introduction and evaluation, and the best materials were incorporated to start intrapopulation selection. The more important populations that we had worked before the LAMP project are: Suwan DMR (BR 105), Composto Planta Baixa Dentado (BR 106), Composto Planta Baixa Flint (BR 107), Tuxpenõ-1 (CMS 08), Amarillo Cristalino (CMS 03), Pool 21 (BR 111), Pool 22 (BR 112), Pool 25 (CMS 14), Cateto Colombia Braquitico (CMS 18), Amarillo del Bajio (CMS 22), Cateto Colombia (CMS 25), Dentado Composto (BR 126), Composto Amplo (CMS 30), CMS 36, Composto Vega Precoce (CMS 50), Centralmex, Flint Composto, Maya, Azteca, etc.

2. Accessions Selected from LAMP

The selected accessions were those of Stage 3 to be crossed with the testers BR 105 and BR 106. But until this time, no accession from LAMP has been selected to be used in our breeding program.

Today in Brazil, the medium and big farmers have preferences for earliness, shorter plant height, semi flint or flint grain, and high productivity. The small farmers do not have strong preferences, but we have improved varieties (early, intermediate, and late) for different Brazilian regions. On the other hand, the high cost and the time required for improving the yielding ability of the accessions do not compensate at this time. In the future after evaluation for special characteristics, the maize accessions will be important for breeding and direct utilization or as sources of resistance to incorporate into elite materials.

3. LAMP Stage 5

3.1 Accomplishments in stage 5

For stage 5, the following activities were planned:

A. Evaluation of 2,000 S_1 lines in nursery rows (HA 5)

B. Experiments testing the best testcrosses for each tester from different countries (HA 1)

C. Testing of 100 elite HA 1 accessions per se in acid soils

D. Mass selection with biparental control with PE 01 and Pasco 014 (HA 1)

In spite of delays in receiving some materials, all work was carried out with success, and the results are presented with a brief description.

A. Evaluation of 2,000 S_1 from HA 5 (temperate) in Nursery Rows

It was planned that the planting date should be in November 1992. The seeds were late in arriving, and it was only possible to plant in 1994. Only 837 S1 lines were received, and the number of kernels varied from 20 to 40. Each S1 inbred line was planted in a 2 m row, and many of them had poor germination. The rain was normally distributed, but a large number of these lines showed poor adaptation. During the growing season, a strong disease incidence of (*Exserohilum turcicum*) occurred. From the planting date until harvest, many lines died (lack of adaptation), and others did not produce seed and showed plant height of less than 20 cm. Because of this, the best 10% of the lines were selected according to their yielding ability. These lines are shown below:

Item	Ear #	Source
384	130	ARZM 16-026
387	133	ARZM 16-026
517	263	ARZM 16-026
532	278	ARZM 16-026
597	8	URZM 13-061
716	127	URZM 13-061
754	165	URZM 13-061
768	179	URZM 13-061

B. Experiments Testing the Best Testcrosses for Each Tester from the Different Countries

The activities planned were to evaluate the best testcrosses (TC) for each tester (T) according to the following work plan:

Country	Locations	Testers (T)	Testcrosses
Bolivia	2 in Santa Cruz	Suwan	3
Brazil	Sete Lagoas, Janauba	BR 105, BR 106	6
Colombia	Palmira, Turipanã	ICAV 258	3
Guatemala	Cuyuta	HB 83(m)	3
Mexico	Cotaxtla, Iguala	H-511, H-422, V-424	9
Paraguay	Caacupé, Cap. Miranda	Guarani V-312	3
Peru	Piura, Cañete	PM 102(m), PM-212(m),PM701 (m)	9
USA	Tlaltizapan	HC 128 x HC 219	3
Venezuela	2 in Maracay	Ceniap PB 8(h)	3
		TOTAL	39

All countries shipped the seeds, but some problems occurred with the number of treatments or because we received torn bags. We received: from Mexico 8 testcrosses (TC) and 2 testers (T); from Paraguay 4 TC; from Peru 3 T and 6 TC; and from Bolivia 2 T and 5 TC. In order to complete a 7x8 lattice, two additional checks from Brazil were used. The trials were planted in Sete Lagoas-MG (02/11/93) and Propriá-SE (05/13/93), and the harvest occurred after six months. The experimental design was a 7x8 lattice with 2 replications, and the plot was 2 rows of 5 meters which gave a population density of 50,000 plants/ha.

BR 105 x BR 106 was used as an intercalate check. The trials were carried out with adequate moisture because supplementary irrigation was applied when necessary.

During crop development the following characteristics were measured: days to 50% tassel (DT), days to 50% silk (DS), % stand, plant height in cm (PH), ear height in cm (EH), % broken stalks (BS), % root lodged (RL), number of ears with disease (ED), ear weight in kg/ha (EW), and grain weight in kg/ha (GW). The coefficient of variation (%) for EW and GW were 19.5 and 20.2 in Propriá-SE and in Sete Lagoas were 13.0 and 13.8, respectively. The mean yield values for the two locations are presented in Table 1. The combined analysis of variance for both location showed significant differences among testcrosses in DS, PH, EH, BS, RL, ED, EW and GW, but no significance was found for the testcross x location interaction. Table 2 shows mean values over two location of the 20% best testcrosses considering DT, DS, PH, EH, BS, RL, EW, and GW and the origin for each accession and tester. It can be seen that among the best testcrosses, 90% involve Brazilian accessions or testers. The intercalate check produced 6,780 kg/ha and 5,670 kg/ha for ear weight and grain weight, respectively. However, there are testcrosses with nearly as good yields that show a better performance for stalk and root lodging. The testers HC 128 x HC 129 and V 424 showed a very good score for resistance to broken stalks and root lodging in both locations. These testers can be used as sources for utilization in breeding programs.

C. Testing Elite Accessions in Acid Soils (HA 1)

According to the work plan, on November 23, 1992, a trial was planted in Sete Lagoas-MG with Brazilian accessions and with those that were sent by other countries: Bolivia - 5 accessions; Guatemala - 7 accessions; Venezuela - 5 accessions; Brazil - 17 accessions and 4 cultivars to complete the lattice; Colombia - 22 accessions; Paraguay - 4 accessions; Peru - 10 accessions; United States - 7 Caribbean accessions. The trial was planted in *latosolo vermelho escuro, distrófico* soil with 40% of aluminum saturation and was fertilized with 16-56-32 kg/ha (NPK) at planting. Thirty days after the planting date, the trial received 40 kg/ha of nitrogen. No problems with rain distribution occurred during the developing stages. The experimental design was a triple 9x9 lattice, and the plot was formed by one row with a length of 4 m giving a population density of 50,000 plants/ha. The BR 136 population, selected for aluminum resistance, was included as the intercalate check. During the growing season, the following traits were measured: days to tassel (DT), days to 50% silk (DS), plant height in cm (PH), ear height in cm (EH), % stand, % broken stalks (BS), % root lodged (RL), number of ears, and ear weight in kg/ha (EW). The ear weight data were adjusted to 14.5% moisture. Entry means are shown in Table 3. The mean values for EW varied from 212 kg/ha to 4,148 kg/ha, and other traits showed large variations. The analysis of variance showed significant differences among entries for traits. BOZM 1168, CMS 0508 III, SE 033, RN 007, and PAZM 08063 showed higher yields than the local check variety, BR 136 (IC).

For DT and DS, the accessions, in most cases, were later than the check. For the other characteristics, we found accessions with lower plant height, broken stalks and root lodging. These results are very useful because we can use these accessions as sources for aluminum tolerance to begin a breeding program to this stress condition.

D. Mass Selection with Biparental Control with PE 01 (BR 051403) and Pasco-14 (HA 1)

In accordance with the established program for stage 5, accessions PE 01 and Pasco-14 were submitted to two cycles of mass selection with biparental control. The first cycle of selection was planted in September 1992 and harvested in February 1993, in a field of 800 m2. All ear shoots were covered with shoot bags, and only plants that had two shoots/plant were pollinated. One day before pollination, tassels of prolific plants were bagged. The next day pollen was collected, and a bulk from this pollen was used to pollinate the second ear shoots. Then these ears were protected with a special paper bag to avoid contamination and bird attacks. During the pollination time, more than twenty tassels were taken daily in order to make a pollen bulk.

After pollination of the second ears, the plastic bags for the first ears were removed in order to permit pollination. Besides prolificacy, shorter plants and those plants free of foliar diseases were selected. After harvest, 50 kernels were taken from each selected ear to form a bulk that was used to begin the next cycle. In each cycle more than fifty second ears were harvested. The female flowering for Pasco-14 and PE 01 occurred 105 days after planting, showing that they are very late. For plant height, Pasco-14 showed values of 278 cm and 258 cm for the first and second cycle, respectively; and for ear height these values were 179 cm and 155 cm, respectively. In the PE 01 population, the values were 247 cm and 240 cm for plant height in the first and second cycle, respectively; and for ear height these values were 149 cm and 135 cm, respectively.

The second cycle was planted in April 1993 and harvested in October 1993. The methodology used for both accessions was the same for the first and second cycle. Seed available from each cycle of selection is shown below:

PE 01	-	Cycle 1	2.3 kgs
PE 01	-	Cycle 2	3.7 kgs
Pasco 014	-	Cycle 1	0.2 kgs
Pasco 014	-	Cycle 2	2.0 kgs

3.2 Plans for the Future

It is intended to continue working with germplasm conservation and utilization in breeding programs. First of all, introgression of temperate material into tropical elite varieties and inbred lines is needed in order to get earliness and to improve the productivity level. Secondly, selecting accessions for marginal areas (biotic and abiotic stress) is needed.

The expectations for the future are related to accessions that were regenerated and selected for special characters such as resistance to foliar diseases and ear diseases to form maize synthetics.

4. Importance of LAMP for Brazil

Besides accomplishing the evaluation of the native and foreign germplasm, it was a very good opportunity to know the morphological characterization because in the future we are planning to organize a core collection. Another beneficial aspect was the regeneration of accessions. There are, however, other factors that are more important at this moment, such as screening accessions for resistance to foliar diseases and finding accessions with adaptation and good yield potential in environmental stress conditions (acid soils, low N and P in the soils, drought tolerance, etc.). The network established with researchers in other Latin American countries will continue to enhance cooperation and the interchange of germplasm in the future, which is extremely important for developing countries.

Table 1. Mean yield values for Sete Lagoas - MG and Propriá - SE, Brazil, Agricultural Year 1993, of the testcrosses, testers and checks.

Pedigree	Sete Lagoas		Propria		Average	
	Grain weight Kg/ha	% over Control	Grain weight Kg/ha	% over Control	Grain weight Kg/ha	% over Control
BR105 X BR106 (Control)	6203	100%	5133	100%	5668	100%
R. DOM 150 x (HC128 x HC219)	6099	98%	4842	94%	5471	96%
BR 052051 (Se32) x BR105	6148	99%	4298	84%	5223	91%
BR 052060 (Se33) x HB83 (m)	6726	108%	3682	72%	5204	90%
BR 052060 (Se33) x (HC128 x HC219)	6647	107%	3745	73%	5196	90%
BR 051403 (Pe01) x BR105	6172	100%	4134	81%	5153	90%
BR 051501 (Pe11) X PM102 (m)	5847	94%	4445	87%	5146	90%
BR 051403 (Pe01) X BR106	5799	93%	4311	84%	5055	89%
BR 052060 (Se33) x BR105	5626	91%	4178	81%	4902	86%
BR 052060 (Se33) X PM212 (m)	5485	88%	4170	81%	4828	85%
BR106	5295	85%	4352	85%	4824	85%
BG002 x HB83 (m)	5427	87%	4072	79%	4750	83%
BR 051721 (Rn 07) X BR106	5592	90%	3907	76%	4750	83%
BR105	5509	89%	3695	72%	4602	80%
HC128 x HC 219	5560	90%	3518	69%	4539	79%
Chis 775 x Suwan	4499	73%	4526	88%	4513	80%
BR 051675 (Pe27) x (HC128 x HC219	4807	77%	4124	80%	4466	79%
BG 070403 x HB83 (m)	5146	83%	3649	71%	4398	77%
BR 050024 (C. Manaus) x BR105	4944	80%	3851	75%	4398	77%
Nay 148 x H511	5805	94%	2960	58%	4383	76%
Col 38 x H422	4942	80%	3790	74%	4366	77%
Chis 775 x V424	4420	71%	4274	83%	4347	77%
BR 051501 (Pe11) X PM212 (m)	5354	86%	3334	65%	4344	76%
Pasco 14 x PB8 (h)	4941	80%	3681	72%	4311	76%
BR 031381 x Suwan	4128	67%	4269	83%	4199	75%
Ant 343 x ICAV258	4631	75%	3709	72%	4170	73%
Guat. Gpo.21-18A x PB8 (h)	5263	85%	3070	60%	4167	72%
BR 0311381 x BR105	4838	78%	3418	67%	4128	72%
PB8 (h)	5100	82%	3086	60%	4093	71%
Sint Elite (check variety)	4845	78%	3326	65%	4086	71%
Val 343 x PB8 (h)	5009	81%	3142	61%	4076	71%
BR 051501 (Pe11) x BR106	4461	72%	3632	71%	4047	71%
Guat. Gpo.21-18A x Suwan	4410	71%	3595	70%	4003	71%
BR 201 (check hybrid)	4935	80%	3058	60%	3997	70%
Guat. 209 x Suwan	4304	69%	3643	71%	3974	70%
Tams 129 x H511	4615	74%	3127	61%	3871	68%
Suwan	4437	72%	3290	64%	3864	68%
HB 83 (m)	5423	87%	2295	45%	3859	66%
Val 404 x ICAV258	4187	67%	3407	66%	3797	67%
Sin 74 x V424	3927	63%	3568	70%	3748	66%
Sin 74 x H511	4513	73%	2928	57%	3721	65%
BG 070809 x BR106	4334	70%	3092	60%	3713	65%

Table 1. Mean yield values for Sete Lagoas - MG and Propriá - SE, Brazil, Agricultural Year 1993, of the testcrosses, testers and checks (continued).

Pedigree	Sete Lagoas		Propria		Average	
	Grain weight Kg/ha	% over Control	Grain weight Kg/ha	% over Control	Grain weight Kg/ha	% over Control
BR 030929 (094 R2) x PM701 (m)	4126	67%	3282	64%	3704	65%
Ant. 377 x ICAV258	3876	62%	3347	65%	3612	64%
Pairumani H 101	4144	67%	3022	59%	3583	63%
Tams 106 x BR106	4163	67%	2981	58%	3572	63%
Col 38 x V424	3741	60%	3172	62%	3457	61%
BR 051501 (Pe11) x PM701 (m)	3591	58%	3278	64%	3435	61%
Sin 70 x H422	4270	69%	2322	45%	3296	57%
PM212 (m)	4100	66%	2490	49%	3295	57%
PM701 (m)	3444	56%	2964	58%	3204	57%
BR 044083 (C. JaibaIII) x PM701 (m)	3410	55%	2460	48%	2935	51%
Tams 103 (Mex.) 103 x Suwan	3307	53%	2487	48%	2897	51%
H422	3489	56%	859	17%	2174	36%
ICAV258	1834	30%	2179	42%	2007	36%
PM102 (m)	2367	38%	1470	29%	1919	33%
V424	2067	33%	814	16%	1441	25%
MEAN	4707		3394		4050	

Table 2. Mean characteristic values across two locations for the best 20% of the testcrosses and the check (C) and the origin for each accession (AC) and tester (T). Sete Lagoas - MG and Propriá - SE, Brazil. Agricultural Year 1993.

ENTRIES	DT*	DS	PH	EH	BS	RL	EW	GW	ACC	TES
R.Dom 150x(HC128 x HC219)	60	63	250	131	10	14	6400	5470	USA	USA
Se 32xBR-105	57	62	250	153	16	12	6300	5220	BRA	BRA
Se33 xHB83 (m)	60	64	253	160	13	19	6280	5200	BRA	GUA
Se33x(HC128 x HC219)	60	63	258	146	12	15	6370	5200	BRA	USA
Pe01xBR-105	61	63	253	150	20	11	6280	5150	BRA	BRA
Pe11xPM-102(m)	63	68	252	145	18	20	6350	5150	BRA	PER
Pe01xBR-106	60	64	250	140	13	20	6230	5050	BRA	BRA
Se33xBR-105	57	63	259	157	15	11	6030	4900	BRA	PAR
Se33xPM-212(m)	60	64	282	181	24	20	5990	4820	BRA	PER
BR-106	60	62	235	133	16	17	5890	4820		BRA
RN 07 x BR-106	59	63	271	157	22	19	5820	4750	BRA	BRA
BR-105 x BR-106(C)	58	62	247	145	18	14	6780	5670	BRA	BRA

DT* Sete Lagoas only

Table 3. Means obtained with elite accessions, intercalate check (IC), additional treatments (AT), in acid soils conditions. Sete Lagoas - MG, Brazil. Agricultural Year 1992/93.

ENTRIES	PEDIGREE	DT	DS	PH	EH	BS	RL	DE	EW
1	BOZM 0093 C. Blanco	71	76	186	119	17	34	54	3,012
2	BOZM 0082 C. Amarillo	68	74	155	85	4	34	80	1,560
3	BOZM 0303 C. Amarillo	69	74	175	98	7	41	67	2,317
4	BOZM 1168 C. Amarillo	72	78	197	99	22	33	19	4,148
5	BOZM 1155 Pérola	75	84	202	125	9	45	42	2,834
6	Guate GPO 4-1 A	58	64	146	69	0	61	42	1,391
7	Guate GPO 5-1 A	59	68	139	73	0	70	41	1,123
8	Guate GPO 13-2 A	67	75	145	71	0	45	29	1,317
9	Guate GPO 21-18A	68	74	166	89	3	52	25	2,506
10	Guate 110	60	66	151	80	5	46	26	1,490
11	Guate 209	67	73	180	111	4	48	23	1,956
12	Guate 740	68	73	137	70	0	34	28	516
13	BG 070809	69	74	139	73	0	81	20	1,521
14	BG 002	69	74	149	79	0	43	32	2,270
15	BG 070809	69	74	177	94	2	28	19	1,831
16	BG 070404	70	75	144	78	3	51	23	1,867
17	BG 070422	69	76	149	78	14	43	55	1,873
18	CMS 0508 III	64	68	160	74	0	44	22	3,799
19	CMS 06	70	73	162	89	12	42	22	3,265
20	Tuxpeño	71	78	147	83	5	33	39	1,894
21	PE 011	69	74	196	86	12	58	29	3,188
22	094 R 2	70	75	163	75	2	45	27	3,349
23	BA 038	71	77	159	93	0	40	32	2,631
24	Flint Comp. Ne. MIII- HS	70	75	158	93	5	46	21	3,033
25	Composto Manaus	69	74	187	99	1	46	19	2,987
26	PE 01	69	73	159	95	3	37	21	3,144
27	Comp. Jaíba III	69	74	176	104	10	39	10	2,567
28	AL 15	69	75	183	104	9	33	33	2,510
29	PE 27	68	74	159	82	5	49	29	3,150
30	SE 33	70	77	190	107	5	33	26	3,540
31	RN 07	70	76	185	99	3	34	23	3,500
32	SE 03	70	74	177	106	5	42	13	3,060
33	SE 28	70	75	170	97	4	27	19	3,170
34	SE 32	68	74	161	79	6	37	10	3,328
35	ANT. 308	69	74	163	87	6	26	21	959
36	ATL. 308	70	75	180	106	5	5	20	212
37	ATL. 328	66	69	143	67	3	46	35	923
38	BOL. 308	73	79	153	83	32	33	33	1,575
39	BOL. 326	80	86	159	85	18	20	30	584
40	COR. 309	79	86	135	84	18	30	25	1,034
41	MAG. 310	72	76	131	82	15	33	30	1,995
42	MAG. 346	71	80	132	69	29	29	27	811
43	MAG. 362	73	82	140	88	11	37	50	1,017
44	MAG. 388	78	83	145	74	22	36	15	1,158

Table 3. Means obtained with elite accessions, intercalate check (IC), additional treatments (AT), in acid soils conditions. Sete Lagoas - MG, Brazil. Agricultural Year 1992/93 (continued).

ENTRIES	PEDIGREE	DT	DS	PH	EH	BS	RL	DE	EW
45	MAG. 478	73	81	163	72	12	25	40	933
46	TOL. 403	73	82	158	93	6	28	47	902
47	ANT. 373	70	78	143	74	2	32	42	2,062
48	ANT. 377	78	85	188	97	17	35	15	1,985
49	HUI. 305	72	80	173	97	27	26	32	1,549
50	HUI. 355	84	88	194	120	8	46	41	1,063
51	NAR.628	78	84	188	101	12	49	26	1,630
52	VAL. 310	71	79	144	84	15	21	28	2,036
53	VAL. 325	71	76	188	119	4	57	27	2,108
54	VAL. 343	69	72	176	100	25	24	36	1,145
55	VAL. 380	70	79	186	125	34	27	43	1,572
56	VAL. 404	70	77	152	92	9	36	33	1,965
57	PAZM 08063	71	78	190	105	5	38	32	3,506
58	PAZM 03002	71	75	194	105	7	23	45	2,386
59	PAZM 07069	64	70	164	79	0	34	38	3,314
60	PAZM 01020	74	78	188	109	0	46	16	2,924
61	SAN MARTIN 126	69	75	183	111	1	29	23	3,073
62	Loreto 021	71	77	166	89	18	34	28	2,307
63	Piura 163	64	71	137	91	0	26	50	287
64	Piura 196	67	73	156	89	2	91	78	426
65	Lima 13	70	79	173	87	11	34	46	1,984
66	M. de Dios 22	70	76	191	113	16	28	21	2,915
67	San Martin 111	70	76	197	118	7	26	26	2,717
68	Piura 229	62	70	142	81	25	32	57	994
69	Ucayali 012	71	77	153	100	4	40	28	2,321
70	M. de Dios 46	73	83	167	97	12	29	46	2,057
71	PER GP 3	70	76	155	95	27	49	38	2,718
72	RDOM 150	69	76	157	90	9	43	24	1,876
73	BVI 155	74	78	199	130	38	28	40	2,608
74	BARB GP 2	74	78	168	99	12	36	22	2,699
75	SCRO GP 1	69	73	134	80	2	45	60	1,273
76	SCRO GP 3	68	72	159	72	7	55	38	2,161
77	Cuba 164	69	77	154	77	3	54	27	2,345
78	BR 201 (AT)	68	74	145	67	4	36	38	3,031
79	CMS 30 (AT)	69	73	176	87	3	49	25	3,238
80	CMS 4C (AT)	68	72	164	76	2	32	22	3,839
81	CMS 14C (AT)	68	73	168	91	0	35	19	3,382
	BR 136 (IC)	**68**	**72**	**171**	**87**	**7**	**43**	**15**	**3,424**

CHILE LAMP FINAL REPORT

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1. Genetic Materials Used in Breeding Plans

Variedad Coihueco: an orange flint kernel variety adapted to the Central-South region. It has been developed by full-sib selection of the Ocho Corridas race.

Compuesto Colorado Cono Sur (Southern Cone Colorado composite): Formed with flint kernel genetic materials from the South American Southern Cone countries: Argentina, Bolivia, Brazil, Chile, Paraguay, and Uruguay. Materials from Chile belong to the Camelia racial composite.

Compuesto Semidentado Amarillo Cono Sur (Southern Cone Yellow Semident Composite): Derived from Chilean and Argentinean varieties. Chilean materials are several landraces from Chile and "Alequat" which is a composite formed with CIMMYT germplasm.

Open pollinated varieties: Two varieties, one of the Choclero type and the other belonging to the Camelia race were obtained.

2. Chilean Selected Accessions

The selected accessions resulted from the evaluation of the germplasm since 1985 (855 accessions). In the first stage, the superior 20% were selected (147 accessions) according with the following values of selection:

Yield = >7,900 Kg/ha (15% seed moisture)

Earliness: days from planting to harvest = < 92

Plant height: =< 300 cm

Broken and lodged plants: root lodged and broken plants = < 15%

The second stage of selection was done based on results of regional trials, grouping the accessions by maturity. From these trials, the superior 10% was selected with the same parameters used in the first stage. This stage of selection resulted in 16 elite accessions.

In the final stage, the 16 Chilean accessions together with 62 accessions from Argentina, Brazil, Uruguay, and USA were evaluated. In this stage, the selection parameters were the following"

Yield = > 10,000 Kg/ha

Caloric units = < 800

Plant height = < 300 cm

The sixteen elite accessions were crossed by three testers (B73 x B14A, Oh43 x Mo17, and Del Plata 101), and the testcrosses were evaluated in yield trials. Parameters of selection were the same as those used in the first stages; in addition, an index of prolificacy that at least one ear per plant was required. Only one Chilean accession was selected (CHZM05015).

3. Activities in Stage 5

3.1 Accessions used in this stage

Following the evaluation and selection of the materials that was done in the different homologous areas of 4 countries, 4 elite accessions were selected:

ARZM17056 (Argentina)

ARZM16026 (Argentina)

CHZM05015 (Chile)

URZM1089 (Uruguay)

3.2. Activities during the 1994/95 season.

Seed of selected accessions from Argentina and Uruguay were received, and two planned breeding projects were initiated, which resulted in:

- Self the best plants from each population, and 740 S1 lines were obtained

- Cross and backcross the accessions with the lines of INIA 160, and 178 crosses were obtained.

3.3 Plans for 1996/97

- Complete 400 to 500 S_1 lines of the 4 selected accessions.

- Backcross the accessions x line crosses, using the accession as recurrent parent, in order to have 75% of the genes from each accession in the crosses.

3.4 Future Plans

The evaluation of the S_1 lines is going to be continued. The superior ones will be crossed with two distinct heterotic testers. The top 10% of the lines selected on the basis of their testcross performance will be recombined next year to complete the first cycle.

4. The Importance of Lamp for Chile

The evaluation of LAMP has permitted:

- To identify genotypes with special traits such as early maturity adapted to short summer seasons (Araucano), drought resistance (Maiz de Rulo y Semanero), and adaptation to very high elevation, as much as 3700 masl.

- To work with genetic materials with a good potential for grain production, from Amarillo de Malleco and Cristalino Chileno races, as well as green corn production from races such as Choclero and Diente de Caballo.

- To develop hybrids adapted to the Northern conditions of Chile. There are races with good ability to develop sweet and floury hybrids, with drought tolerance and high salt concentration tolerance.

COLOMBIA LAMP FINAL REPORT

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1. Breeding Materials Used in Colombia

The Table 1 shows how the germplasm has been used in Colombia.

2. Accessions Selected from Lamp

2.1 Accessions According to Homologous Area

HA 1 (C.I. Turipaná and C.I. Palmira):

Ant 308, Atl 308, Atl 328, Bol 308, Bol 328, Cor 309, Cor 351, Mag 310, Mag 346, Mag 362, Mag 388, Mag 478, Tol 403, Ant 373, Ant 377, Hui 305, Hui 355, Nar 628, Val 325, Val 343, Val 380, Val 404, Val 310.

HA 2 (C.I. Tulio Ospina):

Cau 454, Hui 317, Hui 358, Hui 386, Hui 387, Hui 388, Nar 481, Nar 625, Val 410, Val 418.

HA 3 (C.I. La Selva):

Ant 423, Ant 439, Ant 485, Ant 494, Boy 328, Tol 384, Cun 342.

HA 4 (C.I. Tibaitatá):

Ant 504, Ant 536, Ant 560, Ant 564, Ant 567, Boy 377, Boy 382, Boy 494, Cun 573, Nar 626, San 361.

2.2 Criteria Used in Selection

C.I. Turipaná:

High yield potential. Kernels are flint to semi-flint. Color is yellow to white. Plant height below 3 m. Ear height below 1.7 m. Easy to shell.

C.I. Palmira:

High yield potential. Kernels are flint. Color is yellow to white. Small plant height.

C.I. Tulio Ospina:

High yield potential. Prolific. Flint and floury kernels. Color is yellow or white.

C.I. La Selva:

High yield potential. Vigorous plants. Plants resistant to disease. Large and flint kernels. Color is yellow or white. Montaña ear type. Intermediate maturity.

C.I. Tibaitatá:

High yield. Choclero type. Prolific. Type of kernel is flint, semi-flint, floury. Color is yellow and white.

3. Activities in Stage 5

3.1 Accessions Evaluated:

C.I. Turipaná (HA 1)

From Colombia:

Cor 309, Atl 328, Mag 310, Mag 388, Bol 328,	
Ant 373, Tol 403, Val 343, Ant 377 and Val 404	= 10

From Mexico:

Chis 775, Tams 103, Tams 129, Nay 148, Sin 70, Sin 74	= 6

From Brazil:

Tuxpeño 1, BR-105, Pe-01, Se-32, BR-106, Se-33	= 6

From Guatemala:

Guat Gpo 21-18A and Guate 209	= 2

From Caribbean Pto. Rico:

Cuba 164, and Saint Croix Gpo 1	= 2
Subtotal:	26

C.I. Tulio Ospina (HA 2)

From Colombia:

Hui 317, Hui 358, Hui 387, Nar 625, Val 410, Val 418 = 6

From Mexico:

Dgo 32, Coah 21, Tams 119, Tams 129,

Jal 222, Pue 4, Nay 289 = 7

From Guatemala:

Criollo Amarillo Cojulum = 1

Subtotal: 14

C.I. La Selva (HA 3)

From Colombia:

Ant 439, Boy 328, Tol 384 = 3

From Guatemala:

Guate 308, Guate 434, Guate 500,

Criollo Amarillo Cojulum, Criollo Blanco J.J. Espital = 5

From Bolivia:

BOZM-1224 = 1

Subtotal: 9

C.I. Tibaitatá (HA 4)

From Colombia:

Ant 504, Ant 536, Ant 560, Ant 564, Ant 567,

Boy 377, Boy 382, Boy 494, Cun 573, Nar 626, San 361 = 11

From Bolivia:

BOZM-1224, BOZM-0862, BOZM-0978 = 3

From Guatemala:

Guate 434, Guate 500 = 2

From Perú:

Jun 164, Apuc 06, Cuz 363, Cuz 364,

Aya 72, Aya 119, Apuc 72, Apuc 090		= 8
	Subtotal:	24
	Grand Total:	74

3.2 Stage 5 Accomplishments

Stage 5 was completed with accessions and testcrosses from HA 3 (C.I. Selva).

Accessions of HA 1 were evaluated in a hot humid climate (C.I. Tulenapa).

Accessions from HA 1 were included in the selection of tolerance to low nitrogen at C.I. Turipana.

Testcrosses were made with the accessions from Guatemala with the improved varieties ICA V 453 (white) and ICA V 402 (yellow) from HA 3.

Second evaluation of accessions HA 1 in a hot humid climate (C.I. Tulenapa)

3.3 Expectations of Stage 5

The LAMP project allowed Colombia, after 40 years, to evaluate and charcterize the native collections and thereby allowing us to use them in different projects according to the specific needs of each region (populations early, prolific, floury, flint, yellow, white, thick stalk, tillers, etc.).

Also in this Stage we were able to obtain a series of populations (varieties or hybrids) that could possibly be used immediately; that is if we take advantage of the vigor that the hybrids showed in the crosses with the accessions (heterosis).

4. Steps Followed to Improve the Accessions Selected from LAMP

In the Caribbean region, we began using 12 Colombian collections from HA 1. In this project we are looking for populations that utilize little nitrogen, with high yields and good adaptability. This project is being conducted in C.I. Turipana (Monteria, Cordoba) with evaluations being made during two seasons. The best accessions were Cor 320 and Val 343. Afterwards, S1 lines were developed in plots with low nitrogen, which were used in making composites, hybrids, synthetics, etc.

There is also a possibility of starting a project that would improve the native Puya race in the Uraba region (there are approximately 100 thousand hectares of corn planted). In the completion of the evaluation of accessions from HA 1 during two seasons, the best accessions were Mag 338, Mag 342, Val 410, Hui 305, Nar 628, and Cor 351. These accessions were superior to the local variety Puya race by 30 to 65% (1,000 to 1,500 Kg/ha). Some of these accessions belong to the Puya race. They are white and have the characteristic of easiness to shell which most of the farmers want (in this region there is no equipment for shelling).

There is another project that can be started, which would utilize the accessions from HA 3 to find plants that would be resistant to diseases especially tar spots (*Phyllachora maydis*). This would be conducted in a moderately cold climate in the Andean region of the country in C.I. La Selva.

5. Importance of LAMP for Colombia

The work done demonstrated that there exist materials with great genetic potential, not only in our country, but also in the other Latin American countries that participated. This will help us to find the solution to our problems that we have experienced in our country, such as diseases (smut on the tassel in the Caribbean region, foliar disease in the moderate cold climates of the Andes, rotting of the ear in cold climates, etc.), adaptability (intermediate climate in the Andean region), adverse climate conditions (drought, excessive water, freezing), and unproductive soils (excessive aluminum in the Colombia Orinoco region, lack of fertility in the majority of maize growing region, etc.).

From the experience learned from LAMP, the areas of warm climates in Colombia would have to be paired up with countries from Central America, Caribbean, Venezuela, and Brazil; for the intermediate climates in the Andean region would be Mexico and Central America; and for the cold areas would be Guatemala, Peru, and Mexico.

Table 1. Germplasm used in Colombia.

Collection	Improved Variety	Breeding Method	Description
Ant 428	Diacol H 451	Hybridization	Montaña BF Yield
Ant 439	Diacol H 401	Hybridization	Montaña AF Yield
Boy 371	Diacol V 551	Mass Selection	Sabanero, BF
Blanco Rubí	ICA V 554	Full sib family selection	Sabanero BF
Cun 365	Diacol H 501	Varietal hybridization	Sabanero,
Ecu 466	Diacol H 501	Varietal hybridization	Mischca-Chillos
Cun 431	ICA H 556	Varietal hybridization	Sabanero-Early
Cacahuacintle	ICA H 556	Varietal hybridization	Mexico-Early
Hso Mosquera	ICA V 507	Prolif. Mass Selection	Sabanero AH
Nar 330	ICA H 302	Hybrids among lines	Común, AF
Socorrano	ICA V 304	Hybrid. and Mass Selec.1	Cacao, AH
Sogamoceño	ICA V 508	Prolif. Mass Selection	Sabanero-Cacao, AHC
Gua 314	ICA V 108	Varietal Hybrid. and Selec.	Negrito, Black kernel and, Early
CIMMYT 307	ICA H 353	Varietal Hybridization	Several adapted Races and Yield
CIMMYT 319	ICA V 157	Mass Selection	White Trop. Mix. BF, CH.
Rocamex V7	ICA V 552	Full sib family Selec.	Mexico, BF, Yield
Ant 357	Promissory	Composites	Montaña, Resist. to stalk & ear rot.
Ant 440	Promissory	Composites	Montaña, Resist. to stalk & ear rot.
Ant 443	Promissory	Composites	Montaña, Resist. to stalk & ear rot.
Cho 318	Promissory	Composites	Clavo, Resist. to stalk & ear rot.
Cun 499	Promissory	Composites	Amagaceño, Resist. to stalk & ear rot
Nar 354	Promissory	Composites	Común Resist.to stalk & ear rot
Ecu 466	Promissory	Composites	Mischca-Chillos Resit. to stalk & ear rot.
Criollo Guavatá	VE 45	Mass Selection	Cacao, BH
Boy 399	MB 524	Mass Selection	Sabanero, BF, early
Boy 555	ICA H 558	Hybridization	Sabanero, BF
Cacahuacintle	ICA H 558	Hybridization	México, BH
Montaña	ICA V 402	Ear to-row Selec.	Montaña, AF, Vigorous stalk
CIMMYT 307	ICA V 155	Mass Sel. for yield and plant height	Tuxpeño, BF, SD
Criollo Choco	MB 310	Mez 90 Maize Chococito	Chococeño, AF, Toler. Humidity
Urrao 5	L 1	Line development	AF, HCE
Ven 1	L 1	Line development	AF, HCE
Col, Mex, USA Cuba, Ven, Bra Arg y Pto Rico	ETO	Sibs & multiple crosses	Difer. races, AF, World Genet. Res.
Mex 497, Chi 350 Ven 383, Ven 336 Mex 493 y Bol 302	MB 323	Hybrid. & Composite	Several races and colors, Early
Mez. Maíces Caribe	ICA V 106	Composite & Mass Sel.	Several races, AF, Early
Morocho Amarillo	ICA V 507	Prolif. Mass Sel & Yield	Sabanero, AF, High altitude
Porva Blanco	ICA V 554	Prolif. Mass Sel	Sabanero, BF. Altitude
Blanco Rubí	ICA V 555	Prolif. Mass Sel.	Sabanero, BF
Per. 330	MB 37	Ear to row Sel.	AF, Yield
Pto. Rico 605	L. 38	Line development	AF, HCE
Cuba 325	L. 29	Line development	BF, HCE
Nar. 330B	L.28, L.317, L.320	Line development	Común, BF, HCE
Criollo Bco	L.12	Line development	Costeño, BF

Table 1. Germplasm used in Colombia (continued).

Collection	Improved Variety	Breeding Method	Description
Montería Criollo Allo Theobrom.	L.13	Line development	Costeño, AF

B = white A = yellow F = flint H = floury SD = semident

GUATEMALA LAMP FINAL REPORT

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1. Genetic Material Used in the Breeding Program in Guatemala

Homologous Area 1

For HA 1, mainly genetic materials from CIMMYT have been used. Open pollinated varieties were generated from those materials. The characteristics of CIMMYT populations are shown in Table 1.

Homologous Areas 2 and 3

The genetic materials used in these areas came mainly from native landraces collected in different geographic areas of Guatemala, located at elevations varying from 1,400 to 2,900 masl. Several populations were generated using the native germplasm, which are grouped in two groups (Altiplano Central and Altiplano Occidental) as shown in Table 2.

2. Elite LAMP Accessions

Criteria of selection used in the selection of accessions for each homologous area were based mainly on yielding ability, plant height, ear height, resistance to leaf and ear diseases, and others. The selected accessions are as follows:

Homologous Area 1

Guate Gpo 4-1A, Guate Gpo 5-1A, Guate Gpo 13-2A, Guate 110, Guate 740, Guate Gpo 21-18A (yellow kernel), Guate 209 (yellow kernel)

Homologous Area 2

Criollo Amarillo Cojulún, Criollo Blanco J.J. Espital, Criollo Blanco Pedro Hernandez

Homologous Area 3

Guate 308, Guate 434, Guate 500

3. Activities in Stage 5

3.1 Present Activities and Use of LAMP Populations

In 1995 in HA 1, S_2 lines from the seven elite accessions were selfed, generating 623 S_3 lines (see Table 3).

3.2 Plans for 1996

- To follow the breeding procedure with the S_3 lines from HA 1 elite accessions.
- Germplasm bank conservation activities of the selected germplasm.

3.3 Future Plans

- To use the elite accessions for generation of hybrids and open pollinated varieties.
- More definitive characterization of the selected accessions to identify desirable characteristics that the genetic material used at present does not have.
- Regeneration and conservation plans for the elite accessions.

3.4 Expectations from the Stage 5

- Amplifying the germplasm basis in order to generate varieties or hybrids that outyield the materials generated before LAMP. That superiority has to be expressed in more yield and other agronomic characteristics.
- Identify special traits in the evaluated accessions in order to incorporate them into the improved materials used the present time.

4. Steps Taken in Breeding the Lamp Selected Accessions

- Evaluation and seed increase.
- Testcrosses
- Generation of lines from the selected accessions.
- Incorporation of the selected accessions into the Maize Program base populations (mainly those populations adapted to the homologous areas 2 and 3).
- Testcrosses to test the combining ability of the lines.
- Single, three ways, and double cross hybrid formation.

5. Importance of Lamp for Guatemala

With the identification of local and foreign accessions, the maize breeding program genetic base is amplified and can be used to solve problems related to:

Low grain yield.

Overcoming the apparent yield ceiling of the improved materials.

Water deficit (drought).

Excess humidity (rain).

Soils and pH.

Leaf diseases and ear rot.

Low temperature damage (freezing).

Soil nutrients use efficiency.

Table 1. Genetic Material Used in the ICTA Maize Program

Pop. #	Name	Characteristics	Cycle
34	Blanco Subtropical	Blanco-Crist.Sub-Trop.	Medium
32	Eto Blanco	Blanco-Crist.Trop	Medium
23	Blanco Cristalino-1	Blanco-Crist.Trop.	Medium
30	Blanco Cristalino-2	Blanco-Crist.Trop.	Medium
25	Blanco Cristalino-3	Blanco-Crist.Trop.	Complete
21	Tuxpeño 1	Blanco-Dent.Trop.	Complete
22	Mezcla Tropical Blanca	Blanco-Dent.Trop.	Complete
29	Tuxpeño Caribe	Blanco-Dent.Trop.	Complete
43	La Posta	Blanco-Dent.Trop.	Complete
62	Blanco Cristalino QPM	Blanco-Dent.Trop.	Complete
26	Mezcla Amarilla	Am-Crist.Trop.	Medium
27	Amarillo Cristalino-1	Am-Crist.Trop.	Complete
24	Antigua Veracruz 181	Am-Dent.Trop.	Complete
28	Amarillo Dentado	Am-Dent.Trop.	Complete
36	Cogollero	Am-Dent.Trop.	Complete

Blanco = White Am = Yellow Crist. = Flint Trop. = Tropical

Table 2. Genetic Materials Generated and Used by the Guatemalan Maize Program.

Population	Origin	Collection place	Grain color	Adaptation(masl)
	Altiplano Central (Central Highlands)			
V-301	Criollo Blanco	Bárcenas	B (white)	1400-1800
V-302	Criollo 4	Parramos	A (yellow)	1400-1800
Bárcenas 71	Criollo Grushin	San José Pinula	A	1400-1800
Don Marshal	Criollos Superiores	Several	A	1400-1800
Don Marshal	Segregantes blancos	Several	B	1400-1800
Chanin	Criollos Locales Pool 29, 33 y Amarillo Bajío	Several	A	1400-1800
V-304	Criollo 34	Patzicia	A	1800-2000
	Criollo 48	Balanyá	A	
	Criollo 89	Balanyá	A	
V-305	Criollo Blanco	Patzún	B	1800-2000
	Altiplano Occidental (Western Highlands)			
San Marceño	Criollos Locales	San Marcos	A	2400-2500
Guatemala Xela	Criollos Locales	Quetzaltenango	A	2200-2500
Compuesto Blanco	Criollos Locales	Chimaltenango	B	2200-2500
Toto Amarillo	Criollo 605-76	Totonicapan	A	2500-2900
Chivarreto	Criollo 612	San Francisco El Alto	A	2500-2900

Source: Mario Roberto Fuentes: "Desarrollo de germoplasma de Maíz para el Altiplano de Guatemala. 1995"

Table 3. Lines Generated from HA 1 Elite Accessions Selected in Lamp. Guatemala, 1996.

Accession	S_1 Lines 1992A	S_2 Lines, 1993A	S_3 Lines, 1995C
Guate Gpo 4-1A*	91	419	97
Guate Gpo 5-1A*	67	284	65
Guate Gpo 13-2A*	128	540	286
Guate Gpo 21-18A	38	171	56
Guat 110*	56	237	27
Guat 209	32	146	49
Guat 740*	26	125	43
TOTAL	438	1922	623

* White kernel accessions

MEXICO LAMP FINAL REPORT

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1. Genetic Material Used in the Breeding Program in Mexico

In the past the basic materials used in the Mexican Maize breeding programs were:

HA 1. Breve de Padilla, Ratón, Carmen, San Juan, Lagunero de 3 meses, all of these belong to the races Ratón and Tuxpeño Norteño. Llera II, Llera III, SLP.20, SLP-21, Capiten 63, Capiten 66, Ver-15, Ver-39, Coah-8 belong to the Tuxpeño race. The CIMMYT materials Compuesto 19, Población 22, Población La Posta, Población Tardía Blanco Dentado, and Cristalinos Amarillos de Cuba were also used.

HA 2. Bolita 422, Bolita Compuesto I, Oax-10, and Cafime belong to the Bolita race. Zac-58 is a representative of the Cónico Norteño race. Gto-59, Gto-35, Urquiza 66 are part of the Celaya race. Jal-35 and Jal-636 belong to the Tabloncillo race. Ver-15 is representatives of the Tuxpeño race.

HA 3. Mich-22, Mex-37, Mex-39, Hgo-5, Hgo-4, Hgo-3, and Hgo-55 belong to the Chalqueño race. Mich-21, an accession extensively used, is a combination of Chalqueño and Cónico races. Tlax-151, Tlax-169, Pue-6, and Pue-657 are representatives of the Cónico race. Tlax-206 and Pue-686 are a combination of Cónico and Arrocillo.

2. Elite LAMP Accessions

The elite accessions in the LAMP project were:

Mexican accessions:

HA 1	HA 2	HA 3
CHIS-429	DGO-32	AGS-23
CHIS-567	DGO-147	CHIH-165
CHIS-645	DGO-159	CHIH-204
CHIS-775	DGO-187	DGO-56
COAH-53	JAL-31	DGO-177
COL-54	MOR-162	GTO-140
DGO-86	NAY-318	HGO-231
SIN-70	PUE-4	MEX-263
TAMS-125	SLP-146	MEX-301
TAMS-146	SON-24	MEX-701

Introduced accessions:

HA 1	
ANTIOQUIA-373	COLOMBIA
NARIÑO-628	COLOMBIA
VALLE-310	COLOMBIA
PERNAMBUCO-11	BRASIL
PERNAMBUCO-27	BRASIL
BARBADOS GP2	USA-Caribbean
B.VIRG ISL-155	USA-Caribbean
SAINT CROIX 1	USA-Caribbean
CUBA-164	USA-Caribbean
SAN MARTIN 111	PERU

HA 2	
VALLE-410	COLOMBIA
CRIOLLO BLANCO	GUATEMALA
PEDRO HERNANDEZ	
HUILA-387	COLOMBIA
HUANUCO-70	PERU
LIMA-86	PERU

The parameters used to select the accessions were yield, heterosis, combining ability, earliness, lodging, and ear rots.

The selected materials have been given to the Corn Breeding Program of INIFAP and to the Instituto Mexicano del Maíz of the Universidad Autónoma Agraria "Antonio Narro", in order to be planted and evaluated, and to select those materials which fit their needs.

3. Stage 5 Activities

During LAMP stage 5, two projects were conducted: the diallel cross yield trials and the HA 1 uniform yield trial. The results of these experiments were reported in the 1994 LAMP meeting.

In the last two years, seeds for thesis projects were given to two students: one leading to the designation of a core collection of the Cónico race, and the other one directed to observe the differences between the early collections and the materials used today by the farmers in the region Sierra Norte de Puebla. With the information produced it will be possible to estimate the changes in the genetic composition of the two sets of materials and to see the possibility of in-situ conservation. If some of the introduced materials outyield the materials being used today, these will be given to the farmers, and we will teach them how to use them in a very simple breeding program executed by themselves.

In the near future INIFAP, through the Genetic Resources Program, plans to cooperate with national and international institutions in order to understand some aspects of the evolution and the variability of corn, as well as the use of corn germplasm to benefit farmers.

4. The Future of LAMP in Mexico

In INIFAP, the Corn Breeding Program and the Genetic Resources Program are managed separately; nevertheless, there is interchange of information and materials between both programs.

The 1994 LAMP report pointed out, according to the heterosis analysis, the more convenient breeding method for the selected Mexican accessions. This information is provided to the corn breeders. On the other hand, the use of the testers (single crosses) in crosses with the accessions has been suggested to reduce the seed sale price.

5. Importance of LAMP for Mexico

LAMP has been a very important project to Mexico. The selected accessions can be the base for a new generation of hybrids. As only 30% of the Mexican accessions have been evaluated, efforts will be done to continue the project in order to test all accessions using the same methodology.

The selected materials evaluated in LAMP are ready now to be evaluated for resistance to diseases of economic importance (corn stunt, *Fusarium*, "rayado fino", etc.), as well as resistance to important insect pests. Some Mexican accessions are drought tolerant in the early stage of growth, but it will be important to search for drought resistant materials in the period from flowering to grain filling.

PARAGUAY LAMP FINAL REPORT

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1. Genetic Materials Used in Paraguay

Venezuela 1, which was introduced to Paraguay in 1942, is an adapted and widely used variety. After testing many experimental variety trials from CIMMYT, a family from Population 27 was selected and distributed as Guaraní V-312. In the Southeastern region, hybrids used in Southern Brazil and Northern Argentina are being used.

2. Elite LAMP Populations

Four elite accessions were selected in Paraguay: PAZM-03002 (opaque), PAZM-07069 (yellow floury), PAZM-08063 (yellow flint), and PAZM-14003 (white flint).

3. Activities in LAMP Stage 5

Several accessions have been selected because of their good combining ability with Guaraní V-312 (Paraguayan tester): BG-070422 from Venezuela, Flint Composto, CMS-06, Pe 01, and Se-33 from Brazil; and BOZM-0093 from Bolivia.

In the near future, remnant seed of these testcrosses will be planted for selfing.

PERU LAMP FINAL REPORT

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1. Breeding Materials of the Peruvian Maize Breeding Projects

1.1 Homologous Area 1

There are three different regions for the Homologous Area 1: The Central Coast (La Molina region), the Northern Coast (Piura region), and the Jungle (Huánuco region).

For the Central Coast, the Universidad Nacional Agraria La Molina (UNALM) program has been working since 1960 using a reciprocal recurrent selection program with two populations, Perla x Cuba. Perla is a late maturity landrace with dark yellow flint kernels. Cuba is from the Coastal Tropical Flint race. It is also late maturity with dark yellow flint kernels. Until 1980, the PM (Programa de Maíz) hybrids covered almost 90% of the maize area in the Coast of Peru (roughly 100,000 hectares). Currently, they are used only in the Central Coast on about 20,000 hectares. They are late, about 6 months from planting to harvest in the winter season, and highly resistant to diseases and pests.

In the Northern Coast, both UNALM and INIA of Ministerio de Agricultura maize programs are using mainly CIMMYT materials from populations 24, 26, 27, 28, 34, and 36. PM-102 is a three-way hybrid. The male is a family of Population 24 (Antigua x Veracruz 181), and the female is an interfamily single cross, Population 26 x Population 36.

In the Jungle of Peru, Northern Coast materials are well adapted; however, more adapted materials are required for planting marginal soils. Besides the CIMMYT materials, the Cuban Yellow variety is used as well as many other sources from Cuba and Caribbean regions. PM-701 is a double cross hybrid, formed with 4 Cuban lines developed by PM of UNALM. The most widely planted variety is Marginal 28 formed with three families from CIMMYT's Population 28.

1.2 Homologous Area 2

The Coastal hybrids can be adapted to homologous area 2. However, there are some markets for special variety types. PMV-580 is an opaque variety from the CIMMYT Population J that has been selected for many years in Peru. It is well distributed, but the recessive opaque-2 gene is often not expressed because of outcrossing; it is used mainly as forage and for human consumption. PMV-581 is a cherry kernel variety used for "Chicha Morada", a non-alcoholic and very popular beverage.

1.3 Homologous Area 3

HA 3 is the most important maize production area in Peru. As the diversity is very large, mainly large floury kernel types, the breeding work has been planned to use and conserve the maize diversity. There are eight races that cover about 80% of the maize area: Cuzco, Cuzco Gigante, Cuzco Cristalino Amarillo, San Gerónimo Huancavelicano, Paro, Piscorunto, Morocho, and Ancashino. The university program has produced racial composites from those races, and several improved varieties: Amarillo de Ancash and Compuesto Terciopelo from Ancashino race; PMC-561 from Cuzco Gigante; PMV-584 from Cuzco; Morocho Ayacuchano from Morocho race; and others. The INIA Maize program of Ministerio de Agricultura formed different composites called Complejos Peruanos (CP): CP-I, Early Choclero; CP-II, Late Choclero; CP-III, Early Canchero; CP-IV, Late Canchero; CP-V, Early Morocho; and CP-VI, Late Morocho.

1.4 Homologous Area 4

HA 4 in Peru is the highest place in the world for maize production; most of the farmer lands are over 3000 masl. Because there are many possibilities to increase maize production in those areas (if the cold weather does not cause damage), the university corn program has a very important highland program. Several varieties have been produced since 1980: PMS-636 (Cuzco Gigante x San Gerónimo); PMT-637 (San Gerónimo x Cacahuacintle); PMD-638 (Germoplasma tolerante al frío x San Gerónimo); PMG-639 (Canadiense x PMS-636); PMV-684 (Cuzco Precoz). The program is using almost all the cold tolerant germplasm available, and most of the maize highland diversity.

2. Peruvian Elite Accessions

The elite accessions selected in the six Peruvian regions are shown in Table 1. The main criteria of selection were yielding ability, earliness, plant height, and ear quality. Means for these traits are shown in Table 1. The HA 1 elite accessions were crossed to the male of three Peruvian hybrids: PM-102 (m), PM-701 (m), and PM-212 (m), and two Brazilian testers. Table 2 shows the two best testcrosses with each tester. Yield over the testers PM-102 (m) and PM-701 (m) is considerable in some of their hybrids. The PM-212 (m) outyielded all its hybrids. Some crosses such as Lim 86 x BR-106 outyielded the check PM-212. Crosses by Brazilian testers and PM-102 (m) showed lower plant height.

3. Stage 5

3.1 Selected accessions and activities in Stage 5

Only HA 1 accessions have been used in stage 5. There were four activities:

- Diallel crosses of the best elite accessions as tested for combining ability in Peru. The entries are: Mag 388 (Colombia), Pe 11 (Brazil), Saint Croix Gpo 3 (Caribbean), Lim 86 (Peru), Pas 14 (Peru), S.Mtn 111 (Peru), Lamb 46 (Peru); and three Peruvian testers: PM-212 (m), PM-701 (m), and PM-102 (m) Eight replications of the experiment testing parents and the 45 direct and 45 reciprocal crosses were planted in Cañete (100 miles South of Lima) in two planting dates.
- Diallel crosses of the best 10 elite accessions across countries of HA 1: Pe 11, Se 32, and Se 33 from Brazil; BOZM-093 from Bolivia; Val 343 from Colombia; Guate Gpo 21-18A from Guatemala, Saint Croix Gpo 3, P.Rico Gpo 3 from the Caribbean area; and Lim 86 and Pas 14 from Peru. Four replications were planted in Cañete. Four replications have been shipped to Bolivia.
- S1 lines were developed from the best elite accessions and tested for combining ability in Peru: Mag 388, Pe 11, Saint Croix Gpo 3, and Pas 14. Top 20 S1 lines from Pe 11 and 20 from Pas 14 were selected, these were planted for seed increase and to generate full sib families (FS/S1). One hundred FS families from Pe 11 and from Pas 14 (5 FS for each S1 line) were testcrossed to two

testers: PM-701 (m) and PM-212 (m). Four replications of testcross trials of Pe 11 and Pas 14 crossed to two Peruvian testers were planted in the Central Coast.

- Lim 86 and Pe 11 crossed by CIMMYT breeding materials. Thirteen single cross families of Populations 26 and 36 and 34 of CIMMYT lines and families were crossed to Lim 86 and Pe 11. These crosses to both accessions were tested in two locations on the Coast of Peru in experiments with four replications.

Results shown in the Tables 3 and 4 indicate a high yield and very high heterotic value for Pe 11 x Pas 14 (6.25 T/ha; +40%), but no cross outyielded the tester PM-212(m). However, most of the crosses were superior to the parents and other testers. Almost all the crosses show negative heterosis for days to flower, that means that the hybrids are earlier than the parent average. Pe 11, Pas 14, and Lim 86 reduced drastically the plant height of PM-212(m): 288, 283, and 280 cm for the crosses as compared with 321 cm of PM-212(m). Table 4 shows very high yield of FS CIMMYT families when they were crossed by Lim 86 and Pe 11.

3.2 Plans for Subsequent Years

Homologous Area 1

Building heterotic populations. The objectives for LAMP in Peru is not producing hybrids directly from the elite accessions, but building base populations for increasing the potential of hybrids in the future. Populations will be formed using lines selected for combining ability: lines from Pas 14 and Pe 11 crossed to a PM-212 (m) that is a Perla tester; lines from Pas 14 and Pe 11 crossed to a Cuban tester PM-701 (m); and lines or families from CIMMYT crossed to Lim 86 and Pe 11.

Breeding the LAMP selected accessions. In Peru, the heterosis from crossing Peru x Cuba has been used successfully for many years. However, both sources are tall and late. Now, germplasm earlier and more efficient is needed. Consequently, breeding has to be oriented to build heterotic populations, other than Perla and Cuba, or reduce drastically the maturity and plant height of those populations.

In the LAMP evaluation work in HA 1 in Peru three top accessions were selected: Pe 11 a semident kernel type from Brazil; Pas 14 a flint type from Peru (Cuban yellow race); and Lim 86 a Perla flint type. Two strategies are going to be used to reduce maturity and plant height: a) phenotypic selection in the segregating lines or families from Pe 11 or Pas 14; and b) crossing elite germplasm to CIMMYT breeding materials which are earlier and shorter than any other commercial maize in Peru.

When S_1 lines from Pe 11 and Pas 14 were tested per se, two facts were very evident: variability between lines was very high; and some of them were very good, outyielding the parent population as well as the check variety. As the main objective is to improve the earliness and plant morphology, it was decided to generate full sib families from the best S_1 lines tested per se. To get the full-sib families, only short early plants were pollinated plant by plant, because testing the FS families instead of the S_1 lines will avoid inbreeding depression. Also, a phenotypic selection will be done selecting the families for these characteristics at the time of testcrossing. Only the remnant seed from the selected best lines (as tested for combining ability of their full sib families) will be recombined in the synthetic.

Lim 86 is a very high yielding accession, but very tall and late. S_1 lines from Lim 86 will be planted in a detasseling block where PM-102 (m) will he pollen parent. Testcrosses of the S_1 lines will be used for testing combining ability.

4. Use of Selected Non-elite Accessions

4.1 Additional accessions

Rechecking catalog data resulted in the selection of a number of accessions not classified as elite in the combining ability evaluation. Number of accessions selected for each homologous area after LAMP stage 4 are: HA 1 -- 15 accessions; HA 3 -- 21 accessions; HA 4 -- 5 accessions.

4.2 Accessions for the superior racial composites

There is a racial composite for each race where all accessions pertaining to a race are recombined. There are two composites for each race, a general and a superior one with only the best accessions. Those superior racial composites are used as base populations for the breeding of special agroecosystems, traditional agricultural regions, or for special products such as special type of starch, pigments, sugary, etc. A total of 176 accessions will be incorporated into 25 superior racial composites.

4.3 Special traits.

There is a file listing accessions with special traits. There are two male sterile accessions, Tac 22 and Tac 23; 60 accessions supposedly drought tolerant from the Northern Coast; and 11 cold tolerant accessions.

5. Importance of LAMP for Peru

Peru is an extremely heterogeneous country. Problems originating from ecological heterogeneity can be solved by biological heterogeneity. The many agroecological regions require many improved varieties with good levels of variability. LAMP must provide both diversity and variability.

The Coast of Peru is a high potential agroecological region. Because all of the land is irrigated, soils are good, and there are not strong limiting factors such as drought and cold weather, the productivity can be very high. However, the seed market in Peru is very poor (less than 100,000 hectares are planted to commercial seed). The official programs as PCIM (Universidad Nacional Agraria La Molina Maize Program) must set the standard of productivity. To do that, it must have at hand the proper germplasm.

Table 1. Yield and Other Characteristics of Elite Accessions Selected in Six Peruvian Regions.

H A .	Region	Location	Elite Accession	Yield kg/ha	% over (T)	Days Silk	Plant Height cm	Ear quality	Kernel type	Kernel color
1	Northern	PIURA	Piu 163	5627	93%	61	275		HR SF	RB SL
1		PIURA	Piu 229	5323	88%	63	186		DE HR	BL RB
1		PIURA	Piu 196	5354	88%	62	191		HR SF	RB AM
1		PIURA	Lbque 46	6795	112%	65	205		DE HR	BL AL
		PIURA	Mean Elite acc.	5775	95%	63	214			
1		PIURA	PM-102 (T)	6052	100%	72	193		SD DE	FT/NA
		PIURA	Grand Mean	4539	75%	66	192			
1	Central	LA MOLINA	Lim 86	8138	98%	88	293	6.9	FT SF	AM NA
1		LA MOLINA	Lim 36	6051	73%	80	256	6.5	SF HF HR	RO AM NA
1		LA MOLINA	Lim 13	6110	74%	88	262	6.9	FL	NA AM
		LA MOLINA	Mean Elite acc.	6766	82%	85	270	6.8		
1		LA MOLINA	PM-212 (T)	8298	100%	89	269	7.4	FT SF	NA AM
		LA MOLINA	Grand Mean	4970	60%	82	240	6.2		
1	Jungle	HUANUCO	Lor 21	6004	94%	76	243	8.5	FT SD	AM NA
1		HUANUCO	M.Dios 22	5896	92%	75	262	8.8	FT	AM
1		HUANUCO	M.Dios 46	4134	64%	76	256	7.3	FT SD	AM RB
1		HUANUCO	Pas 14	5431	85%	75	252	7.8	FT	AM NA
1		HUANUCO	S.Mtn 111	3645	57%	78	270	7.0	FT	AM
1		HUANUCO	S.Mtn 126	3471	54%	76	260	7.3	FT SF	AM NA RB
1		HUANUCO	Ucay 12	5528	86%	78	252	8.5	FT	AM
		HUANUCO	Mean Elite acc.	4901	76%	76	256	7.8		
1		HUANUCO	PM-701 (T)	6418	100%	74	240	9.0	FT	AM
		HUANUCO	Grand Mean	4801	75%	76	257	7.7		
2		CARAZ	Hco 70	4935	116%	96	208		HR SF	AM
2		CARAZ	Pas 25	3959	93%	111	193	5.0	FT SF	AM RO
2		CARAZ	Caj 86	4484	106%	93	207	3.5	HR SD	AM RO
2		CARAZ	Anc 105	3580	84%	79	199	2.0	HR SF	AM RO
		CARAZ	Mean Elite acc.	4240	100%	95	202			
2		CARAZ	PMV-580	5551	131%	96	206		HR SD	AM BL
		CARAZ	Grand Mean	3278	77%	93	195	3.4		
3		CARHUAZ	Anc 427	8587	100%	103	215	8.0	HR	AM RB
3		CARHUAZ	Anc 139	8744	102%	113	198	7.0	HR	RO BL
3		CARHUAZ	Caj 163	8584	100%	112	213	7.5	HR	AM BL
		CARHUAZ	Mean Elite acc.	8494	99%	106	202	6.9		

3	CARHUAZ	C.Am.Anc(T)	8062	94%	94	181	5.3 HR	AM BL
	CARHUAZ	Grand Mean	6501	76%	206	188	5.7	

Table 1. Yield and Other Characteristics of Elite Accessions Selected in Six Peruvian Regions (continued).

Region H A .	Location	Elite Accession	Yield kg/ha	% over (T)	Days Silk	Plant Height cm	Ear quality	Kernel type	Kernel color
4	JAUJA	Apuc 06	6400	106%	117	183	7.0	HF	AM
4	JAUJA	Jun 164	6705	111%	110	161	6.8	HR	BL AM
4	JAUJA	Cuz 364	4692	78%	101	150	6.5	HF	RB AM RO
4	JAUJA	CRCCA IV	7070	117%	109	183	7.0	HF	AM RO
4	JAUJA	Cuz 363	4229	70%	101	150	7.3	HF SF	AM PR
4	JAUJA	Aya 119	5838	96%	119	153	7.5	HR HF	AM RO
	JAUJA	Mean Elite acc.	5822	96%	109	163	7.0		
4	JAUJA	PMS-636(T)	4686	77%	102	141	6.3	HR	BL
	JAUJA	Grand Mean	4366	72%	117		6.3		

1=very bad; 9=excellent

Table 2. Yield and Plant Height of 10 Superior Testcrosses by 5 Testers.

Pedigree	Yield Ton/ha	% 0ver Tester	% Over PM212	Plant height cm
Lim 13 x PM-102 (m)	8.37	138%	88%	281
Lbque 46 x PM-102 (m)	8.69	143%	91%	270
Lbque 46 x PM-212 (m)	8.65	83%	90%	344
M.Dios 22 x PM-212 (m)	9.40	91%	98%	352
Lim 86 x PM-701 (m)	8.31	128%	87%	313
Lbque 46 x PM-701 (m)	8.42	130%	88%	300
Tester: PM-102 (m)	6.06		63%	309
Tester: PM-212 (m)	10.37		108%	342
Tester: PM-701 (m)	6.49		68%	289
Lim 36 x BR-105	8.09		85%	277
Lim 86 x BR-105	8.82		92%	304
Lim 36 x BR-106	8.30		87%	296
Lim 86 x BR-106	10.41		109%	315
Check: PM-212	9.56		100%	336

Table 3. Yield (T/ha), maturity (Days), and plant height (cms) of crosses between elite HA 1 accessions and 3 Peruvian testers. (Cañete 1994).

Crosses or Parents	Yield		Maturity		Plant Height	
	T/ha	HX(1)	Days	HX	cms	HX
Pe 11 x Pas 14	6.25	+40.4	83.0	-2.3	303	0.0
Pe 11 x S.Mtn 111	5.60	+ 9.8	78.5	-5.4	294	-3.3
Pe 11 x Lbque 46	5.15	+49.2	77.0	-3.8	282	0.0
Pe 11 x PM-701 (m)	5.20	+20.9	81.0	-3.6	286	+1.8
Pe 11 x PM-212 (m)	5.45	- 8.4	81.0	-5.8	288	-8.9
Pas 14 x Lim 86	5.85	+21.9	82.0	+2.5	308	+7.3
Pas 14 x PM-102 (m)	5.45	+19.8	80.5	-1.8	275	0.0
Pas 14 x PM-212 (m)	5.80	- 1.7	80.0	-4.8	283	-7.5
Lim 86 x PM-102 (m)	5.70	+15.1	78.5	0.0	288	+6.3
Lim 86 x PM-212 (m)	5.50	-11.1	78.5	-3.1	280	+7.3
PM-102 (m) x PM-701 (m)	5.55	+26.1	80.5	0.0	280	+9.8
PM-102 (m) x PM-212 (m)	5.35	-11.6	80.5	-3.2	261	-10.0
PM-701 (m) x PM-212 (m)	5.10	-11.3	81.0	-2.4	278	-2.8
PM-102 (m)	4.70		81.0		259	
PM-701 (m)	4.10		81.0		252	
PM-212 (m)	7.40		85.0		321	

(1)HX = % Heterosis over mean of the parents.

Table 4. Yield (T/ha) 34 of lines and families of CIMMYT were crossed to Lim 86 and Pe 11 and by a family of Population 24 of CIMMYT and thirteen single cross families of Populations 26 x 36 were crossed to Lim 86 and Pe 11

	Lim 86	Pe 11	Pob 24-221
Mean	7.2	6.3	7.7
Tester	7.9		6.6
PM-102	7.6	8.4	8.8
PM-103	8.5	7.6	8.1

CIMMYT FS families.

	Lim 86	% PM102	Pe 11	%PM102
Superior mean	10.1	116	11	122
General mean	8.1		7.9	
Lim 86 per se	4.6			
Pe 11 per se			5.9	
PM-102	8.7		9.1	
PM-103	8.2		7	

UNITED STATES LAMP FINAL REPORT

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1. Basic Breeding Materials in the United States before LAMP

In the United States, thousands of years of breeding were practiced on maize from Mexico and the Caribbean by native Americans. The populations of the native Americans were the source for open pollinated varieties of maize developed in the 1800s from crosses of northeastern flints and southern dents. Parental inbred lines of the first double-cross hybrids were developed from the open pollinated varieties when East (1908), Shull (1909) and others began maize breeding for hybrid development in the early 1900s.

More than half of the germplasm used in U.S. hybrids descended from a strain of the open pollinated variety, Reid's Yellow Dent. The variety was derived from a cross between a late rough dent with an early flint. After winning a prize at the Chicago World's Fair in 1893, the variety spread quickly and was grown by farmers in states from Ohio to Nebraska. Many farmers selected their own strains, so that 30 years later many strains with different characteristics existed. A large number of these strains were used to develop inbred lines in the 1920s.

Surveys conducted periodically (1957, 1964, 1971, 1975 and 1980) by the American Seed Trade Association (ASTA) to determine the extent of use of publicly derived lines in production of commercial hybrids have shown that lines originating from Stiff Stalk Synthetic were prominent in all surveys. Stiff Stalk Synthetic is a maize variety developed by intermating 16 inbred lines in 1933 and 1934. The 16 lines were selected by breeders for having acceptable stalk quality. Although the origins of all of the lines are not certain, most lines were developed from sources that included Reid's Yellow Dent germplasm. Stiff Stalk Synthetic is considered a Reid's Yellow Dent type.

The second most important open pollinated variety contributing to modern breeding materials is Lancaster, which had a very similar origin to Reid's Yellow Dent. One of the most important varieties in the northern Corn Belt states was Minnesota 13. Iodent, an Iowa Experiment Station variety developed by ear to row breeding contributed two inbreds to Stiff Stalk Synthetic, and has contributed to modern breeding materials. Iodent is commonly accepted to be a strain of Reid germplasm. Although perhaps several hundred U.S. maize varieties were sampled by corn breeders in the early twentieth century, very few of them contributed to modern hybrid corn.

The ASTA's 1984 survey of the U.S. farm maize germplasm base indicated that lines from Reid germplasm were included as 44% of the total production in 1984, followed by Iodent (24%) and Lancaster (12%). The predominate source of new inbred line development was single crosses (20%). No ASTA surveys have been conducted since 1984.

Hallauer (1990)[1] suggested that corn breeding projections made for the 1980s would be equally valid for the 1990s in terms of breeding methods applied (pedigree selection) and germplasm sources sampled (elite germplasm). As breeders increasingly rely upon crosses among elite lines, however, the U.S. corn germplasm base is growing narrower. Pedigrees of many or most of public, foundation, and private lines trace to the inbred lines A632, B14A, B37, B73, and B84 for female lines and C103, Mo17, and Oh43 for male lines. While many have advocated the use of tropical maize germplasm for U.S. breeding purposes, little tropical germplasm has filtered through commercial or public breeding programs and reached farmers' fields[2]

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(1) Hallauer, A.R. 1990. Germplasm sources and breeding strategies for line development in the 1990's. Proc. Ann. Corn Sorghum Res. Conf. 45: 64-79.

(2) Goodman, M.M. 1992. Choosing and using tropical corn germplasm. Proc. Ann. Corn Sorghum Res. Conf. 47: 47-64

2. Elite LAMP Accessions

2.1 Accessions Selected from LAMP in the HA 1

Accessions were selected from LAMP for use in U.S. breeding programs based on yield results from Stage 4 testcross experiments conducted in Puerto Rico and Mexico, Stage 4 testcross experiments conducted in all Homologous Area 1 countries, and testcross experiments conducted with Caribbean accessions and Corn Belt (Oh43xMo17 and B14xB73) testers(3). Selected accessions are as follows:

Accessions	PI #
Brit.Virg.Is. 155	PI 583901
CHIS 462 (Mexico)	PI 583888
Cuba 164	PI 489361
Brit.Virg.Is. 103	Ames 9935
Cuba 173	PI 483836
Cuba 117	PI 483816
Dom. Rep. 269	PI 489678
Barbados Gp.2	PI 503885
Dom. Rep. 150	PI 484028
Guatemala 209	PI 498583
Pasco 14 (Peru)	PI 571679
Pe 011 (Brazil)	PI 583912
Puerto Rico Gp. 3	PI 504142
St. Croix 1	PI 484036
St. Croix Gp. 3	PI 504148
Guadalupe 5	PI 498569
Antigua 3	PI 484991
Cuba 110	PI 489357
CHIS 775 (Mexico)	PI 576258
CHIS 740 (Mexico)	PI 583890
SE 33 (Brazil)	PI 583918
PE 01 (Brazil)	PI 583911
SE 32 (Brazil)	PI 583917
Antigua 1	PI 484990

(3) Wu, I. 1993. Determining the value of Caribbean maize (Zea mays L.) populations to improve USA hybrids. M.S. Thesis, Iowa State University.

2.2 Accessions Selected from LAMP in the HA 5

Accessions were selected for use in U.S. breeding programs based on yield results of Stage 4 testcross experiments (Oh43xMo17 and B14xB73 testers because these are the heterotic patterns used in the USA) conducted in the United States and on combined results from experiments conducted in all Homologous Area 5 countries. Selected accessions are as follows:

Accessions	PI number
ARZM 13035	PI 492753
ARZM 16021	PI 516022
ARZM 16035	PI 516036
ARZM 17026	PI 493012
URZM 05017	PI 583937
URZM 13085	PI 583927
URZM 13088	PI 583925
URZM 11003	PI 583939
URZM 13061	PI 583922
FS8A(S)	PI 536619
FS8B(S)	PI 536621
ARZM 16026	PI 516027
ARZM 17056	PI 493039
Cash (Ohio)	PI 278710
CHZM 05015	PI 467165
Golden Queen (Ohio)	PI 452040
URZM 10001	PI 583942
FS8A(T)	PI 536620
FS8B(T)	PI 536622
ARZM 03056	PI 491799
URZM 01089	PI 479145
CHZM 04030	PI 467139
ARZM 01150	PI 491741
Big White (Tenn.)	PI 452054
URZM 13 010	PI 583923
URZM 11002	PI 583938
ARZM 13026	PI 492746

3. LAMP Stage 5

3.1 Accessions used in Stage 5

All of the selected accessions listed above are being used in Stage 5.

3.2 Accomplishements and Plans for HA1 and HA5

3.2.1 1994 Accomplishments in the HA 1

The following accessions were crossed to B73 in a winter nursery near Isabella, PR:

Brit.Virg.Is. 155	PI 583901
CHIS 462 (Mexico)	PI 583888
Cuba 164	PI 489361
Brit.Virg.Is. 103	Ames 9935
Cuba 173	PI 483836
Cuba 117	PI 483816
Dom. Rep. 269	PI 489678

The following accessions were crossed to Mo17 in a winter nursery near Isabella, PR:

Barbados Gp.2	PI 503885
Dom.Rep. 150	PI 484028
Guatemala 209	PI 498583
Pasco 14 (Peru)	PI 571679
PE 11 (Brazil)	PI 583912
Puerto Rico Gp. 3	PI 504142
St. Croix 1	PI 484036
St. Croix Gp. 3	PI 504148
Guadalupe 5	PI 498569
Antigua 3	PI 484991
Cuba 110	PI 489357

These crosses were used in a demonstration planting for a field day held near Ames, IA, and backcrossed when possible to the public inbred line during the summer. Eleven seed companies received samples of the public line crosses.

A graduate student in Iowa State University's Food Science and Human Nutrition (FSHN) Department used most of the elite accessions to study their wet milling and starch quality properties. He is continuing by evaluating public line crosses of selected accessions.

S3 lines (minimum of 50) from each of the following accessions: Antigua 1, Cuba 164, Dominican Republic 150, Jamaica Gp1, Puerto Rico Gp5A, St. Croix Gp. 3 were analyzed for their RFLP patterns. DNA extraction, restriction enzyme digestion, gel electrophoresis, southern blotting, and probe hybridization were performed by Biogenetic Services, Inc., Brookings, SD according to the procedure described by Helentjaris et al., 1986(4). A graduate student in Plant Breeding is analyzing the RFLP patterns for diversity within and among accessions and comparison to Corn Belt lines.

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(4)Helentjaris, T., M. Slocum, and O.S. Smith. 1983. Quantitative analysis of Iowa Stiff Stalk Synthetic. Stadler Symp. Vol. 15. Un. Wisconsin, Columbia.

The above S3 lines were crossed to B73 and Mo17 in isolations in Puerto Rico, then topcrossed to the opposite inbred line e.g. [(S3xB73)xMo17 and (S3xMo17)xB73] in isolations in Iowa in 1992.

The topcrosses were evaluated in three locations in Iowa in 1993 and 1994. The best B73 and Mo17 crosses (yield similar to hybrid check) are being developed into inbred lines for eventual release as breeding lines.

3.2.2 1995 Accomplishments in the HA 1

Twenty-six breeding crosses of the elite accessions were developed by private seed companies by crossing an accession with a commercial inbred line, either of the Stiff Stalk or non-Stiff Stalk heterotic pattern. Fifty of the (25% accession:75% Corn Belt) breeding crosses were developed by sending the breeding crosses to a different company to cross to an inbred line of the appropriate heterotic pattern.

The U.S. cooperators evaluated accessions or breeding crosses for disease and insect resistance; and physical and chemical composition of the kernel. Accessions, public line crosses, and backcrosses were analyzed for oil quality. All data collected on accessions will be entered into the GRIN database.

3.2.3 1996 Plans for HA 1

All experiments and breeding work begun in 1996 will be continued until completion. Pedigree breeding was started in two private breeding crosses that had protein level above 15% (Corn Belt hybrids are typically 10%). Breeding crosses of each heterotic group were topcrossed by two companies to elite inbred line testers and were grown in yield trials at six or more locations across the Corn Belt in 1996. Based on these results, 15 breeding crosses were selected for advancement starting in Winter 1996-7.

Samples of breeding crosses were analyzed for composition, oil quality, and starch was extracted for starch quality analyses. These analyses will be continued as breeding work is done in breeding crosses selected for value-added traits. All data collected on accessions will be entered into the GRIN database.

3.2.4 1994 Accomplishments in the HA 5

The following accessions were crossed to B73 in a winter nursery near Isabella, PR:

ARZM 13035	PI 492753
ARZM 16021	PI 516022
ARZM 16035	PI 516036
ARZM 17026	PI 493012
URZM 05017	PI 583937
URZM 13085	PI 583927
URZM 13088	PI 583925
URZM 11003	PI 583939
URZM 13061	PI 583922
FS8A(S)	PI 536619
FS8B(S)	PI 536621

The following accessions were crossed to Mo17 in a winter nursery near Isabella, PR:

ARZM 16026	PI 516027
ARZM 17056	PI 493039
Cash (Ohio)	PI 278710
CHZM 05015	PI 467165
Golden Queen (Ohio)	PI 452040
URZM 10001	PI 583942
FS8A(T)	PI 536620
FS8B(T)	PI 536622
ARZM 03056	PI 491799
URZM 01089	PI 479145

These crosses were used in a demonstration planting for a field day held near Ames, IA, and back crossed to the public inbred line during the summer. Eleven seed companies received samples of the public line crosses.

A graduate student in Iowa State University's Food Science and Human Nutrition (FSHN) Department used most of the elite accessions to study their wet milling and starch quality properties. He continued by evaluating public line crosses of selected accessions. Another graduate student in FSHN will study the starch quality of four accessions {ARZM 17056, URZM 01089, CHZM 05015, and FS8B(T)} that have been converted to sugary-2. It was previously shown (Campbell et al.,

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(5)Campbell, M.R., P.J. White, and L.M. Pollak. 1995. Properties of sugary-2 maize starch influence of exotic background. Cereal Chem. 72: 389-392.

1995)(5) that exotic populations have genetic modifiers that change the properties of sugary-2 starch, which may be commercially useful.

S1 lines of 73 top 5% HA 5 accessions had been developed in 1993. One thousand S1's were evaluated for composition (%oil, protein and starch) by United AgriSeeds, and corn lethal necrosis by Hoegemeyer Hybrids. Eight non-USA accessions had 25% or more S1 lines with commercial levels of resistance.

3.2.5 1995 Accomplishments in the HA 5

Thirty-six breeding crosses of the elite accessions were developed by private seed companies, by crossing an accession with a commercial inbred line, either of the Stiff Stalk or non-Stiff Stalk heterotic pattern. Eighty 25% accession: 75% Corn Belt breeding crosses were developed by sending the breeding crosses to a different company to cross to an inbred line of the appropriate heterotic pattern.

At Ames, IA, pedigree breeding was initiated in CHZM 05015xMo17, the backcross to Mo17, and two private breeding crosses with CHZM 05015. The goal will be to develop S3 lines. Eighty crosses of S1 lines of CHZM 05015 with B73 were evaluated for grain and forage production at three locations in Iowa and compared with five check hybrids. This experiment was repeated in 1996. Accessions, public line crosses, and backcrosses were analyzed for oil quality. All data collected on accessions will be entered into the GRIN database.

3.2.6 1996 Plans for HA 5

All experiments and breeding work begun in 1996 will be continued until completion. Pedigree breeding was started in a private breeding cross that had protein level above 15% (Corn Belt hybrids are typically 10%). Breeding crosses of each heterotic group were topcrossed by two companies to elite inbred line testers, and are being grown in yield trials in six or more locations across the Corn Belt.

Samples of breeding crosses were analyzed for composition, oil quality, and starch was extracted for starch quality analyses. These analyses will be continued as breeding work is done in breeding crosses selected for value-added traits.

3.3 Plans for Subsequent Years

The best breeding crosses identified in the 1996 yield trials for yield and/or another trait (disease or insect resistance, value-added trait) will undergo pedigree breeding to develop S3 lines. If a private company does the pedigree breeding, they will release a synthetic of the best S2 lines. The lines and synthetics will be released, then curated by the National Plant Germplasm System.

Because the largest use of maize in the USA is for animal feed, methods will be developed for analysis of protein quality, starch digestibility, starch energy, and other feed value indicators for ruminants, swine, and poultry. Breeding crosses will be analyzed for these traits, and lines developed with good feed values and high yield.

3.4 Expectations from Stage 5

In the U.S., the value of exotic germplasm will be well recognized, leading to better funding for collection and maintenance of maize genetic resources. Maize breeders will cooperate to enhance the best LAMP accessions by developing breeding lines with both high yield and combinations of disease resistance, insect resistance, or superior values for maize users. By focusing on evaluating source material for value-added traits and releasing breeding lines with this data, maize hybrids will be developed with superior value for their ultimate use.

4. Additional Steps in Breeding the LAMP Selected Accessions

The S3 breeding lines and synthetics will be sources of new materials for line development for private and public corn breeders. Each company or public breeder will need to use them in their own breeding program. The top 5% LAMP accessions are not necessarily the best accessions for disease and insect resistance or for value-added traits, they are just the most logical set to begin looking for these additional traits. We would like to begin evaluating more of the non-selected accessions for these traits. We would also like to develop breeding crosses with more of the top 5% accessions, evaluate them as topcrosses for yield, then develop S3 breeding lines with the best.

5. Importance of LAMP for the USA

More emphasis on value added traits related to feed value is encouraged by industry and government. Also important are traits related to industrial and food use.

URUGUAY LAMP FINAL REPORT

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BACKGROUND

In 1978, a project to collect maize germplasm was carried out in Uruguay (De Leon, 1978, De Maria et al., 1979). This was part of a regional project sponsored by IBPGR (International Board for Plant Genetic Resources) which had as objectives the collection, conservation, and evaluation of maize germplasm from Western South America. The populations collected in Uruguay were classified by De León, 1978, and De María, 1979 as belonging to the following racial types: 1) Cateto Sulino, 2) Cateto Sulino subrace Escuro, 3) Canario de Ocho, 4) Cateto Sulino Grosso, 5) Cuarentino, 6) Semi-Dentado Riograndense, 7) Dente Riograndense subraces Rugoso and Liso, 8) Morotí Precoce, 9) Cristal, 10) Dente Branco Riograndense, and 11) Pisingallo. According to the racial classification made by Paterniani and Goodman (1977), cited by De María et al.,(7) most of the present racial types belong to the "ancient commercial variety" category, and only two indigenous types subsist: Pisingallo and Morotí. Sixty five percent (65%) of the collected populations are the "orange flint" type; however, there are great variations within the populations.

Eight hundred fifty two populations pertaining to the Maize Collection were evaluated and characterized by De María et al., 1979. Results show the presence of very important variability in some characteristics such as grain yield, forage yield, root lodging resistance, and prolificness (Table 1). The important variability and good performance in those characteristics, added to the good forage yield, tillering ability, and other agronomic characteristics, encourage the development of a breeding program to get local adapted genetic materials with good agronomic characteristics.

Beginning in 1981, racial composites were made with populations of the Cateto Sulino, Semidentado Riograndense, and Dente Branco race groups in the Agronomy School Experimental Station "M.A. Cassinoni" (E.E.M.A.C.) (G. Fernández personal communication). There were two main objectives in making these composites: 1) To maintain the maximum genetic variability of the collected populations as at that time there were no facilities to conserve the population in medium- or long-term storage, and 2) To attempt the use of those materials in a genetic improvement program. The potential for forage production, especially for silage, was great.

1. Breeding materials used in Uruguay

In Uruguay, there were two public maize breeding programs in the past: INIA (former CIAAB) and the University Agronomy School Program. Objectives of both programs were to obtain varieties with good yielding performance.

The INIA program started in the sixties. It used flint kernel type materials from Argentinean public programs and dent kernel types from USA university public lines as the base germplasm. This program produced several cultivars such as the open pollinated varieties E. Bagual and INIA Cimarrón, and the hybrid INIA Orejano. Those cultivars were well adapted to our conditions, and they are well accepted by the farmers. From the middle 1980s, hybrids from overseas companies with breeding programs in Argentina had good adaptation to our growing conditions, and they competed very well with the varieties created by the Uruguayan official program. Starting the nineties, changes in the market regulations and the improvement of the hybrids from Argentina reduced the need to pursue the public maize breeding program. This program for maize grain cultivars was discontinued in 1993, but there is still a small program for forage production.

The University Agronomy School breeding program started in 1982 using the racial composites from the landraces collection De Leon, 1978 and De Maria, et al., 1979 made by the IBPGR- Agronomy School in 1978. From those racial composites, native varieties were generated, mainly from the Branco Dentado (white dent) composite. These varieties are being planted in a limited area, but it is believed that they are potentially very good for silage production. Starting from middle 1980 decade, the Agronomy School was engaged in the LAMP project, doing evaluation and population improvement in the different stages. As in the INIA case, changes in the cultivar market and a drastic reduction in the resources available for research caused the close of the breeding program in 1995.

The LAMP project started evaluating 500 accessions in 1986-87, selecting 100 in the second stage. Only accessions from the Semidentado Riograndense, Cateto Sulino, Dentado Riograndense, and Dente Branco races were selected; and from these, the superior yielding 50% was selected Ozer at al., 1995. From these, 25 accessions were selected in the LAMP stage 2 (Ozer et al., 1995). In the first stages, Ingº Grisel Fernandez and Ing. Gerardo Vivo was in charge of the LAMP work. The selected accessions are not being used because the Agronomy School maize breeding program is closed.

2. Accessions selected from LAMP

2.1 Uruguayan selected accessions

One hundred out of 500 accessions were selected to be evaluated in the second stage. Only accessions of the interested races being chosen for type and color of the grain were selected. From these, the accessions within the top 50% in yielding ability were selected if they did not suffer excessive numbers of root lodged or broken plants. Nearly 25% of each race was selected (Table 2).

Data obtained in this stage were reprocessed in 1995 from the original computerized LAMP files, and a grouping of the accessions into races using the information was done. In general, the evaluated material is medium in earliness, although some accessions have a relatively longer cycle (Cristal, Morotí). The mean yield of the groups is generally below the check. They show very high root lodging percentage, but good ear quality. Plant height tends to be taller than the check. Prolificacy is high on the whole. The variation of the populations permitted the selection of superior accessions for a breeding project.

Four racial groups were selected: Semidentado Riograndense, Dentado Riograndense, Dente Branco, and Cateto Sulino. Accessions from Cateto Sulino and Dentado Riograndense race have similar type and color of the grain, varying from flint to semiflint, and from orange to yellow-orange. Likewise they have medium earliness, similar plant height, and yield less than the mean of the selected accessions. The Semidentado Riograndense type is a race with good characteristics for grain production, semiflint or semident type of grain with yellow-orange color. This racial type is different from the other two cited above because of its higher yield and lateness. Dente Branco is also as Semidente Riograndense, a group with a longer cycle and good yielding, but its type of grain, from semiflint to dent, and white color, it is not the most appropriate for grain production. However, it was evaluated as a superior material for silage production (Ing. G. Vivo, personal communication).

In the 1987-88 season, the evaluation and regeneration of the 100 accessions selected in stage 1 was done. The evaluation was carried on in two locations (Paysandú and Fray Bentos) in two replication trials. In Fray Bentos, the experiment was carried out under irrigation, with two main objectives: 1) To secure the regeneration of the accessions, and 2) To evaluate reaction to moisture stress comparing Fray Bentos with Paysandú. In the summer, precipitation surpassed 500 mm, consequently, the soil moisture conditions were similar in both localities. Finally, the selection of the elite 25 superior accessions (5% of the total) was done, based on data from experiments conducted in 1978-79, in 1986-87 (LAMP stage 1), and those of this stage. Criterion for selection was yielding ability and root lodging resistance.

Analyzing all the information available, 25 accessions were selected to be tested in the following stage. Twelve belong to the Cateto Sulino race, 6 to Dente Branco, 6 to Semidentado Riograndense, and 1 to the Dentado Riograndense race. All accessions are below the check in yield and they have number of days to flower larger than the check (Table 3).

The identifier of accessions used in this report is the same as in the maize catalog for Uruguay: the two first letters correspond to the country where the sample was collected (UR: Uruguay), the following two letters are for the species (ZM: Zea mays), the following two digits correspond to the political division where the sample was collected (01: Canelones), and the last three letters are for the sample number within a given political division.

2.2 Homologous area 5 selected accessions

In stage 3, evaluation of elite accessions was done in different regions within a Homologous Area to detect the level of adaptation to different environments. In 1989-90, experiments were planted to evaluate 73 HA 5 accessions in the E.E.M.A.C. Twenty accessions were from Argentina, 16 from

Chile, 12 from USA, and 25 from Uruguay. The Brazilian accessions did not get into the experiments because they came late. The experimental design was a randomized complete block with 4 replications. Similar experiments were conducted in Argentina (Pergamino), Chile (Santiago and Copiapó), and USA (Iowa and Georgia).

a) Analysis of results from Uruguay

The mean yield was 3759 kg/ha with a standard deviation of 789 kg/ha. Most of the Argentinean accessions occupied the top positions in the yield ranking; only two Uruguayan accessions are within the 15 high yielding accessions. In general, all the accessions had good performance in root lodging tolerance and they show from medium to good prolificacy (Table 4).

b) Analysis across Homologous Area 5

In general, the Uruguayan accessions occupied the superior ranking class in the lower yielding environments (Iowa and Georgia), Table 5. In the best environment with the highest potential (experiments in Santiago and Copiapó, under irrigation), there are other Uruguayan accessions ranking high as in other high yielding locations (Pergamino experiment), suggesting high potential in those accessions. Those two accessions are URZM13073 and URZM13082, both belong to the Cateto Sulino race and have orange flint kernels (Table 5).

The good general adaptation of the evaluated accessions in the different environments is evident, which facilitates the free interchange of this type of genetic materials among HA 5 countries. Although the accession x location interaction was significant in the ANOVA (Vivo et al, 1992), a list of accessions in the 20% superior yielding class across the 6 locations is as follows:

1	URZM1036	9	ARZM3056
2	ARZM17026	10	ARZM16035
3	ARZM16021	11	ARZM16062
4	FS8-BT 12	12	URZM13082
5	ARZM16053	13	ARZM17056
6	CHZM4030	14	ARZM1102
7	ARZM3054	15	CHZM5015
8	ARZM14057		

3.0 Stage 5

The objective of the last stage of LAMP was to incorporate the most promising materials into genetic improvement programs. For HA 5, it was decided to make self-pollination in 3 elite accessions. Those self-pollination were done by Dr. Linda Pollak (Principal investigator, USA). It resulted in 830 S_1 lines: 333 from ARZM16026, 249 from CHZM05015, and 248 from URZM13061.

In the E.E.M.A.C. during 1993-94, an evaluation trial with the 830 S1 lines per se was conducted. The experiment was planted on December 1993, in a design partially randomized without replication. Because the planting date was delayed, there were climatic problems that caused irregular rates of growth and many weeds. The descriptors as defined in LAMP were recorded, and a report was written with the basic information (Olveyra and Ozer, 1994).

First of all, it must be very clear that there was great variability in both, among lines from different countries, and also among lines within countries. Considerable variation within lines was also observed, which can be expected in the first selfed generation. On average, the Chilean materials presented a shorter flowering cycle, contrasting with the Uruguayan lines (Table 6).

The average plant height of all lines was below the check plant height, which is as expected (Table 7). However, the check plant height was lower than it is expected in normal seasons, which is an evidence of the bad environmental conditions of the experiment. It is important to note that the grain yield of the lines is about 50 to 60% below the check, showing great variability between accessions (Table 8). In general, in all evaluated characteristics, there was great variation. Because of that, it is not possible to get important conclusions without running more rigorous statistical analysis.

4. Additional steps in breeding the LAMP elite germplasm

In the coming years the genetic resources of the Uruguayan maize collection will be used to identify genotypes with good forage ability (silage and grazing) from the Dente Branco, Morotí, and Pisingallo racial groups. This will be a joint effort between INIA and the Agronomy School. In the present stage, after the maize breeding program objective is redefined, LAMP is important for our country because it will permit us to evaluate and incorporate native and foreign germplasm. We are mainly interested in germplasm with potential for forage production.

5. Importance of LAMP for Uruguay

During the LAMP project an important amount of information about part of the Uruguayan maize collection was generated. This information comprises trial data from Uruguay and other countries within HA 5. In the successive stages, it permitted the selection of a group of accessions named elite that had good performance for the different evaluated characteristics. A group of accessions from Argentina was selected that had good agronomic performance in our conditions. Besides, this selected germplasm was evaluated for its heterosis expression and also to detect other heterotic patterns. In addition, part of the information and experience generated from the LAMP project has been used to develop a core collection that is currently being used by INIA's breeding program at La Estanzuela. Therefore, it can be considered that the first objective of LAMP was accomplished.

An important regional cooperative work was carried out. Therefore, the responsible people in our country were in contact with most of the LAMP Principle Investigators, especially with the investigators from the same region. They also participated in the LAMP meetings. This cooperative work permitted both, to evaluate our germplasm in other regions and to access other germplasm and to evaluate it in our conditions. LAMP has been cited as an example of cooperative regional work.

Although good agronomic materials have been identified, they have not been introduced into the Genetic Improvement Program of the Agronomy School. This means that little use has been made yet of the potential resources that the project generated. Therefore, the second objective of the LAMP project was not accomplished in Uruguay due to institutional constraints

References

De León, J.L., et al. 1978. Caracterización agronómica y clasificación racial de las muestras coleccionadas en Uruguay bajo el Proyecto IBPGR. En: Primera Reunión técnica de la Facultad de Agronomía.

De María, F.G. Fernández y G. Zoppolo. 1979. Caracterización Agronómica y clasificación racial de las muestras de maíz coleccionadas en Uruguay bajo el Proyecto IBPGR - Facultad de Agronomía. Tesis Ing. Agr. Montevideo, Uruguay. Facultad de Agronomía 49 p.

Olveyra, M. and H. Ozer Ami. 1994. Informe de la etapa V de LAMP. Paysandú. Uruguay. Facultad de Agronomia.

Ozer Ami, H.T. Abadie, y M. Olveyra (1995). Informe final de LAMP. Uruguay. Facultad deAgronomía. Montevideo, Uruguay, 25 p.

Vivo et al, (1992). Analysis de Exprimentos de la Etapa 3 de LAMP para el Area Homologa 5, Paysandu, Uruguay. Reporte Interno de Facultad de Agronomia, 11p.

Table 1. Mean, Standard Deviation (s), Minimum and Maximum of Characteristics Evaluated in 852 Maize Populations in 1979.

Characteristics	Mean	± s	Minimum	Maximum
Days to tassel	77.5 ±	5.6	65.0	102.0
Plant height (cms)	169.7 ±	14.5	94.0	204.0
Degree of tillering	1.5 ±	0.3	1.0	3.5
Root lodged plants (%)	77.1 ±	12.7	15.0	100.0
Prolificness	0.8 ±	0.3	0.04	2.0
Grain yield (Kg/ha)	2 959.1 ±	1 228.9	112.0	6551
Forage yield (Kg/ha)	19 757.3 ±	5 705.9	6300	40500

Source: De María et al., 1979. (7)

Table 2. Number of Accessions in Each Race Evaluated and Selected in Stage 1.

Racial Types	In the Collection	Evaluated	Selected
DENTE RIOGRANDENSE	25	21	6
CATETO SULINO	505	186	50
CRISTAL	6	6	0
MOROTI AMARILLO	91	56	0
MOROTI BLANCO		24	0
SEMIDENTE RIOGRANDENSE	68	63	19
DENTE BRANCO	90	92	25
PISINGALLO	23	1	0
OTHERS	44	0	0
TOTAL	852	450	100

Table 3. Main Descriptors and Agronomic Characteristics of Accessions Selected in Stage 2.

I.D. Accession	Race	Grain Type	Grain Color	Days FF	PH cms	EH cms	Yield kg/ha
URZM01026	DR	SF SD	NA AM	62	200	112	3653
URZM01036	SR	FT SF	NA AM	69	187	118	3567
URZM01062	SR	FT SF	NA	63	183	95	3162
URZM01081	CS	FT SF	NA	60	155	78	3288
URZM01089	CS	FT SF	NA AM	61	168	94	3348
URZM01114	CS	FT SF	NA	63	165	98	3846
URZM02005	CS	FT SF	NA	60	152	76	4886
URZM05071	SR	FT	NA AM	76	200	121	3720
URZM10001	DB	SF SD	BL AM	70	214	126	4294
URZM11002	DB	DE SD	BL	70	215	139	3885
URZM11003	DB	DE SD	BL AM	68	204	118	3988
URZM11023	CS	FT SF	NA	67	186	102	4007
URZM12006	DB	DE SD	BL AM	72	215	131	4131
URZM12044	CS	FT SF	NA	67	194	114	3893
URZM13010	DB	DE SD	RB NA	69	216	134	4476
URZM13050	SR	FT SF	NA AM	63	181	105	3028
URZM13052	SR	SF SD	NA	63	181	97	3562
URZM13061	CS	FT	NA	67	185	110	3739
URZM13073	CS	SF	NA	67	179	98	3952
URZM13082	CS	FT	NA	64	178	103	4316
URZM13085	CS	FT	NA	65	178	97	3307
URZM13088	CS	FT SD	NA	64	178	101	4264
URZM13100	CS	FT	NA	61	169	91	3535
URZM16001	DB	SF SD	BL	69	192	109	2996
URZM18050	SR	FT SD	NA AM	69	207	103	3711
Tester DP-101		FT	NA	56	184	97	5290

I.D: Identifier, F.F: female flower, P.H: plant height, E.H: ear height, DR: Dentado Riograndense, SR: Semidentado Riograndense, CS: Cateto Sulino, DB: Dente Branco, BL: white, NA: orange, AM: yellow, RB: Red white cap.

Table 4. List of Accessions Within the 20% Superior Yielding Class with Information of the Characteristics Evaluated in Stage 3 in Paysandu.

Accession	MF	FF	PH	EH	BP	RL	PRO	Yield	H
ARZM3054	57	61	205.5	112.3	3.5	6.5	1.3	6707.0	21.3
ARZM17034	60	63	195.5	101.5	2.0	1.0	1.6	6205.0	22.0
URZM11023	50	55	156.3	81.3	2.0	4.8	1.5	5612.5	20.0
FS8-BT	56	60	175.3	80.5	2.0	0.0	1.9	5544.0	20.5
ARZM3056	56	61	197.0	109.0	5.0	4.0	1.4	5482.3	21.3
ARZM16042	50	54	162.3	83.0	2.0	1.0	1.3	5271.5	19.3
ARZM1150	56	60	190.0	91.3	3.0	1.0	1.3	5071.3	22.8
ARZM13001	50	55	174.5	80.3	0.8	1.0	1.2	4948.5	19.8
ARZM16035	45	52	158.0	80.3	5.8	1.0	1.3	4861.3	18.0
ARZM16021	49	54	164.5	77.0	1.0	0.0	1.4	4725.5	18.3
CHZM4030	49	54	158.5	79.0	2.0	2.8	1.4	4713.8	18.3
URZM5071	54	58	170.8	83.8	4.5	3.3	1.4	4663.8	19.5
ARZM17026	47	53	157.8	84.8	6.3	1.8	1.2	4659.5	18.3
ARZM18009	50	55	171.0	93.5	4.8	3.8	1.3	4658.0	18.8
ARZM16026	50	55	172.5	90.0	2.0	0.0	1.3	4630.3	19.0

Source: Vivo et al, (1992). Analysis de Exprimentos de la Etapa 3 de LAMP para el Area Homologa 5, Paysandu, Uruguay. Reporte Interno de Facultad de Agronomia, 11p.

LSD for yield: 1144.5 kg/ha MF: male flower (days), FF: female flower (days), PH: plant height (cms), EH: ear height (cms), BP: percentage of broken plants, RL: percentage of root lodged plants, PRO: prolificacy, Yield: grain yield (kg/ha), H: grain moisture (%).

Table 5. Experiment Average Yield Across Accessions (kg/ha) and List of the Six Better Accessions in Each Location.

	Pergamino	Santiago	Copiapó	Iowa	Georgia	Paysandú
kg/ha	5406	9712	8876	2856	3439	3759
1	ARZM16035	CHZM13019	FS8-BT	URZM1036	URZM1036	ARZM3054
2	ARZM16053	CHZM13001	ARZM16062	URZM2005	URZM13082	ARZM17034
3	ARZM13026	URZM13082	CHZM13001	ARZM16056	ARZM17026	URZM11023
4	URZM13073	CHZM3009	ARZM3056	ARZM17026	URZM1114	FS8-BT
5	ARZM1102	URZM10001	URZM13073	URZM1089	ARZM16035	ARZM3056
6	URZM13082	FS8-BT	CHZM5027	URZM11002	URZM1089	ARZM16042

Source: Vivo et al., 1992.

Table 6. Mean ( ) and Standard Deviation (s) of S_1 Lines for Days to Male and Female Flowering.

Variable		Del Plata 101	Argentinean	Chilean	Uruguayan
Male flower (days)	Mean	65.9	61.38	57.39	66.11
	s	5.6	5.6	4.4	5.7
Female flower(days)	Mean	73.84	72.39	68.8	73.7
	s	6.6	6.3	4.4	5.8

Source: [9]Olveyra, M. And H. Ozer Ami. 1994. Informe de la etapa V de LAMP. Paysandú, Uruguay. Facultad de Agronomía.

Table 7. Mean ( ) and Standard Deviation (s) of S_1 Lines for Plant Height (PH), Ear Height (EH), % Root Lodged Plants (RL), and % Broken Plants (BP).

Variable		Del Plata 101	Argentinean	Chilean	Uruguayan
PH (meters)	Mean	1.23	1.04	1.04	1.13
	s	0.3	0.22	0.22	0.28
EH (meters)	Mean	0.62	0.53	0.55	0.63
	s	0.2	0.17	0.17	0.2
RL (%)	Mean	36.83	23.11	29.69	51.29
	s	22.5	20.1	20.0	24.9
BP (%)	Mean	3.44	1.21	3.73	4.35
	s	5.0	3.4	7.0	6.8

Source: Olveyra and Ozer Amí, 1994.[9]

Table 8. Mean (x) and Standard Deviation (s) of S_1 Lines for Grain Yield (Grams per Plot), % Grain Moisture (%h), and Prolificness (PRO).

Variable		Del Plata 101	Argentinean	Chilean	Uruguayan
Yield	Mean	928.1	491.6	371.4	543.6
	s	687.9	373.0	334.6	452.5
% H	Mean	19.4	20.2	15.9	19.3
	s	3.0	3.6	2.3	2.6
PRO	Mean	0.73	0.66	0.68	0.78
	s	0.28	0.26	0.24	0.36

Source: Olveyra and Ozer Amí, 1994.[9]

VENEZUELA LAMP FINAL REPORT

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11 1. Breeding materials used in Venezuela

Before LAMP, the following materials were being used especially for obtaining hybrid maize:

Sicarigua Mejorado, native material with white dent kernels belonging to the Tuxpeño race.

ETO Blanco, from Colombia with white flint kernels. In combination with the former shows extraordinary heterosis and produces the flintiness necessary for industrial uses.

ETO PB, short plant version of the former with white dent kernels from CIMMYT.

Tuxpeño CPB, short plant Tuxpeño selection developed at CIMMYT with white dent kernels.

Suwan 1, material with yellow flint kernels from Thailand used in our breeding program to incorporate downy mildew resistance.

Comp. Thai No 1, yellow flint kernels, DM tolerant, from Thailand.

TIWF, white flint kernels, downy mildew (DM) tolerant, developed at CIMMYT.

Other materials from CIMMYT such as La Posta, Mezcla Tropical Blanca, and Blanco Cristalino 1.

2. Accessions Selected from LAMP

Venezuelan accessions selected during LAMP stage 2 were: BG-002, BG-070403, BG-070404, BG-070422, and BG-070809. During stage 4, the selected foreign accessions were: VAL 343, CHIS 429, GUATE GPO 21-18A, M. de DIOS 046 and PAS 014.

3. LAMP Stage 5

3.1 Accessions used at stage 5.

The accessions used on stage 5 are on Table 1.

3.2 LAMP accomplishments

During 1994, two experiments were conducted testing 36 testcrosses, 19 accessions, and 9 testers. They were planted in two locations of the Maracay region: Maracay on July 4, 1994 and Santa Cruz on July 17, 1994. Testcrosses tested in those experiments were: 6 from Bolivia, 3 from Guatemala, Colombia and Peru, 7 from Brazil, 9 from USA, and 5 from Venezuela. Testers were: 1 from Bolivia, Guatemala, Colombia, USA, and Venezuela, and 2 from Brazil and Peru.

The experimental design was an 8 x 8 lattice with 2 replications. Plots had one 5 m row separated 0.8 m, with 11 hills and 2 plants/hill. Plant population density was about 55,000 plants/ha. The experiments were analyzed combining two locations, using a model where locations and entries were at random. Three characteristics were analyzed: yield, days to silk, and ear height.

For days to silk, there were no significant differences among locations and replications within locations. There were highly significant differences among entries. The interaction location x entries was not significant indicating similar performance of the materials at both locations. After partitioning the sum of squares for location x entries, we detected highly significant differences for the interaction location x testcrosses and accessions vs. testers. The mean for the check PB-8(h) was 62.8 days to silk versus 60.2 days for the earlier maturity testcrosses VAL 343/PB-8(h) and GUATE GPO-21-18A/SUWAN.

For ear height, there were highly significant differences for locations and for entries. The interaction location x entries was not significant . The check PB-8(h), with a mean ear height of 112 cm, was significantly shorter than the testcrosses. Heterosis for this trait was high for RDOM 150 and SCROIX 1.

In the combined analysis for grain yield, differences among locations and replications within locations were not significant. Highly significant differences were detected among testcrosses. The yield of M DIOS 046/PB-8(h) (5.4 T/ha) was significantly greater than the check (3.7 T/ha). There were high heterosis values, especially for S CROIX 1/H128xH219 (176%), BG-070403/43-46X43-68 (156%), and CUBA 164/H128XH219 (151%).

Conclusions:

For the analyzed traits, there were significant differences among entries.

Heterosis was higher for grain yield than for days to silk and ear height.

The outstanding Venezuelan accession was BG-070403.

3.3 Other accomplishments

During 1995 within the NOE Program, many of the accessions tested at LAMP stage 2 were regenerated. Seeds of those materials were sent to CIMMYT and NSSL.

4. Plans for subsequent years

During 1996, we will continue the regeneration program and will evaluate some non-selected materials, which have interesting characteristics for our breeding program, such as husk cover and lodging tolerance.

After 1996, we will begin the utilization of the materials selected at stage 4 and 5 and will continue the interchange of materials and information with colleagues of HA 1.

5. Importance of LAMP for Venezuela

As we expected, there were interesting testcross combinations with potential future use in our breeding program. But the most important aspect of LAMP for our country was to detect the poor conditions for conservation of our collections and to regenerate many of them.

In the future, we will develop useful populations for our breeding program based primarily on the materials of the best performance.

Table 1. Accessions used in Stage 5.

Accessions	Tester
43-46 x 43-68	
ANT 373	ICA V 258
ANT 377	ICA V 258
BARBAD GP2	
BARBAD GP2	HC128 x HC219
BG-070403	
BG-070403	32-46 x 43-68
BG-070404	PM 701(m)
BG 002	
BG 002	32-46 x 43-68
BOL 326	PM 701(m)
BR 105	
BR 106	
BRVIRG 155	
BRVIRG 155	HC128 x HC219
CHIS 429	PB-8(h)
CHIS 775	SUWAN
CMS 0508 III	BR 106
Comp. Manaus	
Comp. Manaus	BR 105
CUBA 164	
CUBA 164	HC128 x HC219
GUATE 209	SUWAN
GUATE GPO 21 18A	PB-8(h)
GUATE GPO 21 18A	SUWAN
HC128 x HC129	
ICA V 258	
M. DE DIOS 046	PB-8(h)
PAS 014	PB-8(h)
PB-8(h)	
Pe 01	BR 105
Pe 11	
Pe 11	BR 106
Pe 27	
Pe 27	HC128 x HC219
PM 701(m)	
PUER GP3	
PUER GP3	HC128 x HC219
RDOM 150	
RDOM 150	HC128 x HC219
RN 07	
RN 07	BR 106
SCROIX 1	
SCROIX 1	HC128 x HC219
SCROIX GP3	
SCROIX GP3	HC128 x HC219
Se 32	

Table 1. Accessions used in Stage 5 (continued).

Accessions	Tester
Se 32	BR 105
Se 33	
Se 33	32-46 x 43-68
Se 33	HC128 x HC219
SUWAN	
TAMS 103	SUWAN
Tuxpeno	SUWAN
VAL 343	PB-8(h)
VAL 404	ICA V 258

THE U.S. GERMPLASM ENHANCEMENT OF MAIZE (GEM) PROJECT

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The Germplasm Enhancement of Maize Project (GEM) in the United States owes its existence to LAMP (The Latin American Maize Project). LAMP provided the information necessary to efficiently select germplasm bank accessions for enhancement. In this regard, LAMP served as the first step to share promising maize materials from the germplasm banks with breeders. GEM will complete the process by returning to the germplasm bank enhanced materials developed from the accessions, that can be directly used in applied breeding programs.

The First Step, LAMP

LAMP involved the cooperative efforts of 12 countries (Argentina, Bolivia, Brazil, Colombia, Chile, Guatemala, Mexico, Paraguay, Peru, United States, Uruguay, and Venezuela) to evaluate maize germplasm accessions of their countries for yield and agronomic characteristics (Salhauna et al., 1991). Pioneer Hi-Bred International provided $1.5 million to the U.S. Department of Agriculture (USDA) Agricultural Research Service (ARS) in 1987 for carrying out a five stage maize evaluation protocol. This was the first coordinated international project to deal with the evaluation of the genetic resources of a major world crop occurred in maize. LAMP evaluated over 12,000 accessions (74% of total maize races) in locations divided into five homologous areas covering latitudes from 34^{o}S to 41^{o}N, longitudes from 44^{o} to 101^{o}W, and altitudes from 29-3300 m above sea level.

In 1991, a catalog and CD-ROM of data of 12,113 accessions evaluated in LAMP's first stage, and 2,794 selected (primarily on yield) accessions evaluated in the second stage in 59 different locations of 32 regions of the 12 countries was published. Based on that data the Principal Investigators in each country selected a total of 268 elite accessions that were crossed with the best testers of each region (Stage 3). Thirty-one testers were used for crossing with the elite accessions. Within a homologous area, Principal Investigators exchanged testcrosses among other Principal Investigators in the same homologous area, so that testcross evaluations were done in more than one country (Stage 4). Data from the testcross evaluations were published in a catalog and updated CD-ROM in 1995. In the fifth stage of LAMP, each Principal Investigator was to enhance selected germplasm to meet his or her country's breeding objectives, yet funding for only a year of small-scale enhancement was available.

Importance of Maize Enhancement for the U.S.

Maize is the major U.S. crop, where approximately 75 million acres are planted each year. The USA is also the world leader in maize production, with the Corn Belt producing almost half of the world's maize. Maize is extremely important to the U.S. economy due to the amount produced, its value to industry, and its export value. As a raw material, maize adds over $16 billion per year to the economy. About 20 percent ($3.2 billion) of the production is exported, providing a positive contribution to the nation's trade balance. Approximately 17 percent are industrially refined. An additional $1.4 billion in refined products is exported. Through feeding livestock that is processed into meat and dairy products, the rest of the crop affects everyone in American society.

Since the early 1960s, there have been frequent and urgent warnings about the genetic vulnerability of maize and the potential value of exotic maize germplasm to decrease this vulnerability. In 1983 a comprehensive survey on the use of exotic germplasm in commercial corn revealed that less than 1% of the U.S. germplasm base consisted of exotic germplasm, and tropical exotic germplasm accounted for only a fraction of that (Goodman, 1985). On a worldwide basis only 5% of available maize germplasm is used commercially. It is prudent to develop alternate breeding populations from exotic sources to insure against unanticipated threats to production, or to accommodate alternate uses.

In contrast to many other crops, maize breeders have continued to focus on short-term breeding goals largely because of the predominance of the private sector in maize breeding and its need for short-term results. This pattern has resulted in the development of a very narrow genetic base of corn produced on the farm, with many companies selling closely related hybrids (Smith, 1988). Private companies are, however, growing increasingly concerned about their narrow germplasm pools and some have even added a germplasm-enhancement component to their breeding programs, although tough competition in the industry results in the tendency to focus on elite proprietary exotics from branch stations within a company. Although breeders are still making 1.5-2.0% per year of genetic gain for yield in adapted materials, it is not known how long these gains will continue. Also, the genetic gain still being achieved does not provide more diverse hybrids needed on the farm for climate and market structure changes that are projected in the future.

Background of GEM

In the USA, the seed source for virtually all corn grown commercially is the seed industry. For any of the LAMP accessions to be useful, some mechanism had to be established to enhance them so they could enter commercial corn breeding channels. The competitive nature of the seed industry made it unlikely that any one company would support an enhancement effort. Funding for public breeders is very minimal and still decreasing, and there are few if any grant sources for germplasm enhancement, so it was unlikely that public breeders could support an enhancement effort. It was clear that a coordinated and cooperative effort among the USDA-ARS, land-grant universities, and industry was needed before the LAMP materials would be used in U.S. breeding programs. It was also clear that coordination and primary funding of the effort would have to be done by the USDA-ARS because of the project's national scope.

Member companies of the American Seed Trade Association (ASTA) with maize breeding programs expressed their conviction for an enhancement effort by pledging in-kind support in the form of winter and summer nursery rows, yield trial plots, and disease observation rows worth about $450,000 annually. In-kind support by industry was important for showing to the U.S. Congress and the USDA industry's commitment to the project, for providing the necessary number of testing environments, for ensuring that the enhanced materials will have commercial relevance, and for providing public programs with routine cooperation and guidance. A sub-committee from the Corn & Sorghum Basic Research Committee of ASTA lobbied key legislators of Congress for permanent base funding to ARS to support the public effort at ARS and university locations. In 1995, $500,000 of permanent yearly funding was appropriated by Congress to support coordination of the enhancement effort at the Corn-Belt ARS location in Ames IA, work on value-added traits in Ames IA, data management of the project at Ames IA, a satellite location at the southern ARS location in Raleigh NC, and support for public cooperators at other ARS and university locations.

The objective of this enhancement effort named U.S. Germplasm Enhancement of Maize (GEM), is to provide to the corn industry materials developed using germplasm enhancement of useful exotic germplasm, with the ultimate aim of improving and broadening the germplasm base of maize hybrids grown by American farmers. GEM is an ongoing project, but to initiate enhancement 50 elite tropical and temperate LAMP accessions were chosen, plus 7 commercial tropical hybrids provided by DeKalb Genetics. The enhancement protocol is for one of the private cooperating companies to cross an exotic material by a proprietary inbred line to make a 50% exotic breeding cross, then for another private cooperator to cross the 50% cross with their proprietary line of the same heterotic pattern to make a 25% exotic breeding cross. All breeding crosses are evaluated for yield as testcrosses, and the best used to develop breeding lines by cooperators. Because proprietary germplasm is used to make breeding crosses, access to breeding materials and data collected on them is limited to GEM cooperators, but the opportunity to become a cooperator is available to all. GEM enhanced lines and synthetics, and all associated data, will be freely available through NCRPIS after their release. Traits targeted for improvement are agronomic productivity, disease and insect resistance, and value-added characteristics.

Organization of GEM

Organization of GEM was based on LAMP's organization. All GEM cooperators function similarly to the LAMP Principal Investigators, by being responsible for the project's execution. Like the LAMP PI's, all the cooperators meet once a year to discuss results and modify procedures. They also have the opportunity to meet at two GEM field days held each year. One is always at Ames, the other rotates among the cooperators. A technical steering group (TSG), 9-11 cooperators, meets four times a year to discuss policies, protocol, and review results. The TSG is composed of at least five members from industry, diverse among large, regional, medium national, and foundation seed companies. USDA-ARS members are limited to two (GEM coordinator and North Carolina representative) and are ex-officio due to conflict of interest. There are also two members from land-grant universities and one can be from a commodity group or processing industry. The GEM coordinator corresponds to the role that Ricardo Sevilla played in LAMP, and is responsible for what is to be done, when, and at what cost. Much of the day-to-day management is the responsibility of three USDA-ARS support scientists, two at Ames and one at Raleigh.

To develop the framework of public/private cooperation, correspondence was initiated with people known to have maize germplasm enhancement interest, asking them to pass the information along to others. From this correspondence, the Germplasm Enhancement (GE) network was compiled. This database includes a group of people, including cooperators, administrators, politicians, and others, who receive the newsletters, invitations to field days, and other general information.

Effective communication is seen as critical to the project's success. Cooperators keep in touch through the newsletter, field days, and the annual cooperators meeting. A world-wide web home page has been developed (http://www.public.iastate.edu/~usda-gem/) that makes it easy to learn about GEM, contact GEM cooperators, obtain data, and order seed. The page also contains links to other important germplasm pages. A program has been developed which will be used to plan, manage, and analyze yield trials. This program will be extended to nursery organization.

The objectives of the GEM location at Ames are to:

1) coordinate GEM by carrying out the protocol with the cooperation of the cooperators
2) analyze and manage GEM data
3) evaluate GEM materials for value-added traits
4) solicit work plans from public cooperators, summarize work plans, distribute funding, and coordinate public cooperator projects in the Corn Belt
5) curate GEM breeding crosses and breeding materials
6) publish and distribute the GEM newsletter
7) cooperate by enhancing selected 25% and 50% exotic temperate breeding crosses and 25% exotic tropical breeding crosses for value-added traits and/or yield
8) organize two field days per year, and conduct one of them in Ames
9) maintain the World Wide Web home page
10) coordinate data collection and seed increase of selected lines or synthetics
11) release in cooperation with developer selected lines or synthetics.

The objectives of the GEM location at Raleigh are to:

1) coordinate enhancement of the 50% tropical breeding crosses for the southern USA
2) coordinate enhancement of the 50% tropical breeding crosses for moving to the Corn Belt
3) coordinate public cooperator projects in the South
4) cooperate by enhancing selected 50% tropical breeding crosses for disease resistance and/or yield
5) provide relevant information for the newsletter and home page.

Protocol of GEM

The basic protocol of GEM is a pedigree breeding system to develop S_3 lines. The coordinator assigns materials and heterotic pattern to be used in this procedure to the participating cooperators.

Public Cooperators

A number of maize researchers at various U.S. land-grant universities and other ARS locations are taking part in the evaluation and enhancement of the germplasm, or will be in the future. This cooperative effort is very important and not only serves as a source of evaluations other than those that the ARS GEM locations and private cooperators are capable of performing, but also provides additional enhanced germplasm and training for future plant scientists. The TSG has prioritized screening for diseases and insects for the USA, and is in the process of prioritizing value-added trait evaluations. Diseases and insects of highest priority included corn rootworm, second generation European corn borer, gray leaf spot, anthracnose stalk rot, aspergillus ear mold, and *fusarium* ear mold. Some funding is available for projects with objectives that are a priority for GEM, as determined by the TSG.

Value-Added Trait Evaluations

Traditionally in the USA, maize has been treated as a commodity, with 95% of production being traded on standard grades and prices. Therefore, farmers were mainly interested in high yields, and breeders have focused on breeding for high yield. In recent years corn grain feeders and processors have become more interested in the quality characteristics of the grain itself and how this affects their business. For example, approximately 107,100,000 metric tons of corn were sold to foreign markets in 1992, of which 640,000 metric tons needed to be removed due to unacceptable quality (broken kernels and foreign matter). The poultry industry has become concentrated and technologically advanced in the past two decades, to the point where minor changes in raw materials can mean significant changes in final costs and profit (Wheat, 1992). Processors are looking into changes in the starch composition of the corn grain that would enable them to refine it into new consumer products that they were unable to produce previously. Maize breeders have begun breeding for these various quality characteristics currently demanded in the marketplace in order to keep corn feeders, processors and farmers competitive at home and in export markets, and to provide consumers with safe and nutritious food products. Since much of the exotic germplasm has undergone selection for many indigenous uses (foods, beverages, etc.) by various cultures, it seems likely that new grain quality characteristics will be found in exotic rather than the narrow-based germplasm now used. A small increase in value to the grain, such as 10 cents per bushel, would increase its annual value by $800 million for an eight billion bushel harvest (Salhuana et al., 1994).

Based on previous experience with LAMP germplasm, GEM cooperators are confident of finding many economically important traits in the original exotic germplasm, which will lead to inbred lines improved for a wide variety of characteristics as well as productivity. For example, 691 Peruvian maize accessions were recently evaluated for resistance to European corn borer leaf feeding (Abel and Wilson, 1995). Eleven resistant varieties were identified, with all 11 commonly grown in coastal valleys of Peru's northern coast. Further analysis indicated that the resistance factor was unrelated to that found in Corn Belt-adapted maize, DIMBOA concentration. Breeding crosses of the resistant accessions with Corn Belt lines also show resistance. Further breeding work to develop Corn Belt-adapted lines with an alternate resistance factor to DIMBOA concentration is proceeding. None of the 11 accessions were included in the top 5% of LAMP accessions, representing the highest-yielding accessions, indicating the importance of screening a wide variety of germplasm for non-yield related traits.

Initially, the evaluations of value-added characteristics will be done in all genotypes chosen for enhancement in GEM. These materials are a logical starting point of our evaluations, as they are diverse exotic materials that have not been evaluated for value-added traits, and are the focus of breeding efforts by GEM's cooperators. Breeding crosses (two-way and three-way crosses) will then be evaluated. This is important for further development of the value-added lines. If an accession or hybrid has a trait of interest, but the breeding crosses do not, it can be assumed that dominant alleles from the Corn Belt parents have influenced the properties. In this situation, further investigation will have do be done to determine whether the properties can reappear through self pollinating the breeding crosses, or if another Corn Belt line should be used, or if further development should be done in the population per se. In other cases, breeding crosses may carry an interesting trait that the accessions do not. For example, none of the original GEM accessions had unusual protein percentage levels, but several proprietary breeding crosses had protein levels above 15%, which is significantly higher than Corn Belt maize. The properties of interest will then be used as selection criteria to develop S_3 lines with improved value-added traits.

Value-Added traits important for corn uses are:

- composition (per cent oil, protein and starch)
- grain quality (hardness, breakage susceptibility)
- starch quality
- starch digestibility
- feed value indicators
- oil quality (fatty acid composition)
- protein quality (amino acid composition)
- dry milling efficiency
- wet milling efficiency
- others (e.g. vitamin composition).

With information about the above traits, the populations entering GEM can be classified for their potential to improve corn for each of its major uses, e.g.. wet milling, dry milling, animal feed, food uses, or specialty areas. Using relevant traits as additional or alternate selection criteria during breeding can produce lines with value-added characteristics.

Currently, the GEM laboratory is focused on analysis of protein, oil and starch quantity in whole grain and evaluations of quality for starch and oil. In the next year the program will include developing methods for amino acid analysis of protein and developing a model for digestibility to measure corn's feed value. Whole grain is nondestructively evaluated for protein, oil and starch quantity with scanning near infrared spectrophotometry (NIRS) with the sample transport module and natural product cell. Starch is evaluated for thermal and pasting properties. Starch is extracted from single kernels in a mini wet-milling system that simulates the method used in industry. The starch is analyzed for thermal properties in the Differential Scanning Calorimeter (DSC).The values of interest generated form the DSC are onset gelatinization temperature, peak gelatinization temperature, total enthalpy and range of gelatinization. These values indicate the amount of energy required to gel the starch and predict the pasting qualities. Determining the pasting qualities requires a larger quantity of starch than the DSC analysis so the starch is extracted on the starch table using the 100g wet-milling method. The pasting properties are measured with the Rapid Visco Analyzer (RVA). The values of interest are pasting temperature, peak viscosity, time to peak, breakdown, minimum viscosity, setback and final viscosity. These values are the industry standard for starch quality.

The oil quality can be determined on individual kernels of grain. The kernels are crushed in a hydraulic press, chemically altered to the methyl ester form and evaluated for fatty acid composition with the Gas Chromatograph (GC). Fatty acid profiles of interest are low saturates (palmitic acid + stearic acid) for healthier oil, high saturates for developing a semi-solid margarine product without hydrogenation and subsequent production of trans fatty acids, and high oleic acid for healthier oil.

GEM has a clear mandate from government and industry to evaluate maize for traits that determine feed value. A model for predicting digestibility would be very useful for the feed industry . The advantage of predicting the protein and starch products resulting from digestion and using this model to screen for better grain as feed ingredients would benefit the industry and consumers. Our laboratory is working on methodology to screen for protein quality, starch digestibility, and other feed value indicators.

Also, the following priorities for screening pests and diseases were developed by representatives of U.S. seed companies: (1=high, 2=medium, 3=low priority):

Insects:

Root Worm	1
European Corn Borer second generation	1
Spider Mites	2
European Corn Borer first generation	3
Fall Armyworm	3
Southwestern Corn Borer	3
Corn Ear Worm	3
Bill Bugs	3
Black Cut Worm	3

Chinch Bug	3
Thrips	3
Leaf Hoppers	3
Leaf Diseases:	
Gray Leaf Spot	1
Southern Rust	2
Viruses:	
Corn Lethal Necrosis	3
SE Complex (MDMV, MDCV)	3
Stalk Rots:	
Anthracnose	1
Fusarium/Gib.	2
Diplodia	3
Charcoal	3
Ear Rots:	
Aspergillus	1
Fusarium	1
Gib.	2
Diplodia	3

All data collected on disease resistance, insect resistance, or value-added traits for accessions will be provided to the U.S. Germplasm Resources Information Network (GRIN) database, accessible on the Internet World Wide Web at http://www.ars-grin.gov/npgs/. All data collected on proprietary breeding crosses will be part of the GEM database, and will be released when S_3 lines or S_2 composites are released.

GEM Status, May 1996

The following table gives numbers of GEM breeding crosses as of December, 1995. All crosses were sent to appropriate companies for making topcrosses (two companies per heterotic pattern). The topcrosses are being grown at a minimum of six locations with private and some public cooperators. They are also being evaluated in disease nurseries with private cooperators.

Conclusion

Maize hybrids in the U.S. have a very narrow genetic base, utilizing only a small percentage of all available corn germplasm. This greatly increases vulnerability to pest problems, may lead to a yield plateau, and makes it difficult to develop hybrids for new market demands. GEM evaluations have shown that exotic germplasm contains genes for resistance to pests, increased yields, and quality traits. Use of this germplasm will help to provide in the future the best raw materials to meet demand for the production of meat, eggs, milk, and many other food and industrial uses.

References

Abel, C.A., R.L. Wilson, and J.C. Robbins. 1995. Evaluation of Peruvian maize for resistance to European corn borer (Lepidoptera: Pyralidae) leaf feeding and ovipositional preference. J. Econ. Entomol. 88:1044-1048.

Goodman, M.M. 1985. Exotic maize germplasm: Status, prospects, and remedies. Iowa State J. Res. 59:497-527.

Salhuana, W., Q. Jones, and R. Sevilla. 1991. The Latin American Maize Project: Model for rescue and use of irreplaceable germplasm. Diversity 7:40-42.

Salhuana, W., L. Pollak, and D. Tiffany. 1994. Public/private collaboration proposed to strengthen quality and production of U.S. corn through maize germplasm enhancement. Diversity 9-10:1-2.

Smith, J.S.C. 1988. Diversity of United States hybrid maize germplasm: Isozymic and chromatographic evidence. Crop Sci. 28:63-69.

Wheat, D. 1992. Corn last commodity to see market differentiation. Feedstuffs (February 17) 34-43.

Table 1. Membership of the Technical Steering Group, 1997.

Member	Group		Expertise
Wilfredo Salhuana	Industry	(Pioneer)	Chair, Breeding, Exotics
Randy Holley	Industry	(Northrup King)	Breeding, Exotics
Kevin Montgomery	Industry	(Golden Harvest)	Breeding
Hiep Pham	Industry	(Cargill)	Breeding, Exotics
Dirk Benson	Industry	(Limagrain)	Breeding, Entomology, Specialty traits
Dave Harper	Industry	(Holden's)	Breeding, Lobbying
Doug Tiffany	Industry	(Pioneer)	Breeding, Specialty traits
Don White	University	(Univ. Illinois)	Plant Pathology
Jim Coors	University	(Univ. Wisconsin)	Breeding, Silage quality
Linda Pollak	USDA-ARS		Coordinator, Breeding, Exotics
Marty Carson	USDA-ARS		Project Leader, Pathology

Table 2. GEM Cooperators.

Private	Public
Bo Jac Hybrid Corn Co.	Manjit Kang, Louisiana, University
Cargill	Zeno Wicks, South Dakota, University
Crows Hybrid Corn Company	Kendall Lamkey, Iowa, USDA-ARS
DEKALB Genetics Corp.	Dennis West, Tennessee, University
FFR Cooperative	Jim Coors, Wisconsin, University
Fred Gutwein and Sons	Brent Zehr, Indiana, University
Golden Harvest	Paul Williams, Mississippi, USDA-ARS
Great Lakes Hybrids	Dale Harpstead, Michigan, University
Growmark	Larry Darrah, Missouri, USDA-ARS
Hoegemeyer Hybrids	Melvin Johnson, Pennsylvania, University
Holdens Foundation Seeds	Richard Pratt, Ohio, University
ICI Seeds	Linda Pollak, Iowa, USDA-ARS
Jung Farms	Chuck Poneleit, Kentucky, University
Limagrain Genetics	Blaine Johnson, Nebraska, University
Novartis	Margaret Smith, New York, University
Northrup King	Robert Stucker, Minnesota, University
Pioneer Hi-Bred Int., Inc.	Jim Hawk, Delaware, University
Wyffels Hybrids	Major Goodman, North Carolina, University
Global Agro Inc.	Marty Carson, North Carolina, USDA-ARS
	James Brewbaker, Hawaii, University
	Pamela White, Iowa, University
	Donald White, Illinois, University
	John Ayers, Pennsylvania, University
	Billy Wiseman, Georgia, USDA-ARS
	Larry Johnson, Iowa, University
	Dean Barry, Missouri, USDA-ARS
	Jon Tollefson, Iowa, University
	Michael Lee, Iowa, University
	Robert J. Lambert, Illinois, University
	Bruce Hibbard, Missouri, USDA-ARS
	Gary Munkvold, Iowa, University
	Arnel Hallauer, Iowa, University
	Paul Scott, Iowa, USDA-ARS
	John Dudley, Illinois, University
	Neil Widstrom, Georgia, USDA-ARS
	Craig Abel, Ames, Iowa, USDA-ARS
	Richard Wilson, Ames, Iowa, USDA-ARS
	Mark Campbell, Truman State U. (Kirksville, MO)
	James Throne, Manhattan, KS, USDA-ARS
	Bradley Binder, Ames, IA, USDA-ARS

Table 3. GEM breeding protocol for developing S_3 lines.

Season	Description
Winter	Private cooperator crosses the assigned accessions with a proprietary line of the same heterotic group to form the breeding cross.
Summer	A different private cooperator crosses the accession x proprietary line breeding crosses with their proprietary line of the same heterotic group to form the three way cross.
Winter	Cross all breeding and three-way crosses with an inbred tester.
Summer	Conduct yield trials of proprietary breeding and three-way topcrosses. Yield trials are conducted in a minimum of six locations, using common and local checks. Results permit selection of the best breeding crosses for further work.
Winter	Self pollinate about 1000 plants of the breeding or three-way crosses selected from topcross trials.
Summer	Plant ear-to-row and self, selecting among and within S_1 families to achieve 200 S_2's. Public cooperators send the Coordinator 100 kernels of the selected S_2's (200 ears). For the private cooperators the S_2's can be considered proprietary material and can be handled according to each company's proprietary material protocol.
Winter	Make 200 S_2 testcrosses with the best inbred tester of the opposite heterotic pattern.
Summer	Yield test all 200 S_2 testcrosses.
Winter or Summer	The 10 best S_2 lines will be recombined by private companies and the seed sent to the Cooperator for seed increase, for evaluations of value-added traits, and for disease and insect resistance, using the in-kind support of cooperators who expressed interest in these evaluations. For the public cooperators, the best S_2 lines will be selfed to the S_3 by the Coordinator and evaluated.
Summer or Winter	The coordinator will release the private-sector's synthetics of recombined S_2's, the public-sector's S_3's , and all relevant data to NCRPIS (North Central Plant Introduction Station) for maintenance and distribution.

Table 4. Public GEM cooperators supported in 1995.

Name	Institution	Materials evaluated	Research
Margaret Smith	Cornell University	temperate breeding crosses	resistant to anthracnose stalk rot
John Dudley, Donald White	University of Illinois	temperate breeding crosses	resistance to 5 leaf blights and rind puncture resistance
Charlie Martinson	Iowa State University	temperate breeding crosses	produce innoculum for GEM evaluations at Ames
John Ayers, Melvin Johnson	Penn State University	temperate accessions	resistance to gray leaf spot
James Coors	University of Wisconsin	temperate accessions and breeding crosses	evaluation of silage potential, demo field, field day
Manjit Kang	University of Louisiana	Tropical and temperate breeding crosses	resistance to *Aspergillus flavus* and maize weevil
Richard Pratt	Ohio State University	temperate breeding crosses	physical and compositional grain quality
Paul Williams, Frank Davis	USDA-ARS, Mississippi	tropical and temperate accessions	resistance to fall armyworm and southwestern corn borer
Neil Widstrom	USDA-ARS, Georgia	tropical and temperate accessions	resistance to *Aspergillus* sp.. infection and aflatoxin production
Billy Wiseman	USDA-ARS, Georgia	tropical and temperate accessions	resistance to corn earworm and fall armyworm
Larry Johnson	Iowa State University	tropical and temperate accessions, subset of breeding crosses	variation in proximate composition, grain physical properties, wet milling properties, and starch functionality
Dean Barry	USDA-ARS, Missouri	tropical and temperate accesssions	resistance to first and second brood European corn borer
Jon Tollefson	Iowa State University	tropical and temperate accessions	resistance to corn rootworm

Table 5. Public GEM cooperators supported in 1996.

Name	Institution	Materials Evaluated	Research
John Ayers	Pennsylvania State University	all 25% tropical breeding crosses	Gray leaf spot eval.
Gary Munkvold	Iowa State Unviersity	100 entries	Fusarium resistance
Margaret Smith	Cornell University	5 25% resistant to anthracnose, yield test the corresponding 50% testcrosses	Anthracnose stalk rot
Jim Coors	University of Wisconsin	5 best for silage--both 25% and 50% versions	Nutritional quality of silage, dry matter yield
Dean Barry	USDA-ARS, Missouri	Accessions selected from last year	ECB, corn rootworm
Richard Pratt	Ohio State University	about 120 tropical (25%) and temperate crosses (?50 or 25%)	Grain quality
Jon Tollefson	Iowa State University	Accessions	Corn rootworm
Lawrence Johnson	Iowa State University	Public crosses we made in Puerto Rico, do we make BC this summer?	Wet milling, starch quality, composition
John Dudley	University of Illinois	tropicals x B73, tropicals x Mo17, best 3-4 tropical accessions for leaf blights	Dudley's method, Leaf blights
Neil Widstrom	USDA-ARS, Georgia	North Carolina topcrosses of 50% tropicals	Yield trial
Manjit Kang	Louisiana State University	North Carolina topcrosses of 50% tropicals	Yield trial, southern rust (P. polysora)
Paul Williams	USDA-ARS, Mississippi	North Carolina topcrosses of 50% tropicals, 50% tropicals	Yield trial, Aflatoxin
Billy Wiseman	USDA-ARS, Georgia	25 50% tropical breeding crosses for armyworm, 25 accessions for earworm	fall armyworm, corn earworm
Dennis West	University of Tennessee	North Carolina topcrosses of 50% tropicals	Yield trials, MDVA-MCDV virus comples
Jim Hawk		Two Corn Belt topcross trialsand associated breeding crosses for Stewart's Wilt	Yield test, drought resistance, Stewart's Wilt

Table 6. GEM Breeding Cross Totals

	Stiff Stalk			**non-Stiff Stalk**		
	50% exotics	25% exotics	total SS	50% exotics	25% exotics	total nonSS
Temperate	20	43	63	16	37	53
Tropical	18	35	53	20	38	58
Total	38	78	116	36	75	111

PROPOSAL OF INTERNATIONAL MAIZE GERMPLASM ENHANCEMENT PROJECT (IMGEP)

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INTRODUCTION

The environment is subject to increased pressures that endanger the sustainability of life. Rapid growth in human populations, poverty, and inefficient agriculture all contribute to the endangerment of sustainable biological cycles that are essential in order to maintain quality of life.

Maize, with a global harvest in 1994 of 467 million metric tons from 128 million ha, ranked second to wheat among the world's cereal crops (USDA, 1995). Some 70 countries produce maize on 100,000 ha or more; 53 of these are developing countries that contributed production of 40% of the global harvest. Worldwide, about 25% of all maize is used for human consumption, 66% for feeding livestock, and 9% for industrial purposes and as seed. In the developing world, however, roughly 50% of all maize is consumed by humans as a direct food source, 43% is for livestock feed, and 7% for industrial and seed purposes. Considering these numbers, research needs to be oriented more for human food and for livestock feed. The most accessible resource to improve maize is the utilization of available genetic resources. However genetic erosion is happening rapidly, reducing the biodiversity, the pillar for survival.

Maize is one of the most important crops in the world, it has a long history of domestication, and has been the subject of intensive breeding. Since needs of the farmers and industry change with time, it is necessary to start looking into new genetic resources that may have the desired new characteristics for their needs. Increasing productivity and quality, insect and disease resistance, tolerance to stress conditions, and additional traits that add value to the grain (starch, protein, oil, etc.) are characteristics that need to be improved in the future.

In order to carry out conservation, evaluation, enhancement, and utilization of genetic resources, the work must be coordinated and joint action between national, international, and private industries is needed. Sufficient financial support is needed from governments and donors along with the commitment to carry the program through the utilization, which demonstrates the importance of genetic resources.

The results from LAMP identified superior accessions and the heterotic group in which these belong. In this article, the use of this germplasm to enhance the basic heterotic pattern and hence to increase the probabilities of being able to develop new sources of breeding material to increase productivity is discussed.

THE BASES OF ACHIEVING IMPROVED AGRICULTURAL PRODUCTIVITY THROUGH PLANT BREEDING

Genetic diversity, to be useful in plant breeding to serve farmers and consumers, must encompass genetic variability that is not present in the materials that breeders are currently working with. It is necessary to have new sources of germplasm for present and future uses since environmental conditions, disease pressure, technologies, and demands from the farmer and consumer are constantly changing. New sources of germplasm must have yield potential with other useful traits so that breeders can be encouraged to use sources of new genetic diversity.

Despite their best efforts, by the late 1920s, farmer breeders in the United States had not been able to raise average maize yields above 1,880 kg ha^{-1} (30 bushels per acre). Plants remained very susceptible to heat and drought stress, and ravages by pests and diseases continued to be disastrous. As a result of research and practical experience gained by breeders from the early part of the 20th century, yield gains for maize increased to 3,136 kg ha^{-1} during 1930-1960, due to the use of double cross hybrids. The rate of yield gain due to genetic change alone tripled again after 1960, due to the utilization of single cross hybrids. These yield gains are due solely to plant breeders achieving increased managerial control over germplasm used to produce hybrids. Effective plant breeding requires vastly more effort to improve crop yields than mass selection and seed saving which are the strategies of farmer breeders.

Modern corn agriculture in the U.S. uses hybrids from a cross of two inbred lines, which gives the current average yield of about 8,152 kg ha^{-1} (130 bushels per acre). The improvement in yield is due to years of selection by breeders to improve agronomic characteristics such as reduced plant height, the ability of plants to stay alive until maturity, reduced stalk and root lodging, the upright leaf trait, tolerance to European corn borer, and greater stress tolerance that allows consistent yields at high plant densities.

The bases for successful and sustainable progress in plant breeding are the following:

- the ability to find useful genetics affecting traits of agricultural importance
- the ability to recombine genetics favorably affecting agronomic traits into new varieties that are overall better adapted to the target environment of the farmer and the demands of the consumer or processor

Key resources that are necessary to achieve these objectives are:

- available sources of useful genetic diversity
- adequate knowledge of these genetic resources to facilitate sourcing of useful germplasm
- adequate availability of technologies and skills to enable sourcing, manipulation, and effective transference of germplasm from exotic sources into adapted and improved varieties
- adequate knowledge of customer needs and target environment
- adequate funding to support the relatively long-term programs of research and product development that are required in plant breeding (10-15 years) and in effective sourcing of exotic genetic diversity (15-25 years).

THE CHALLENGES ASSOCIATED WITH EXOTIC GERMPLASM

The approach of using new germplasm, especially exotic materials, depends on the current yield level. If this is low, any introduction of exotic germplasm will permit increases in yield in a more rapid way than if a higher yielding material were currently in use; if the yield is high, it will take a longer time to beat this yield.

The problems that breeders face in working with exotic germplasm are many fold and substantial. They include:

- most accessions are not useful
- most of the landrace germplasm do not have good agronomic characteristics
- few data exist to select those accessions that might be useful.
- exotic germplasm has linkage groups that are unadapted to other environments, and several generations of pre-breeding are required to recombine improved adapted linkages
- exotic germplasm is photoperiod sensitive and consequently unadapted to evaluate in most agronomically-productive temperate regions
- the improvement of landraces lags behind current elite breeding programs,
- a long term persistent effort of 15-25 years or more is required from the initial selection of a landrace and the inclusion of a portion of its germplasm into a commercial variety

Corn breeders working in the USA during the 1920s and 1930s tried with extreme patience and hard work to obtain useful genetics from open-pollinated varieties. However, the relatively poor performance of those open-pollinated varieties compared to the first cycle inbred lines that were derived from those varieties forced breeders to concentrate their further efforts upon pedigree breeding and population improvement using inbred lines. Breeders are under pressure to create new varieties with improved performance, and to do this they must have useful sources of diversity. Breeders could not devote their time to making slower improvements with landraces or in focusing their efforts to conserve genetic diversity from the landraces. The imperative was to make progress in improving agronomic performance in order to provide farmers with better yields and the nation with a more secure food and an improved economy. In order to achieve these objectives, inbred lines that were bred from the landraces became the parents of new breeding populations. In cases where the actual yield level is high, the line derived using exotic germplasm will be used only for breeding crosses, at least in the first cycle, and not as a parental line for a commercial hybrid.

GENETIC RESOURCES FOR MAIZE BREEDING

Increasing food demands and the need to use land, air, and water resources with greater sustainable make it necessary to evaluate germplasm to find new sources that can contribute to these demands. It is a fervent wish that all countries will contribute to this effort so that world hunger may be eliminated.

In order to accomplish this difficult task it will be necessary to obtain accessions with passport data that have enough quantity and quality of seed so the germplasm can be evaluated and selected, the selected germplasm is submitted to a process of enhancement and after that the best material may be included in a research program for breeding and product development. If we only continue to add collections into gene banks and maintain their viability without having even a minimum level of evaluation information on the material, then the collections will, for the majority, continue as unused stocks of seed.

On a global basis, the need is to get besides yield, new unique important traits that will improve the uses of corn for food. Since there is more demand to improve environmental conditions, some reductions of chemical inputs may be necessary and this will be only possible if new genes are found that decrease the demand for these products. Also, many soils in the world have aluminum toxicity so it would be desirable to find some genes that will contribute to tolerance to this stress. We could also find genes for heat and drought tolerance; likewise for cold. Improving kernel quality through increased protein; oil, and starch would be beneficial. These are some of the examples in which the maize genetic resource can contribute and be used.

These are neither easy nor rapidly completed tasks. Great amounts of time, effort, and patience are required. Decades of regeneration, adaptation, evaluation, and pre-breeding are needed to work with just a handful of the many populations that are stored in gene banks or that are utilized in agriculture as landraces or local varieties that are exotic to other regions. However, these efforts are critically important so that germplasm resources can be more effectively and widely available through breeders to the world's farmers.

REGENERATION

This task is very difficult to implement for one institution since it is necessary to have several environmental conditions, landspace, personnel, storage facilities, etc. to do so. Success will require the implementation of a well coordinated plan with partnerships between national and international programs to enhance the capacity of these programs to conserve and regenerate vulnerable ex-situ collections.

Several institutions cooperated in this task:

- Pioneer Hi-Bred Int. regenerated 300 accessions per year at Homestead from 1981 to 1987. The total number of accessions regenerated in this period was 1,985. Five hundred grams of these accessions were sent to NSSL and the rest to CIMMYT. Agronomic information was taken and published in two catalogs, which were distributed.
- A cooperative project involving USDA/ARS and North Carolina State University, coordinated by M. Goodman, regenerated national and international accessions held by national programs in Colombia, Mexico and Peru. The total number of accessions regenerated was 1,295 for Colombia, 1,714 for Mexico, and 1,676 for Peru. This regeneration took place from 1985 to 1992. Sample seeds of these accessions were sent to NC-7, Ames, and the rest of the seed was retained by each country.
- During the first and second stages of the LAMP project, regeneration took place in order to allow an evaluation of the materials. A total of 1,522 accessions were regenerated and seed samples were sent to NSSL.
- CIMMYT, USAID and USDA/ARS cooperated in a regeneration project involving 13 countries. During the period of 1991-1994 seed samples of 3,133 accessions were received. The plans are to regenerate over 7,000 Latin American landrace accessions.

In most of these regeneration projects seed samples are retained by each of the donor countries and duplicate samples are sent to CIMMYT and NSSL.

EVALUATION

Evaluation of maize global genetic resources is critical to determine which germplasm to use in the program. In order to do that, it is necessary to exchange landrace germplasm freely. It is important to exchange germplasm since there are many examples to demonstrate that foreign germplasm is better than native genetic resources.

In 1987 Pioneer Hi-Bred Int. recognizing that the preservation, documentation, distribution, evaluation and utilization of accessions in the different germplasm banks must be done through coordinated efforts among the different national and international organizations involved, provided $1.5 million to the U.S. Department of Agriculture (USDA), Agricultural Research Service (ARS) to carry out a 5 year maize evaluation project. This effort was named the Latin American Maize Project (LAMP). This project was the first coordinated international project to deal with the evaluation of genetic resources of a major world crop species. LAMP is based on the cooperative effort of 12 countries: Argentina, Bolivia, Brazil, Colombia, Chile, Guatemala, Mexico, Paraguay, Peru, United States, Uruguay, and Venezuela. The main objective of LAMP is to evaluate the agronomic characteristics of over 14,000 accessions found in Latin America and U.S. germplasm banks so they might then be used in breeding programs (Salhuana, 1991).

In planning LAMP (Salhuana, 1988, 1991) the varying responses of the accessions to different environmental conditions (primarily altitude and latitude) were recognized and five Homologous Areas (HA) were defined as:

HA 1	Below 1200 m. and below 26^0 N or S
HA 2	1200 to 1900 m. and below 26^0 N or S
HA 3	1900 to 2600 m. and below 26^0 N or S
HA 4	Above 2600 m. and below 26^0 N or S
HA 5	above 26^0 N or S

LAMP established a five-stage evaluation sequence. The first two stages were for reducing the number of accessions to a feasible number in order to cross them with testers to determine combining ability. In the second stage, 270 accessions were selected as follows: 100 tropical accessions were selected in HA 1, 78 temperate accessions in HA 5, and 89 in HA 2, 3 and 4. In the third stage, the selected materials were interchanged between countries in order to cross with the chosen tester. In stage 4, testcrosses, check hybrids, and varieties were planted in replicated trials in each of the homologous areas and data were recorded for 17 traits including yield. (Salhuana, 1995).

As a consequence of LAMP there now exists a more precise determination of the status of maize stored in germplasm banks in Latin America with respect to:

1) the number of accessions in each gene bank,
2) the quantity and quality of seed for each accession,
3) the identification of accessions that need regeneration,
4) the adaptability of the accessions and races to permit a more thorough and effective exchange of germplasm between regions.

The best topcrosses results for yield, averaged over locations, for HA 1 are in Table 1. Unfortunately, some of the accessions were not tested in all the countries due to insufficient seed or the difficulty of exchanging the germplasm. In some countries they used two testers with different heterotic pattern to identify which heterotic group the collection belongs to. In almost every country, the best yielding topcrosses are better than the checks, indicating the great yield potential that these accessions have in the country. Also, there are some of the accessions that combined well with several testers, so this can be used in a cooperative breeding program with the participation of the countries in which the accessions showed a good yield.

The best yielding topcrosses in each country for HA 5 are in Table 2. It is recognized that the best yields of the topcrosses for each tester are not superior to the hybrid B73 x Mo17. Of course, this is expected since the testers are not the lines involved in this hybrid. On the contrary, the testers are slightly related line hybrids, and the cross between these two hybrids (a double cross) cannot be better than B73 x Mo17. Even so, there are some topcrosses that yield similarly to this hybrid.

The performance of the topcrosses of the accessions in several countries HA 1 and HA 5 shows that it will be desirable to start a joint project in the enhancement of the selected accessions.

GERMPLASM ENHANCEMENT

Useful principles and methodologies for enhancing germplasm to improve its performance has been outlined by Eberhart et al. (1996).

Most of the LAMP germplasm is unadapted to exotic locations and requires enhancement in a long-term approach of conversion and selective adaptation by corn breeders at numerous environments throughout the major corn growing regions of the U.S. The total process is too large and long-term for public or private institutions to accomplish individually, so it will be more feasible if it is done as a joint effort between several cooperators. Throughout many years of investigations seed companies have developed inbred lines and hybrids that have demonstrated an increase in maize productivity. Possibly the most productive maize germplasm in the world is now found in these lines and hybrids. For the LAMP material to be more useful, it was important for the accessions to be crossed with commercial proprietary inbred lines.

An unprecedented public/private research effort to broaden the genetic diversity of U.S. corn hybrids using enhanced maize germplasm derived from selected LAMP accessions has been initiated as the U.S. Germplasm Enhancement Maize project (US-GEM) (Salhuana, 1994). This is a unique example of collaboration in which 19 public entities and 21 private seed companies are working together with the objectives of increasing the productivity and genetic diversity of maize grown in the U.S.

The companies have made crosses of the LAMP material with their proprietary inbred lines. Their collaboration was increased by providing in-kind support to allow the necessary replication, nurseries, winter nurseries, and environments for selective adaptation. The accessions have been crossed with proprietary inbred lines, and they have been crossed to a second inbred line of another company in order to develop 75% temperate material to give it higher yield potential, improve its agronomic characteristics, and give the added adaptability needed for further breeding. The breeding crosses with 50% and 75% temperate material were crossed to tester inbred lines and placed in yield tests in order to identify the breeding cross from which to start the final selection process.

The proposal for this new collaborative project named the International Maize Germplasm Enhancement Project (IMGEP) would build upon the Latin American Maize Project (LAMP) and the U.S. Germplasm Enhancement Project (US-GEM). The crosses will bring to the breeding programs of the participating countries, genes of yield and good agronomic characteristics. After a process of adaptation and conversion the material will be adapted to the environments of the participating countries. It is our vision that the IMGEP and the US-GEM projects work together. This will be beneficial to all countries due to the fact that the exchange of germplasm among countries will be facilitated.

Following are the goals for the cooperating countries:

1. In a cooperative effort, increase the country's productivity by using germplasm enhancement in crosses of selected LAMP accessions, tropical hybrids, and improved material from the participating countries.
2. Reducing the cost of using of chemical products to control disease, insect and weeds, plus the necessity to have better environmental control make finding germplasm that can help to solve these problems a priority.
3. There is a need for germplasm that has resistance to the different types of stress conditions existing in different parts of the world (heat and drought tolerance, aluminum toxicity, etc.).
4. The demand on the end users of corn, consequently the farmers, to find sources with better quality and industrial traits (protein, starch, oil, etc.).

Some Background on selected LAMP accessions and crosses with temperate inbred lines

The US-GEM project selected 23 tropical accessions originally from Brazil, Mexico, Cuba, Barbados, British Virgin Islands, Dominican Republic, Puerto Rico, St. Croix, Antigua, Guatemala, and Peru. It was permitted to utilize 7 tropical hybrids from DeKalb. Also, 27 accessions were selected from Argentina, Chile, Uruguay, and the U.S. These accessions were assigned in groups of 4 to the 21 companies to make the crosses with their temperate inbred lines. These materials were then assigned to different companies so that they could proceed with the crosses to a second inbred line to give the required adaptability, in order to proceed with the selection process.

Approaches

The heterotic pattern is a key factor in utilizing germplasm for breeding populations and to maximize population-cross performance. Breeders working in different countries within each homologous area are encouraged to use either a common or a similar superior heterotic pattern as a basis for choosing populations for improvement. Exchange of elite inbreds among breeding programs over time would result in an improvement of broad adaptability of commercial hybrids and would permit more effective population improvement with a minimum risk of loss of genetic variability from genetic drift because of small effective population sizes.

1. Select the crosses on the basis of yield trials.
2. Crosses with the best tropical material in the area will be chosen according to the adaptability and disease resistance.
3. Self, select, and produced testcrosses.
4. Yield trials through countries.
5. Select the best performance lines to be used in hybrids.

Anticipated Results

The exchange of germplasm and the joint effort in the selection will amplify the benefit to other sectors or regions of similar environmental conditions and will permit the selection of other characteristics besides yield that are important to the country.

Global Imperatives and the Role of the Private Industry

Private funds are more likely to be forthcoming for enhancement or pre-breeding of germplasm. The GEM project provides an example of collaborative activities to evaluate useful germplasm. Such activity provides an example where the public and private sectors can join together. Pre-breeding is neither too basic, risky, or long-term for the private sector to engage in, nor does it result in genotypes that are so far along in the process of research toward product development that there is a need for strong intellectual property protection. Consequently, germplasm is evaluated, enhanced, and made freely available; and it can even include some component of proprietary germplasm to help adapt the exotic component. The breeding community should seek to encourage more pre-breeding and enhancement of germplasm including participation by farmer-breeders, national breeding programs, and International Agricultural Research Centers (IARCS) along with input from the private sector.

No single organization, nation or region has the complete range and depth of the capacity required to optimally improve its agriculture. No variety has yet been bred that is perfect. Agriculture shows us a legacy of intercontinental exchanges of germplasm and mutual interdependence that stems back over several millennia. In the industrialized world, during the last three decades, plant breeding has played a significant role enabling the proportion of income that is spent on food to be cut in half. Yet most are unaware of this "food dividend" or simply take the benefits for granted. In order to meet the increasing demands for food and to protect the environment, we must recreate an appreciation of our mutual dependence upon agriculture and provide the investment and support that is due for the support of current and future generations.

REFERENCES

CIMMYT. 1988. Recent Advances in the Conservation and Utilization of Genetic Resources: Proceedings of the Global Maize Germplasm Workshop. Mexico, D. F.

Eberhart, S.A., W. Salhuana , R. Sevilla and S. Taba. 1995. Principles for tropical maize breeding. Maydica 40: 339-355

Salhuana, W. 1988. Seed increase and germplasm evaluation. In Recent Advances in the Conservation and utilization of Genetic Resources: Proceedings of the Global Maize Germplasm Workshop, pp 29-38. Mexico, D.F.: CIMMYT.

Salhuana, W., L. Pollak and D. Tiffany. 1994. Public/Private Collaboration Proposed to Strengthen Quality and Production of U.S. Corn through Maize Germplasm Enhancement. DIVERSITY 9: 77-78.

Salhuana, W., R. Sevilla (eds.). 1995. Latin American Maize Project (LAMP, Stage 4 results from homologous area 1 and 5. ARS Special Publication, Beltsville.

Salhuana, W. 1995. Latin American Maize Project Leaves Untapped Legacy of Agricultural Riches. DIVERSITY 11:6.

USDA. 1995. Agricultural Statistics 1994. National Agricultural Statistics Service. Bernan Lanham, Maryland.

TABLE 1.- Mean yield of the selected topcross for Homologous Area 1.

COUNTRY	BOLIVIA	BRASIL	BRASIL	COLOMBIA	GUATMALA	MEXICO	MEXICO	PARAGUAY	PARAGUAY	PERU	PERU	PERU	PERU	USA P.RIC	VENEZUELA	GRAN MEAN
TESTER	**SUWAN**	**BR105**	**BR106**	**ICA-V 258**	**HB-83 (m)**	**H-422**	**H-511**	**BR105**	**BR106**	**SUWAN**	**PM102 (m)**	**PM212 (m)**	**PM701 (m)**	**HC128 HC219**	**PB-8 (h)**	
ACCESSION:																
CHIS-740	3415	**7145**	6025	5121	3854			6026	4863	4522	5962			4012		**5095**
CHIS-775	**4735**	6893	6425	3169	4307	5273	5382	5525	7754	4427				4724	2987	**5133**
PAS -014		6734	6965			5297	4932	6142	7596		**6259**	3866	3780	5211	**4336**	**5556**
PE 01	3699	6786	**6994**	4465	5298	5582	5083	4669	**7598**	3740	5199	5199	5013	4559	3356	**5149**
PE 11	3709	6065	6664	**5189**	5534	5517	**5708**	5952	7102	4054	5771	5639	**5299**	4912	3856	**5398**
RDOM 150	3951	6120	5654	4409	3851	**5578**	5361	6122	5397	4066	6007	**5783**		**5428**	4240	**5141**
SE 33	3484	5969	6648	4627	**6005**	5175	5643	**6254**	5491	**5008**	4712	5226	4832			**5313**
TUXPENO 1	4518	5908	5779	2922	5121	5265	5122	4483	6502	3339	5803	3810	4085	4844	2518	**4668**
ACCE. MEAN	3946	6457	6355	4272	4830	5378	5273	5477	6680	4227	5559	5002	4735	4793	3549	**5102**
BEST CHECK:																
SUWAN-1	3371									**3736**				4067		
H-511						**5533**	**5346**									
HC128HC219	4916													**5221**		
PB-8(h)															**3957**	
PM-102											4871	**5402**	**5824**	3334		
PM-701											**5270**	4433	5181	4116		
BR-201		**6346**	**6153**													
HB-83	**5365**			**5492**	**4942**											
GUARV-312								**5716**	**7210**							

Table2.- Mean yield of the selected topcrosses of area homologous 5.

TESTER	PEDIGREE	ARGEN	RANK	CHILE	RA	URUG	RA	U.S.	RA	MEANS	RA
B73xB14A	**ARZM03056**	5455.5	22	12311.5	14	5736.5	6	5703.1	22	7301.7	15
B73xB14A	**ARZM16026**	5901.5	7	12483.8	11	4291.0	29	5931.0	15	7151.8	7
B73xB14A	**CHZM05 015**	5416.4	19	11080.3	56	4003.0	37	**6883.6**	3	6845.8	9
B73xB14A	**URZM10 001**	5285.0	21	**13060.5**	4	**6602.0**	1	6248.3	10	**7798.9**	8
B73xB14A	**URZM11 003**	5235.0	23	11505.0	38	4356.0	28	5224.0	58	6580.0	38
B73xB14A	**URZM13 010**	5911.1	8	11746.0	32	4661.0	21	5953.6	18	7067.9	10
B73xB14A	**URZM13 085**	5640.3	14	12182.5	20	2699.0	69	6501.6	7	6755.8	6
B73xB14A	**FS8-Bt**	**6201.1**	4	12764.3	5	3334.0	56	6433.5	9	7183.2	4
Checks:											
	B73xB14A	4052.0	73	10924.3	60	**3872.0**	47			6282.8	74
	OH43xMO17			9165.0	75	3349.0	55	5407.1	31	5973.7	65
	B73xMO17	**6747.1**	3	**16039.3**	2			**7176.6**	2	**9987.7**	3
LSD (0.05)		708.7		1276.8		2190.4		863.9			
Oh43xMo17	**ARZM03056**	4933.0	40	12262.0	11	**5172.5**	5	4149.5	75	6629.3	67
Oh43xMo17	**ARZM16026**	5798.0	10	12022.3	21	4328.0	14	5656.9	33	6951.3	19
Oh43xMo17	**CHZM05 015**	4979.4	32	11024.5	54	3321.5	47	6438.6	11	6441.0	31
Oh43xMo17	**URZM10 001**	5826.1	8	11828.5	28	4239.5	17	6581.8	8	7119.0	10
Oh43xMo17	**URZM11 003**	5750.4	12	**12969.3**	4			6458.4	10	**8392.7**	9
Oh43xMo17	**URZM13 010**	4328.8	65	11296.8	50	4452.5	12	5392.4	44	6367.6	66
Oh43xMo17	**URZM13 085**	5848.5	6	12133.3	13	3101.5	54	**6822.0**	5	6976.3	6
Oh43xMo17	**FS8-Bt**	**6095.3**	5	12875.3	6	3495.0	41	6080.1	15	7136.4	8
Checks:											
	B73xB14A	3185.5	74	11484.8	40	**4492.0**	11			6387.4	84
	OH43xMO17	4384.8	66	11402.5	42	3458.0	43	5702.0	27	6236.8	58
	B73xMO17	**6701.0**	2	**16339.5**	2			**7316.4**	3	**10119.0**	5
LSD (0.05)		768.7		1204.0		2235.1		958.7			

SUMMARY AND RECOMMENDATIONS

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EXPECTATIONS

Diverse germplasm is essential for highly successful research and breeding activities. The genetic diversity of materials needs to be sustained to minimize the vulnerability inherent in the growing of uniform and closely related materials over wide areas. In order to increase the diversity of maize source materials, the LAMP project was conducted with the objective of evaluating maize landrace collections in order to select the best germplasm so that breeders might utilize the elite collections in their breeding programs.

To accomplish this objective, several accessions were selected from each participating country for exchange among countries. This allowed us to observe the behavior of the accessions when placed in an alien environment. This has increased the possibilities of easily interchanging these materials in the future. This project established the number of accessions that each country possessed, the amount and quality of the seed, the list of the accessions that needed to be regenerated, the description of the geographical location where each accession was collected, and the range of adaptability of the accessions and races.

In order to do research with maize genetic resources, it is necessary to have a good number of viable seeds; hence, the regeneration activity is very important. Fortunately, the regeneration in maize accessions was done by the private and public sector through the initiation of projects involving Latin American countries. A joint effort is desirable in any activity involving the genetic resource, especially in regeneration in which more than one geographic area of adaptability is necessary for success.

Undoubtedly, the most important aspect of genetic resources is the utilization of the material, and this cannot be done if there is no evaluation and enhancement of the materials. Most of the LAMP germplasm is unadapted to exotic locations and requires enhancement in a long-term approach of conversion and selecting for adaptation by corn breeders in numerous environments. The total process is too large and long-term for public or private institutions to accomplish individually, so it will be more convenient if it is done as a joint effort between several cooperators. Throughout many years of investigations, seed companies have developed inbred lines and hybrids that have demonstrated an increase in maize productivity. Possibly the most productive maize germplasm in the world is now found in these lines and hybrids. For the LAMP material to be more useful, it was important for the accessions to be crossed with commercial proprietary inbred lines.

The cooperation of the public/private breeding sectors of each country and international institutes is necessary, because there is no one institution that can do all of the activities necessary in working with the genetic resource. One example of this collaboration is the GEM project that has the collaboration of the public and private sector. It is necessary to extend this benefit internationally so all the participating countries have the benefit of better germplasm. It is important that all plant genetic resource workers become full partners in plant breeding teams.

If we work together we can obtain germplasm that will be have better adaptability with yield and other characteristics like tolerance to biotic and abiotic stress, and have better value added traits that will be increase the merit in food for human and animals. Also, there is a high probability that the projects will identify new unique characteristics that can benefit the breeding program.

COUNTRY CONTRIBUTIONS

A great part of LAMP's success is due to the Principal Investigators and administrators of each of the participating countries. Their ideas, enthusiasm, support, and excellent work resulted in achievements that are going to be beneficial to each participating country and to the world community.

In the final reports of each country, a common denominator was that LAMP permitted the identification of new germplasm equal to or better than the materials that were being used in each of the countries. The exchange of germplasm between countries was beneficial, because it permitted the identification of superior foreign germplasm that was not looked at before.

Germplasm enhancement was started in each country using different breeding methodologies with native material and in some cases with foreign germplasm. In the USA, this activity was initiated with the collaboration of private and public institutions, in which breeding crosses were formed between accessions and proprietary inbred lines of the companies. This initiated a process of selection in populations having 50% or 25% exotic germplasm. It is desirable that this type of project be extended to other countries with the benefit of having very productive breeding populations.

The adaptability test permits us to identify the movement of germplasm through several environmental conditions. In the case of HA 5, the latitude boundary needed to be readjusted in order to exchange the germplasm.

The identification of germplasm resistant to certain pests and the determination of value added traits for the breeding crosses (accession/line) have merit.

USE OF BIOTECHNOLOGY

New capabilities to introduce very exotic genetics are becoming increasingly available from biotechnology. For example, European corn borer resistance genes from the bacterium *Bacillus thuringiensis* have been introduced into crop plants. Transformation technologies now make it easier to transfer genes for insect resistance from a bacterium into maize. Transformation technologies also make it much easier to transfer genes into maize from other genera than it is to transfer useful genetics from teosinte, which appears to be the closest wild relative of maize, through crossing and repeated backcrossing. Conventional procedures impose 3-7 years of additional time and effort to segregate and recombine genes and break up linkage blocks that would otherwise render the genotype poorly adapted to agriculture. It is critical to realize that the most important traits in agriculture are controlled by groups of genes, which by themselves have a small effect. For the foreseeable future, the most useful genetic diversity will be found in the crop species itself. Advances in biotechnology can help to more effectively source and utilize this diversity.

Biotechnology can contribute in at least two broad areas in plant breeding. Genetic markers can identify important genes or chromosome regions and genetic transformation can move potentially useful exotic genes into inbred lines.

SOCIAL AND ECONOMIC IMPACT OF LAMP

The importance of Genetic Resources will be easier to demonstrate when economic payoffs ensue from safeguarding those resources, which are the product of several thousands of years of evolution and human experimentation. This is very difficult to demonstrate since precise information about the use of genetic resources does not exist. We can cite some examples of the use of maize genetic resources. Around 20-30 broadly based improved synthetic populations are widely dispersed around the tropics and increasingly contribute to production as varieties or as parents of inbreds. Thailand developed a very well-distributed population Suwan-1. Colombia formed the widely used ETO synthetic. Other important varieties that are used in the tropics are Tuxpeño, Ecuador 573, and Coastal Tropical Flint and Dent. The economic impact that these varieties have in the different countries has been difficult to measure.

In the USA, the effective utilization of new germplasm is more challenging due to existing high levels of yield and the different environmental conditions that exotic corn is not adapted to, especially due to photoperiod effect. However, there are some examples that can be mentioned. Goodman made excellent progress in adapting tropical maize to grow in the southern area of the USA. Salhuana developed many inbred lines adapted to the southern USA and one particularly adapted to Iowa from one tropical population, which are now being used in breeding programs. In the decade study of Duvick (personnel communication) the number of landraces utilized in the five most important inbreds are incremented from

5 in 1930 and 1940, 9 in 1950, 11 in 1960 and 1970, 23 in 1980, and 27 in 1990. There are several examples of utilization of landraces in disease and insect resistance. Also there are good efforts between EMBRAPA (Empresa Brasileira de Pesquisa Agropecuaria) and CIMMYT to develop maize varieties and hybrids tolerant to soils containing toxic levels of aluminum.

Biological realities mean that unevaluated and unadapted exotic germplasm will usually have little to no economic worth to a plant breeder or farmer, and that any programs to store and utilize exotic germplasm will have to compete for resources with other long term and more basic research programs. Many breeders will simply not have the resources to devote to such long term and high-risk programs of research and product development. Given the long term and high-risk nature of working with exotic germplasm, it is extremely difficult to put economic values upon exotic accessions. However, our long term survival together with that of the environment in which we live is critically dependent upon successfully sourcing and utilizing useful genetic diversity.

The success of the LAMP project was founded upon the cooperative efforts of the Principal Investigators who believed that it was necessary to collaborate with strategies focused on success without being daunted by the limitations that would inevitably occur. The results of the LAMP project demonstrated that it is imperative to exchange germplasm among countries without restrictions since experiences from several countries have shown that the best germplasm is often derived from foreign accessions. The utilization of the selected germplasm for the tropics, temperate and highland areas will bring to the region the increase in yield and other agronomic characteristics for which they were selected, with the consequence to have a higher quality supply for human and animal consumption.

Another more extensive cooperative project is the GEM in which private industry is participating by contributing the proprietary inbred lines in crosses with the best LAMP accessions as well as with in kind support helping with nursery rows, yield test plots, and isolation rows. The alliance among countries and with the collaboration of private industry will help ensure success of present and future projects in genetic resources, especially in this period of time in which financial resources are scarce because genetic resource activities must compete for funds from other investments that can yield more immediate, but less long-term benefits. Collaboration helps additional important traits to be identified in exotic germplasm since some cooperators have the facilities and expertise that others do not have.

CHALLENGES AND FUTURE TASKS

The immediate challenges must therefore be:

1) To securely conserve genetic diversity
2) To characterize genetic diversity
3) To more completely evaluate genetic diversity in pre-breeding and enhancement programs
4) To provide resources to accomplish these tasks
5) To develop and apply new biotechnologies to improve the effectiveness of germplasm conservation, evaluation, and utilization
6) To continue to improve the efficiency of agriculture and its degree of harmony with the environment by successful plant breeding

Perhaps the major challenges will be to accomplish the tasks relating to conservation, evaluation, and germplasm enhancement of exotic germplasm in a world where immediate needs for improvement are needed in agricultural production and where restraints upon funding are present. Heated debates are occurring concerning equities and responsibilities among nations in a world that is increasingly globalized, but fractured economically and technologically. To do this difficult task it is necessary to have joint efforts that allow more complete evaluation, and enhancement of germplasm. Otherwise, the germplasm will languish unused and without prospects of benefits to be derived to anyone be they breeders, farmers, or consumers; and it is to consumers that the most benefits of improved agricultural productivity flow. We must strive by working within the FAO, the Convention on Biodiversity, within national governments, and within private industry to ensure that funds are provided and programs can be developed including both the public and private sectors, nationally and internationally, that will enable increased access, evaluation and effective source of a broader base of germplasm. Plant breeding programs will then be in a better position to serve the needs of agriculture and the environment. There are roles for every participant to play.

CONCLUSIONS

Gene banks are established in different countries with limited funds. A great amount of support is dedicated to preserving germplasm without the associated funding needed to conduct evaluation and enhancement. This is an unsatisfactory condition since germplasm is not being optimally utilized if it is only being preserved. However, this situation is true for national and international programs in most regions of the world. The global financial support for conservation, and evaluation of genetic resources is insufficient and appears to be coming more restricted each year. Although national budgets are shrinking to cut budget deficits, the priority placed by governments on funding the conservation, evaluation and preliminary enhancement of genetic resources for food and agriculture should increase. These activities cannot be funded for the most part by the private sector, and the long-term public good of conservation establishes this endeavor as a prime function of providing national security that must be funded by the government. It becomes indispensable to work together among nations and among the private and public sectors in the different aspects of genetic resource activities, especially in evaluation and enhancement. To complete these tasks, it is necessary to exchange germplasm among countries. We strongly believe that success will come through cooperation of participating countries. It is therefore imperative that conditions of access and benefit sharing that are emerging at the FAO and under the aegis of the Convention on Biodiversity take into account the benefits that accrue from access and exchange of germplasm and the realities that are associated with sourcing and utilizing exotic genetic diversity for food and agriculture.

Plant breeders will need to effectively look for new germplasm diversity in order to remain competitive within their industry. Strong intellectual property protection has been criticized by some as leading to a reduction in genetic diversity. Utility patents place protected inbred lines and hybrid varieties into the public domain after 20 years. This period may sound long but in breeding terms it is not. Twenty years represent about two cycles of elite breeding and less than one cycle of breeding using exotic germplasm. Consequently, once protection from Patents and Utility Patents has expired breeders will be faced with direct competition from germplasm that was once in their proprietary domain. If breeders are not already prepared with new more productive genetic diversity then they will be heading for a significant loss of demand for their products. For privately funded breeding organizations, the results of being unprepared with new more productive genotypes would be reduced market share, reduced income, drop in share-value, loss of jobs, with potential buy out or bankruptcy looming on the horizon.

However, despite the clear needs for successful breeding organizations to maintain a source of useful new genetic diversity, the practical realities of obtaining and allocating funding are likely to result in shortfalls of private investment and effort into basic programs that otherwise could have helped to deliver useful germplasm for the long-term. It is imperative to provide for these shortfalls. The conservation of genetic resources for food and agriculture is an activity that for the most part must be funded by the government.

Private investors will not provide significant funds for conservation of plant germplasm for future plant breeding because the time-frame for receiving returns on investment are not only extremely long, they are very tenuous and uncertain. But private funds can be used for a collaborative enhancement research where the public and private sectors can join together. Pre-breeding results in genotypes that are far along in the process of research but still require a process of breeding in order to be utilized in a commercial product.

In general, there is not one institution in the world that can do the regeneration, evaluation, and enhancement alone. Any of these activities need to have the collaboration of several institutions to be successful. The goal in executing these activities is to have germplasm that can increase the productivity in each country and also solve the demands that each country has in productivity, quality of the grain, or to solve biotic or abiotic problems.