AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D. C. 20523

BIBLIOGRAPHIC INPUT SHEET

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Batch 77

1. SUBJECT CLASSIFICATION

A. PRIMARY
Serials — Y-AF00-0120-0000

B. SECONDARY
Food production and nutrition--Plant production--Cereals--Maize

2. TITLE AND SUBTITLE
CIMMYT annual report on maize improvement, 1975

3. AUTHOR(S)
(101) CIMMYT

4. DOCUMENT DATE
1977

5. NUMBER OF PAGES
~~68p.~~ 72p.

6. ARC NUMBER
ARC

7. REFERENCE ORGANIZATION NAME AND ADDRESS
CIMMYT

8. SUPPLEMENTARY NOTES (Sponsoring Organization, Publishers, Availability)
(Research summary)

9. ABSTRACT

10. CONTROL NUMBER
PN-AAF-186

11. PRICE OF DOCUMENT

12. DESCRIPTORS
Maize

13. PROJECT NUMBER

14. CONTRACT NUMBER
AID/ta-G-1083 GTS

15. TYPE OF DOCUMENT

AID 590-1 (4-74)

CIMMYT REPORT ON MAIZE IMPROVEMENT 1975

CIMMYT
75
MAIZE

Correct citation: CIMMYT Report On Maize Improvement: 1975, Centro Internacional de Mejoramiento de Maíz y Trigo, 1974. El Batan, Mexico. The CIMMYT Report On Maize Improvement is published annually in English and Spanish, copies are available upon request.

CIMMYT: The International Maize and Wheat Improvement Center (CIMMYT) receives major financial support from government agencies of Canada, Denmark, Federal Republic of Germany, United Kingdom, and United States of America and from several international or private institutions: Ford Foundation, International Bank for Reconstruction and Development, Inter-American Development Bank, International Development Research Centre, The Rockefeller Foundation, United Nations Environmental Programme, and the United Nations Development Programme. Responsibility for this publication rests solely with CIMMYT.

CIMMYT Report On Maize Improvement: 1975

A Report on the Maize Improvement Program
of the International Maize and Wheat Improvement Center
El Batan, Mexico

CENTRO INTERNACIONAL DE MEJORAMIENTO DE MAIZ Y TRIGO 1977
International Maize and Wheat Improvement Center
Apdo Postal 6-641, Mexico 6, D.F. Mexico

AWB-667

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1.0 Introduction

Scientists in 45 countries throughout the world now participate directly in CIMMYT's international maize progeny, experimental variety and elite experimental variety trials. And, in 1975, CIMMYT staff visited over 40 of these nations in maize improvement roles designed to encourage further systematic testing — as field level counselors, helping with the management and analysis of trials, and in liason between agencies and countries.

Field reports from these visits around the world show a remarkable similarity in some observations. Many countries, for example, have now developed advanced technology and materials sufficient to meet immediate maize requirements. But a host of barriers remain — and in the recounting of these problems, the field reports form a sort of "composite" of viewpoints from the developing countries.

In the paragraphs below, we have merged many of these observations into a single hypothetical critique. We intend it as more than an exercise —with the hope that dedicated scientists around the globe can make a concentrated and systematic examination of these common restraints to maize production.

CIMMYT does not presume to have the answers for such questions; however, the success of our continuing work with national maize improvement programs often hinges on the development of effective strategies to meet these challenges.

In spite of recent record cereal crop production, _____ remains a food grain importing country.

Average yield per acre in_____ is low — about equal to most countries that consider themselves part of the Third World. There has been no real change in yield per acre for about 6-8 years.

It is safe to assume that there are 30 to 40 percent more people to feed in_____ than there were 10 years ago. Increasing the area under production has increased total national production, but there can be very little, if any, further increase in the area of production.

What, then, will be the food situation in_____ , 10 years hence? On the basis of the past 10 years history, the future looks grim.

Does _____ have the potential to greatly increase food grain production? The answer has to be yes absolutely. _____ has the farmers, the resources, and the technology to double food grain production on the acreage now used for that purpose.

If_____ has this production potential, then what are the constraints? Why has production not gone up? In our view, the current system will defy all efforts to increase production. There is a real need to stop and look at this system; to look at what has happened — more important, what has not happened.

As an example, a floor price was set for maize, and the government said the maize price would not fall below that price. Yet, the prevailing market price is below the floor price and there are large stocks of maize from the last crop still with the farmers. They cannot move the surplus. Where are the agencies that are to procure these crops? Obviously, present agencies are not adequately equipped, or motivated, or both, to meet the country's grain marketing needs.

It is examples like this that turn the farmer off. He cannot — will not — invest or take higher risks when he cannot depend on a reliable price and the profitable removal of his crop at harvest.

Associated with the good crops and inadequate markets is complacency on the part of the non-agricultural sector of the society. Let there be a food shortage and again food production will become a crisis issue in the eyes of the non-agriculturists.

Can the policy makers not see that there must be a steady, progressive, and continuous policy that will encourage production in every way? Only if there is such a policy can the nation expect to lift and sustain itself above the burdening food import status.

What are some of the factors that might be taken into consideration? Marketing and storage are totally inadequate to handle the needs of that part of the society that are not food producers. Further, if production were to double, as it certainly could, there would have to be a mechanism to handle millions of tons more grain than is marketed today. What agency is capable of this task? Is any such agency in existence? It seems doubtful that the private sector will come forward with the investment necessary to deal in these large quantities.

In fact, if the marketing is to be done by the government, then it can be successful only if put into the hands of a marketing company with the talents and freedom to operate. Traditional government agencies can never be successful marketing units if operated through traditional government systems.

Now, without surpluses, what would a marketing company market? By the same token, without a market to take in and absorb production, we cannot expect production to greatly increase. The greatest market expanding factor is freedom to export. Exportation of food grains requires facilities and efficient management.

Extension of Technology

We have noted that _____ has the technology to double agricultural production. This is a correct statement; however, there is a tremendous task of transferring that technology – getting it used.

Let's look at extension. In reality, it is fair to say that there is no extension service in _____. What the "extension service" really does is to act as a marketing agent for government commodities such as fertilizer, insecticides, sprayers, etc. They are not people who have the time or the skills to do true extension work. The functions they perform are important, but they are not extending technology; this fact should be recognized and accepted.

One very capable production agronomist in each district, with mobility and freedom to operate, could be a far more effective agent of change (the extension role) than the dozens of people at the district level on the "extension payroll." The agronomist would also be less costly.

Development of Technology

If _____ has the technology to double production, should the government then continue to support agricultural research? Yes and no. If the government does not take the necessary steps to assure that the present technology is put into use, then developing new or more technology has only prestige or "snob" value to the country. If the necessary changes are made to implement the technology available, then it is urgent that agricultural research continue to be supported.

It seems only logical that there is also a need to rethink what agricultural research is all about. There is a need to put a brake on wasteful operations and greatly accelerate others.

Some of the factors limiting the quality of agricultural research are: quality of the staff, quality of the experimental stations, and limitations of mobility of staff for moving out and conducting much of the needed research at the farm level.

Administration Effects

All functions of agriculture at the government level are handled in the traditional civil service system. Yet this system is too slow and cumbersome to deal with the needs of agriculture. If agricultural research and related functions are to reach a degree of efficiency that the country needs, then revolutionary changes will have to be made in the administrative system.

Another stifling situation is the system of promotion. As long as the seniority system operates, it is difficult to put the best person on the job. Promotion should be based on the quality of work that a person does and the impact that this work can have on production.

Further, there should be a system where a person can be promoted without changing crops emphasis. In other words, the present system of promotion that forces a person to move from Assistant Botanist Wheat to Botanist Millets, for example, greatly lessens the possibility of any stability or continuity in the system.

The whole system of employment and promotion must be changed if it is to capitalize on the talents of its agricultural research and production personnel.

Summary

_____ has the potential to double food crop production on existing lands. The technology is available, but the overall system greatly hinders the implementation of the production technology.

Many agencies supposedly are operating to service agricultural production. Few, if any, are efficient; most are quite ineffective. Many of these agencies have been overhauled constantly over the years. Yet in 1976 they still do not work.

Is it not time for_____ to stop, look, think, and reorganize the total agricultural research, production and marketing system into an effective operation with freedom for invention and imagination to work?

In the following pages, the findings reported from collaborating maize programs reflect a steady advance in the technological aspects of production. Perhaps our most crucial future task will be shoulder-to-shoulder work with national program colleagues as they assess their overall agricultural production systems and design faster delivery mechanisms to put proven technology to work in farmers' fields.

2.0 Overview of Maize Improvement Process

CIMMYT's maize improvement work stresses varieties and practices that can be used in farmers' fields in the newly developing countries -- such fields comprise most of the world's maize area; and their yields are generally the lowest.

We have described the system that carries the flow of materials from the germplasm bank and introductions: through the "funnel" of development and testing, to the naming of elite varieties and use by national programs in demonstration trials and release as new varieties. (See 1973 Maize Improvement Report). This maize improvement concept is now delivering progeny, experimental variety, and elite variety trials to national maize programs throughout the world. A brief resume of this process is shown in the Appendix (page 63). In cooperating with these programs, the aim is to develop appropriate technology as a joint venture -- so that the new varieties or practices are tested as an integral part of the process of development and delivery to the countries.

CIMMYT's maize improvement operations are built around two closely related concepts: (1) developing improved technology and (2) delivering the technology at the farm level in many countries. Our research program cooperates directly with national programs providing practical in-service training for their young scientists, at CIMMYT. We now work with scores of national programs: (1) with formally constituted programs involving public agencies such as ministries of agriculture, universities, and other organizations; (2) with private interests, such as seed companies, with independent groups or associations; and (3) with groups that have no formal designation. Our training stresses on-the-farm experience, with instruction and use of improved practices under conditions that are found in the trainees' home countries.

As noted, CIMMYT scientists try to look at the development of improved varieties through the eyes of the farmer-producer, anticipating the risks and potential benefits as the farmer sees them in making his crop planting decisions. The variety development program at CIMMYT attempts to provide the range of maturities, grain types, textures, and colors, that are needed to meet both the highland and lowland ecological conditions of tropical areas of the world. A constant stream of germplasm flows into the basic complexes from the CIMMYT germplasm bank, as well as from other bank resources, national programs, and wherever other sources of valuable traits may be identified.

For convenience in the general management of the maize improvement process, the operations of the maize program have been divided into several stages, with the two major divisions calle the Back-up Unit and the Advanced Unit. The Back-up Unit involves new introductions, testing of combinations, and building population complexes. The Advanced Unit is primarily the delivery vehicle into national programs; the materials are much more homogeneous and thus nearer commercial use. Simultaneous progeny evaluation at several sites provides a great deal of information in the gradual improvement of populations, so that the testing of varieties is an intrinsic part of the development process. Immediate multiplication of materials can be done at any stage of development, with knowledge of the performance accumulated during the selection of the progenies over previous cycles.

3.0 Advanced Unit Operations: 1975

3.1 INTERNATIONAL TESTING AND DISTRIBUTION - 1975

International testing and distribution of the maize materials in CIMMYT's program involves three closely linked steps: (1) tests to identify populations or varieties most suitable for a given location; (2) progeny trials of the identified varieties, and (3) recombination of superior progenies to form the experimental varieties (decided upon in collaboration with local programs that would use the variety for production).

Population Numbers

Advanced materials have been assigned population numbers 21 through 48, inclusive. (Numbers 1 through 20 are reserved for experimental variety trials, bank entry evaluations, etc.) Progenies are being generated in Mexico during the winter (December-April) and grown in progeny trials during the summer season, so that one cycle of selection is completed each year. (A small number of materials probably will be handled in alternate season of the year to provide the same service to locations on the other side of the equator).

High Quality Protein Conversion

Each advance population is simultaneously converted to its opaque-2 equivalent during the above process. A few rows of an opaque counterpart are planted adjacent to each advanced population: to be backcrossed to the parent population during the progeny generating cycle. These crosses are sib-mated during the progeny trial period in the summer, and the opaque-2 segregate kernels again planted adjacent to the recurrent parent for the next backcross.

Companion Nurseries

In the Companion Nurseries, at the CIMMYT sites in Mexico, two replications are devoted to yield comparisons, and one replication each to diseases, insects, and agronomy high density plantings. When possible, all the materials are artificially inoculated with leaf diseases, stalk rots, and ear rots -- as well as infested with insects. Thus, the related supporting disciplines are involved in the routine of developing the improved populations as an integral part of the program.

Elite Experimental Varieties

As the experimental varieties are developed, they will be involved in another level of evaluation to form Elite Experimental Varieties (ELV). These ELV's will be evaluated for the first time in 1976. Such testing provides for more precise comparisons of experimental varieties themselves, and also provides a means for the identification of the most suitable materials for individual sites. The ELV's can be identified -- for use as commercial varieties at specific sites and for further study of their dependability of production over ranges of varied environments. As the ELV's are identified, immediate on-farm trials are made to assess production potential.

The progeny and varietal testings are conducted in conjunction with regional and national programs at cooperating sites. Such programs thus get a detailed look at each set of progenies and have available a series of alternatives for utilization of the germplasm represented. Reserve seed is maintained in order to permit several options as a follow-up.

3.1.1 EXPERIMENTAL VARIETY TRIALS: 1975 FINDINGS

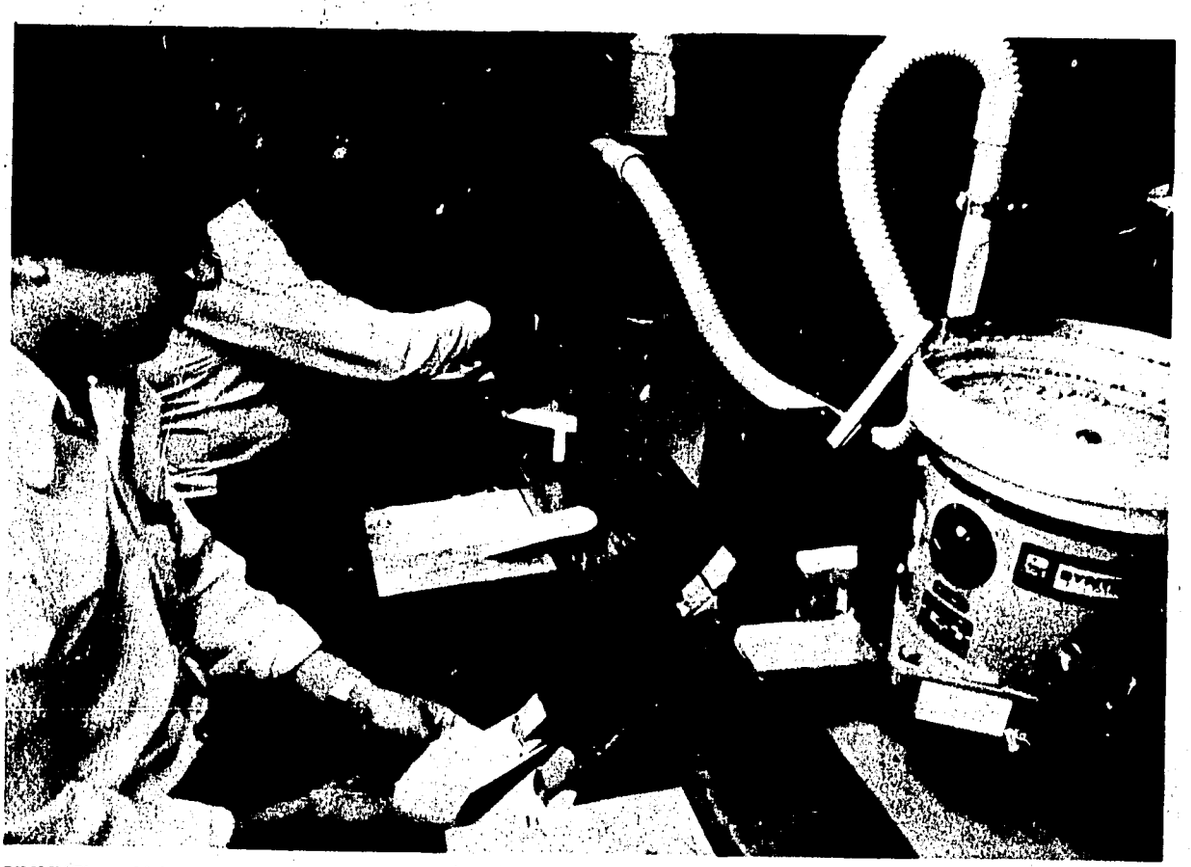
Based on evaluations of the 28 advanced populations in the 1974 IPTT's, 93 experimental varieties were formed for use in 1975. Reports were received from 154 different world-wide locations by the cutoff date (December 15, 1974), so that these 93 varieties could be assembled and distributed in 1975, as EVT's No. 11 through 17 (Table 3.1.1). Results arriving later (by July 1, 1975) provided a basis for 48 additional experimental varieties.

CIMMYT published the preliminary results of the 1975 trials in December, 1975 -- permitting the national programs and CIMMYT to better plan their 1976 testing. Data were received from about one-third of the experimental variety trials. Delay in reporting of some trials is expected due to differences in planting dates in different climatic zones, abnormal weather, and occasional shipping problems. Trials which produce delayed results are still highly useful, enabling each collaborator to relate his local observation to the world data (Trial reports listed in Section 10). Because of seed limitations, plot size had to be reduced to two, 5-meter rows (instead of four, 5-meter rows). The

TABLE 3.1.1. CIMMYT'S INTERNATIONAL MAIZE TESTING PROGRAM, 1975
DISTRIBUTION OF EVT

TRIAL No.	GROUP OF EXPERIMENTAL VARIETIES	SOUTH AMERICA						CENTRAL AMERICA								CARIBBEAN				MEXICO						AFRICA												ASIA												EUROPE		TOTAL
		BRAZIL	PARAGUAY	CHILE	COLOMBIA	ECUADOR	PERU	BELIZE	COSTA RICA	EL SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	PANAMA	HAITI	JAMAICA	DOM. REPUBLIC	GUADELOUPE	MARTINIQUE	PUERTO RICO	TRINIDAD	TLAXCALANA	TLALCO	MEXICO	ALGERIA	EGYPT	ETHIOPIA	GHANA	IVORY COAST	KENYA	MALAGASY REPUBLIC	MALAWI	REP. CENTRAFR.	SOUTH AFRICA	TANZANIA	ZAMBIA	BANGLADESH	INDIA	INDONESIA	IRAN	KOREA REP.	NEPAL	PAKISTAN	PHILIPPINES	SOUTH VIETNAM	THAILAND	TURKEY	YEMEN A.R.	HUNGARY	YUGOSLAVIA	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	
11	EXPT. VAR. REPEAT TR.I 1974	2		3			1			3																	1	1		3	1	1					1				1	2										20
12	TLWD	2	1		1		1		2	1	1	1	1		1	1	1		1	1	1		1		1	1		1	1	1		1		1		1	1																25
13	TLYD - TLYF	2	1		1	1	1		1	1	1	1	1	1	2	1	1	1		1	1		1													1		1								1						24
14	TIYF - TIWF - TIWD	2	1		1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1				1		1		1	1					1	1	1	1	1	1	2	1	1			1					36
15	OPAQUE 2	2	1		1				1	1	1	1	1	1	1	1	1	1		1	1	1				1		1	1		1			1	1		1			1	1	1			1						27
16	TEMPERATE	1	2	1	1	1	1				1							1	1		1	1	1	1	1	1				1					1	1	1	2		1		3	2		1		2		1	1	32
17	HIGHLAND	1	2	1		1	1	1			1	1									1			1	2		1		1						1																	15
	TOTAL:	2	4	6	1	9	4	5	2	1	4	8	6	4	4	4	4	4	3	5	4	5	2	5	1	4	1	3	4	4	3	3	1	1	6	4	2	5	1	2	1	7	4	3	2	3	2	1	1	1		380

TLWD: TROPICAL LATE WHITE DENT.
TLYD: TROPICAL LATE YELLOW DENT.
TLYF: TROPICAL LATE YELLOW FLINT.
TIYF: TROPICAL INTERMEDIATE YELLOW FLINT.
TIWF: TROPICAL INTERMEDIATE WHITE FLINT.
TIWD: TROPICAL INTERMEDIATE WHITE DENT.



CIMMYT's seed laboratory prepared over 80,000 seed envelopes in 1975.

border effects would probably have been reduced greatly by harvest of the two center rows in the larger plot.

3.1.1.1 EVT-11 General Variety Trial (Table 3.1.2)

The varietal cross ETO x Tuxpeño was one of the top yielders across all sites. This material was shorter than all local checks, except the Brachitic-2 included in Ivory Coast. Although poor yields were obtained with Entry 21 (Antigua x Rep. Dominicana), this is a short, early variety and competition could have masked its good yield potential. In the Lomé (Togo) trial, this variety showed good yield performance, not significantly different from the best yielding variety.

3.1.1.2 EVT-12 Tropical Late White Dent Experimental Varieties (Table 3.1.3)

Entry 4 (Exp. Var. Máquina 7422) shows consistent good yields across all locations, except in Tlaltizapan (Mexico), and Cuyuta (Guatemala), where it drops to a level not statistically different from the poorest yielder at these locations. Similarly, Entry 5 (Exp. Var. Poza Rica 7422) does not differ significantly from the best yielders, across all locations. Entry 7: Honduras 7322, Entry 8: Obregón 7322, Entry 9: Tlaltizapan 7322, and Entry 10: Across 7322, were also good yielders in most locations (Except Entry 10 in Nyakpala, Ghana, where it was not statistically different from the poorest yielding variety). These varieties, in most cases, are shorter than the mean of the varieties in each location.

Table 3.1.3 shows that poorest yields generally were obtained by Entry 32 (Braquíticos and Entry 35 (AED x Tuxpeño), and experimental varieties derived from these populations. These Braquíticos are short varieties, and were in unfair competition when grown next to taller varieties. AED x Tuxpeño)a cross of temperate x tropical germplasm) yielded poorly as a result of poor adaptation to tropical condition (where most of the trials were planted).

3.1.1.3 EVT-13 Tropical Late Yellow Flint/Dent Experimental Varieties (Table 3.1.4)

Entry 8 (Tocumen 7428), Entry 9 (Yousafwalla 7428), Entry 10 (Poza Rica 7428) and Entry 14 (Obregon 7328), showed consistently high yields across sites; except Yousafwalla 7428, in Bodles (Jamaica), and Palmira (Colombia), where it was relatively low in yield and did not differ statistically from the lowest yielding variety, Entry 4 (Yousafwalla 7427). As in EVT-12, all of these experimental varieties had consistently higher yields than the local adapted checks. These higher yields were not associated with an increase in plant height and days to silk. In Cuyuta (Guatemala), Guaymas (Honduras), Palmira (Colombia), Delhi (India), Tlaltizapan and Poza Rica (México), local-check yields did not differ statistically from the poorest yielding experimental variety. However, in San Cristóbal (Rep. Dominicana), San Andrés (El Salvador), and Bodles (Jamaica), local checks had higher yields than the best performing experimental varieties.

Experimental variety gains can be found by comparing their yields with those of the parent population from which the varieties were derived. Most of the parent populations consistently show yield levels statistically different from their experimental varieties.

3.1.1.4 EVT-14 Tropical Intermediate Yellow/White Flint/Dent Experimental Varieties(Table 3.1.5)

The best performing experimental varieties were: Entry 13 (Yousafwalla 7435), Entry 14 (Poza Rica), and Entry 21 (ETO x Tuxpeño). The poorest varieties across locations were Entry 20 (ETO Blanco), Entry 22 (Antigua x Rep. Dominicana), and Entry 23 (Blanco Pfister x Varios). In most cases, the best experimental varieties were shorter than the best local check, except in Palmira (Colombia), and Cuyuta (Guatemala).

3.1.1.5 EVT-15 Opaque-2 Experimental Varieties (Table 3.1.6)

These data discussed in Section 3.5.

3.1.1.6 EVT-16 Temperate Experimental Varieties (Table 3.1.7)

The most widely adapted, high yielding experimental varieties were: Entry 10 (Pirsabak 7442, Entry 11 (Obregón 7442), Entry 13 (Obregon 7446) and Entry 14 (Tlaltizapan 7446). Entries 10, 11 and 14, in general, were similar in height to the best local checks. In Portoviejo (Ecuador), Gemiza (Egypt) and Tlaltizapan (México), the four best performing experimental varieties were shorter than the local checks.

Poorest performance was shown by Entry 19 (Pirsabak 7448), Entry 20 (Obregón 7448), and Entry 35, its base population, Compuesto de Hungary. The effect of selection from this base population in this material is demonstrated by Entry 18 (Adapazari 7448), which was a better yielder than the others.

3.1.1.7 EVT-17 Highland Experimental Varieties

Tests were made at 2 locations in Mexico. The best yielding materials were Entry 9 and Entry 10 (Highland Intermediate White Floury);(Pools 8A and 8B respectively); Entry 2 (Highland Early White Dent); and Entry 8 (Highland Intermediate White Dent). The poorest yielder in both locations was Entry 16 (Mezcla Amarilla x Lineas Illinois), a cross of tropical x temperate germplasms.

Table 3.1.3
(Cuadro)

Year: 1975
(Año)

Trial: NVT 12
(Ensayo)

Mean across locations
(Promedios a través de localidades)

Entry No. and Name (Entrada No. y Nombre)	Kg./Ha.	Days Silk (Días flor.)	Plant Ht. (Alt. Planta)
1 Tuxpeño-1	4068	68	168
2 Mex. Trop. Blanco	4487	67	168
3 Blanco Criollito-1	4371	63	158
4 Ver. 181 x Ant. Cos. 2	3741	69	181
5 (Mix. 1-Col. 1) ETO	4711	68	208
6 Mezcla Amarilla	3894	64	173
7 Amarillo Crist. - 1	4754	67	201
8 Amarillo Tuxpeño - 2	3436	67	169
9 Tuxpeño Cuerbo - 3	4790	68	196
10 Amarillo Dentado - 1	4048	69	214
11 Brasileiro	4611	73	183
12 Tuxpeño Cuerbo - 1	4488	67	200
13 Cogollero	4322	67	221
14 Tuxpeño c_2	3581	69	194
15 (Ver. 181-Ant. 2) c_2	3571	65	201
16 Yellow H.E. c_2	3776	65	205
17 White H.E. c_2	4184	64	208
18 La Posta	4847	73	225
19 Serie Cris.	4481	68	204
20 Blo Blanco	4001	65	181
21 Ant. x Rep. Dom.	3851	61	184
22 Blo x Tuxpeño	3884	66	194

Table 3.1.3
(Cuadro)

Year: 1975
(Año)

Trial: NVT 12
(Ensayo)

Mean across locations
(Promedios a través de localidades)

Entry No. and Name (Entrada No. y Nombre)	Kg./Ha.	Parent Pop. (Pob. Parentales)	% Parent Pop. (% Pob. Parentales)	Days Silk (Días flor.)	Plant Ht. (Alt. Planta)
1 Cuyuta Vaq.	4016	Tuxpeño 1	104.3	68	200
2 Sinaloa Vaq.	4420	"	113.4	68	201
3 Pura Raza Vaq.	4484	"	100.3	68	210
4 Nayarit Vaq.	4320	Mex. Trop. Blanco	102.6	68	222
5 Pura Raza Vaq.	4074	"	107.1	68	227
6 Pura Raza Vaq.	4406	"	98.3	68	210
7 Nayarit Vaq.	4400	"	99.7	68	220
8 Chiapas Vaq.	4341	"	97.8	68	220
9 Tlaltizapán Vaq.	4011	"	100.0	68	97
10 Acaxtlán Vaq.	4000	"	104.3	68	214
11 Cuyuta Vaq.	4471	Tuxpeño Cuerbo 3	105.5	68	210
12 Pura Raza Vaq.	4000	"	110.6	68	221
13 Chiapas Vaq.	4300	Brasileiro	106.4	71	204
14 Pura Raza Vaq.	4000	"	100.4	70	190
15 Nayarit Vaq.	4000	Tuxpeño Cuerbo 1	100.0	68	220
16 Pura Raza Vaq.	4000	"	100.0	68	204
17 Tlaltizapán Vaq.	4000	"	100.0	68	200
18 Chiapas Vaq.	4070	"	101.8	68	222
19 Acaxtlán Vaq.	4000	"	100.0	68	200
20 Sin Vaq.	4000	La Posta	117.0	71	243
21 Pura Raza Vaq.	4700	"	115.1	72	240
22 Tlaltizapán Vaq.	4000	"	115.0	71	243
23 Chiapas Vaq.	4057	"	115.1	71	230
24 Acaxtlán Vaq.	4000	"	100.0	71	217
25 Sin Vaq.	4000	ASEM Tuxpeño	100.0	68	212
26 Pura Raza Vaq.	4000	"	100.0	68	221
27 Tlaltizapán Vaq.	4000	"	100.0	68	222
28 Acaxtlán Vaq.	4000	"	100.0	68	220
29 Tuxpeño 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30 Mex. Trop. Blanco	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31 Tuxpeño Cuerbo 3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32 Brasileiro	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
33 Tuxpeño Cuerbo 1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Table: 3.1.4
(Cuadro)

Trial: [illegible]
(Ensayo)

Year: [illegible]
(Año)

Means across Locations
(Promedios a través de Localidades)

Entry No. and Name (Entrada No. y Nombre)	Kg./Ha.	Parent Pop. (Pob. Parentales)	% Parent Pop. (% Pob. Parentales)	Days Silk (Días flor.)	Plant Ht. (Alt. Planta)
1 Cuyuta 7427	4694	Amarillo Crist. 1	108.6	68	234
2 Delní 7427	4372	"	103.4	68	232
3 Tecumán 7427	4879	"	106.3	69	236
4 Tuxtlawala 7427	4136	"	97.5	68	231
5 Poza Rica 7427	4712	"	111.4	67	235
6 Obregón 7427	4336	"	102.5	69	236
7 Acroos 7427	4554	"	107.6	69	240
8 Tecumán 7428	5416	Amarillo Dentado 2	117.9	69	242
9 Tuxtlawala 7428	4929	"	106.9	68	230
10 Poza Rica 7428	5219	"	112.8	69	240
11 Tecumán 7328	4567	"	98.8	68	237
12 Poza Rica 7328	4615	"	99.8	69	230
13 Tlaltizapán 7328	4095	"	88.4	69	233
14 Obregón 7328	4677	"	101.2	68	235
15 Acroos 7328	4488	"	97.1	69	236
16 Cuyuta 7430	4752	Amarillo Dentado 1	103.6	68	237
17 Delní 7430	4306	"	93.8	68	233
18 Tuxtlawala 7430	4637	"	101.8	67	230
19 Obregón 7430	4596	"	100.2	68	233
20 Acroos 7430	4768	"	104.4	69	237
21 Poza Rica 7436	4930	- - -	- -	69	240
22 Amarillo Crist. 1	4230	- - -	- -	68	235
23 Amarillo Dentado 2	4620	- - -	- -	69	236
24 Amarillo Dentado 1	4586	- - -	- -	70	241

Table: 3.1.5
(Cuadro)

Trial: EVT 14
(Ensayo)

Year: 1978
(Año)

Means across Locations
(Promedios a través de Localidades)

Entry No. and Name (Entrada No. y Nombre)	Kg./Ha.	Parent Pop. (Pob. Parentales)	% Parent Pop. (% Pob. Parentales)	Days Silk (Días flor.)	Plant Ht. (Alt. Planta)
1 San Andrés 7428	4491	Blanco Cristalino 1	94.3	68	218
2 Los Ángeles 7428	4676	"	98.2	69	224
3 Poza Rica 7428	4660	"	97.0	68	223
4 Acroos 7428	4674	"	98.2	68	220
5 Poza Rica 7424	4444	Antigua x Ver. 181	113.6	68	231
6 Poza Rica 7424	4420	(Mex. in Col. Cpo. 13ETO	108.4	69	231
7 Delní 7428	4287	Maíces Amarillos	93.8	69	214
8 Los Ángeles 7424	4383	"	103.8	68	223
9 Tecumán 7428	4402	"	96.6	68	221
10 Tuxtlawala 7428	4281	"	94.3	68	217
11 Poza Rica 7428	4368	"	101.7	68	220
12 Acroos 7428	4368	"	101.8	68	223
13 Tuxtlawala 7428	4888	[illegible]	114.8	68	227
14 Poza Rica 7428	[illegible]	"	120.8	69	241
15 Acroos Cristalino 1	4760	- - -	- -	69	236
16 San [illegible] Ver. 181	[illegible]	- - -	- -	69	235
17 Poza [illegible] Cpo. 13ETO	[illegible]	- - -	- -	71	238
18 Maíces Amarillos	[illegible]	- - -	- -	71	230
19 [illegible]	[illegible]	- - -	- -	68	241
20 [illegible]	[illegible]	- - -	- -	69	[illegible]
21 [illegible]	[illegible]	- - -	- -	69	[illegible]
22 [illegible]	[illegible]	- - -	- -	69	[illegible]
23 [illegible]	[illegible]	- - -	- -	70	[illegible]

Entry No. and Name (Entrada No. y Nombre)	Kg./Ha.	Parental Pop. (Pob. Parentales)	% Parent Pop. (% Pob. Parentales)	Days Silk (Días flor.)	Plant Ht. (Alt. Planta)
1 Gemisa 7437	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2 Pirsabak 7437	[illegible]	"	[illegible]	[illegible]	[illegible]
3 Obregon 7437	[illegible]	"	[illegible]	[illegible]	[illegible]
4 Acroos 7437	[illegible]	"	[illegible]	[illegible]	[illegible]
5 Delhi 7438	[illegible]	(Ver. 101 x Amt. Opa. 2)Vem. 1 a_2	117.7	[illegible]	[illegible]
6 Rampur 7438	[illegible]	"	117.1	[illegible]	[illegible]
7 Pusa Rica 7438	[illegible]	"	114.2	[illegible]	[illegible]
8 Delhi 7439	[illegible]	Yellow N.E. a_2	[illegible]	[illegible]	[illegible]
9 Pusa Rica 7439	[illegible]	"	[illegible]	[illegible]	[illegible]
10 San Andres 7440	[illegible]	White N.E. a_2	[illegible]	[illegible]	[illegible]
11 Rampur 7440	[illegible]	"	[illegible]	[illegible]	[illegible]
12 Pusa Rica 7440	[illegible]	"	[illegible]	[illegible]	[illegible]
13 Cayuga 7441	[illegible]	Compuesto K (N.E.) a_2	[illegible]	[illegible]	[illegible]
14 Pusa Rica 7441	[illegible]	"	[illegible]	[illegible]	[illegible]
15 Acroos 7441	[illegible]	"	[illegible]	[illegible]	[illegible]
16 Mapaln Amarillo 62	[illegible]	- - -	- -	[illegible]	[illegible]
17 (Mex. 1xCol. Opa. 1)ETO a_2	[illegible]	- - -	- -	[illegible]	[illegible]
18 Amar. Dentado 62	[illegible]	- - -	- -	[illegible]	[illegible]
19 Tuxpeño 62	[illegible]	- - -	- -	[illegible]	[illegible]
20 (Ver. 101 x Amt. Opa. 2) Vem. 1 a_2	[illegible]	- - -	- -	[illegible]	[illegible]
21 Yellow N.E. 62	[illegible]	- - -	- -	[illegible]	[illegible]
22 White N.E. 62	[illegible]	- - -	- -	[illegible]	[illegible]
23 Compuesto K (N.E.) 62	[illegible]	- - -	- -	[illegible]	[illegible]

Table: 3.1.7
(Cuadro)

Trial: EVT 18
(Ensayo)

Year: 1978
(Año)

Means across Locations
(Promedios a través de Localidades)

Entry No. and Name (Entrada No. y Nombre	Kg./Ha.	Parental Pop. (Pob. Parentales)	% Parent Pop. (% Pob. Parentales)	Days Silk (Días flor.)	Plant Ht. (Alt. Planta)
1 Rampur 7433	5836	Amarillo Subtropical	110.8	63	242
2 Pirsabak 7433	5414	"	103.8	62	232
3 Tlaltizapan 7433	5716	"	106.6	62	235
4 Rampur 7434	5864	Blanco Subtropical	107.7	63	234
5 Pirsabak 7434	5966	"	110.0	62	238
6 Obregon 7434	5428	"	107.1	62	239
7 Tlaltizapan 7434	5857	"	109.5	63	244
8 Adapazari 7442	4962	ETO x Illinois	105.0	61	239
9 Gemisa 7442	4644	"	90.3	59	232
10 Pirsabak 7442	5890	"	124.6	62	240
11 Obregon 7442	6208	"	131.4	62	238
12 Pirsabak 7446	4400	Amarillos Pakistan	91.6	58	219
13 Obregon 7446	5696	"	116.2	59	230
14 Tlaltizapan 7446	5752	"	117.3	59	229
15 Pirsabak 7447	6205	Blanco Pakistan	120.4	60	233
16 Obregon 7447	6100	"	119.3	59	231
17 Tlaltizapan 7447	5685	"	117.6	59	235
18 Adapazari 7448	5428	Compuesto de Hungary	102.7	59	244
19 Pirsabak 7448	3301	"	107.7	56	196
20 Obregon 7448	2985	"	100.5	56	203
21 Amarillo Bajio	4094	- - -	- -	59	221
22 Compuesto Argentino 1	3964	- - -	- -	59	221
23 Compuesto Argentino 2	5461	- - -	- -	59	230
24 Compuesto Argentino 3	5300	- - -	- -	60	223
25 Pool 27	3000	- - -	- -	56	215
26 Pool 32	5000	- - -	- -	63	248
27 Pool 33	4854	- - -	- -	59	239
28 Pool 34	5027	- - -	- -	62	248
29 Tuxpeños N.E. 62	5135	- - -	- -	62	236
30 Amarillo Subtropical	[illegible]	- - -	- -	63	240
31 Blanco Subtropical	[illegible]	- - -	- -	64	241
32 ETO x Illinois	4754	- - -	- -	62	231
33 Amarillos Pakistan	[illegible]	- - -	- -	61	230
34 Blancos Pakistan	[illegible]	- - -	- -	56	231
35 Compuesto de Hungary	[illegible]	- - -	- -	60	[illegible]

Pollinated ears are examined at harvest.

Selected ears are shelled; clean seed put in plastic containers.

3.1.2 INTERNATIONAL PROGENY TRIALS (IPTT)

A total of 137 "IPTT" trials were distributed in a total of 16 countries, plus 5 locations in Mexico, as shown in Table 3.1.8. Data obtained until February 15, 1976, are shown in Tables 3.1.9 to 3.1.13. These tables allow companion of the means from 250 families tested during 1975 with the mean of the new set of about 100 selected families to be used in the regeneration of the population. Also, comparisons can be made among Experimental Varieties and best checks.

3.1.3 SEED INCREASES FOR DISTRIBUTION

During summer 1975, all Experimental Varieties tested in EVT's were increased to meet demands of national programs for further testing. These seed increases are used to constitute future Elite Experimental Variety Trials, and to have sufficient quantities for national program requests.

3.2 NEW POPULATIONS AND MERGES

3.2.1 MERGING OF POPULATIONS

During the 1975 testing cycle, several populations were merged on the basis of similiarities and backgrounds, as shown in Table 3.2.1, which lists the populations and number of families included from each.

3.2.2 NEW POPULATIONS

The best families of some of the Highland Pools were selected and 250 half extracted for international evaluation in 1976. The IPTT numbers assigned were:

Source Pool	A.U. Population Name	1976 IPTT No.
2	Blanco Dentado Precoz de Altura	52
3	Blanco Harinoso Precoz de Altura	53
4	Amarillo Cristalino Precoz de Altura	54
5	Amarillo Dentado Precoz de Altura	55
8	Blanco Harinoso Intermedio de Altura	58
10	Amarillo Dentado Intermedio de Altura	60

In Mexico, the yield trials will be planted concurrently with a crossing block in isolation in modified ear-to-row selection. After information returns from collaborators, 5 ears from each of the 20% best families will be included in the next year's yield evaluation and recombination.

3.3 TWO POPULATION GROUPS: NORTHERN AND SOUTHERN HEMISPHERES

In general, planting dates South of the Equator differ from those in the North, thus, (1) results returned from those areas are not used in the regeneration of families for the next cycle of evaluation, and (2) the experimental varieties are extracted and tested one cycle behind the rest of the locations. CIMMYT has divided the Advanced unit populations into 2 groups to be evaluated in locations that do not coincide with Mexico's main planting season. CIMMYT's Advanced unit populations will be distributed as follows:

POPULATIONS: GROUP 1		POPULATIONS: GROUP 2	
IPTT No.	Population Name	IPTT No.	Population Name
22	Mezcla Tropical Blanco	21	Tuxpeño 1
23	Blanco Cristalino 1	25	(Mix.1 x Col.Gpo.1) ETO
24	Antigua Gpo.2 x Veracruz 181	26	Mezcla Amarilla
27	Amarillo Cristalino 1	28	Amarillo Dentado
31	Braquíticos	29	Tuxpeño Caribe
32	ETO Blanco	30	Blanco Cristalino
33	Amarillo Subtropical	34	Blanco Subtropical
35	Antigua x Rep. Dominicana	36	Cogollero
39	Yellow H.E.o_2	37	Tuxpeño o_2
42	ETO x Illinois	38	PD(MS)6 H.E.o_2
43	La Posta	40	White H.E.o_2
44	AED x Tuxpeño	48	Comp. de Hungría
52	Blanco Dentado Precoz de Altura		
53	Blanco Harinoso Precoz de Altura		
54	Amarillo Cristalino Precoz de Alt.		
55	Amarillo Dentado Precoz de Alt.		
58	Blanco Harinoso Intermedio de Alt.		
60	Amarillo Dentado Intermedio de Alt.		

Populations in each group will be alternately yield tested and planted in nurseries in Mexico for the development of families, thus fitting all planting dates with a different set of populations in alternate years.

TABLE 3.1.8. CIMMYT'S INTERNATIONAL MAIZE TESTING PROGRAM 1975

DISTRIBUTION OF IPTT

No.	POPULATION	SOUTH AMERICA 1 COLOMBIA	2 ECUADOR	3 PERU	4 VENEZUELA	CENTRAL AMERICA 5 COSTA RICA	6 EL SALVADOR	7 GUATEMALA	8 HONDURAS	9 NICARAGUA	10 PANAMA	MEXICO 11 YUCATAN	12 POZA RICA	13 TLALTIZAPAN	14 CHAPINGO	15 JIRA	ASIA 16 [illegible]	17 [illegible]	18 [illegible]	19 [illegible]	20 [illegible]	21 [illegible]	22 [illegible]	23 [illegible]	24 [illegible]	25 [illegible]	26 [illegible]	27 PAKISTAN	28 [illegible]	29 TURKEY	30 [illegible]	31 [illegible]	TOTAL
21	TUXPEÑO 1					X	X						X					X	X	X														6
22	MEZCLA TROPICAL BLANCO	X			X				X	X			X							X														6
23	BLANCO CRISTALINO 1							X	X				X				X									X	X							6
24	ANTIGUA x VER.-181			X				X			X		X		X								X											6
25	(MIX.1 x COL. SPO.1) ETO				X					X			X					X			X						X							6
26	MEZCLA AMARILLA		X	X					X				X						X						X									6
27	AMARILLO CRISTALINO 1		X	X						X	X		X									X												6
28	AMARILLO DENTADO			X		X	X						X									X			X									6
29	TUXPEÑO CARIBE								X				X					X	X	X	X													6
30	BLANCO CRISTALINO 2				X		X						X			X		X			X													6
31	BRAQUITICOS							X		X			X	X	X	X																		6
32	ETO BLANCO				X	X							X		X											X	X							6
33	AMARILLO SUBTROPICAL							X						X	X									X		X		X						6
34	BLANCO SUBTROPICAL													X	X		X	X								X		X						6
35	ANTIGUA x REP.DOMINICANA	X	X				X						X									X	X											6
36	COGOLLERO		X					X			X		X							X				X										6
37	TUXPEÑO O_2												X			X	X		X	X	X													6
39	YELLOW H.E. O_2			X				X					X						X			X	X											6
40	WHITE H.E. O_2							X	X				X					X		X	X													6
42	ETO x ILLING'S													X	X		X	X										X		X				6
43	LA POSTA				X	X							X		X	X		X																6
44	AED x TUXPEÑO												X	X	X	X	X	X																6
48	COMPUESTO DE HUNGARY													X	X								X							X	X	X		6
	TOTAL:	2	4	5	5	4	4	7	5	4	3	0	19	6	9	5	5	9	5	6	5	4	4	2	2	4	3	3	0	2	1	1	138

TABLE 3.1.9.- Summary of performance of full sib families developed from Advanced Unit Populations. Data from Internationa Progeny Testing Trials, 1975.
TROPICAL LATE WHITE FLINT/DENT MATERIALS:

IPTT No.	Site & Exp.	Variety	Yield ton/ha Mean 250 fam.	C.V.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Plant Height cm. Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Days to flower Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Checl
Braquítico 31	Poza Rica	7531	6.16	16	6.58	8.03	7.76	177	176	179	203	63	63	63	63
	Obregón	7531	4.50	22	4.89	6.49	6.06	207	206	207	223	68	67	67	66
	Tlaltizapan	7531	9.29	18	5.45	11.92	9.75	218	200	226	245	74	62	72	72
	Across sites	7531	5.84	-	5.45	7.06	6.82	209	200	209	225	64	62	63	63
ETO Blanco co 32	Poza Rica	7532	6.22	13	6.50	7.91	8.70	209	206	207	215	61	61	62	62
	Obregón	7532	3.66	26	3.94	5.81	5.10	228	225	231	261	64	63	62	69
	Alajuela	7532	5.32	13	5.21	6.59	7.20	216	212	219	269	78	77	76	87
	Across sites	7532	4.97	-	4.91	6.23	7.00	218	216	225	215	68	65	67	73
La Posta 43	Poza Rica	7543	6.46	20	7.09	8.22	6.86	257	254	253	268	63	62	62	65
	Obregón	7543	5.00	21	5.29	6.95	5.98	272	269	274	251	66	65	64	70
	Cotaxtla	7543	5.44	16	5.86	6.28	5.87	280	277	273	303	59	58	59	60
	Across sites	7543	5.63	-	5.56	6.86	6.24	270	268	266	274	62	61	62	65
AED x Tuxp. 44	Gemelas	7544	8.08	20	8.63	10.57	9.08	263	262	260	291	66	66	66	68
	Poza Rica	7544	4.30	23	4.71	5.33	5.28	252	252	250	263	60	60	60	60
	Obregón	7544	3.97	20	4.33	5.81	5.24	247	245	245	235	63	63	61	62
	Tlaltizapan	7544	9.21	14	8.86	11.63	9.13	274	258	275	283	64	62	63	65
	Across sites	7544	6.25	-	6.85	7.66	2.06	260	258	260	268	63	62	63	63

TABLE 3.1.10.- [illegible] Progeny Testing Trials, 1975.
[illegible]

IPTT No.	Site & Exp.	Variety	Yield ton/ha Mean 250 fam.	C.V.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Plant Height cm. Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Days to flower Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check
Blanco Cristalino-1 23	Cuyuta	7526	3.43	27	3.93	4.81	3.42	222	219	220	223	52	51	52	51
	Gemelna	7526	7.06	15	7.34	8.06	8.00	256	254	249	253	66	66	66	68
	Poza Rica	7526	6.38	15	6.58	7.75	7.88	208	223	212	213	60	60	60	61
	Across sites	7526	5.47	-	5.80	6.78	6.47	230	224	233	243	59	60	59	60
	La Máquina	7524	3.06	23	4.14	5.43	4.67	196	195	194	210	58	58	57	58
	CEIAT	7524	6.79	17	7.06	8.40	9.12	228	227	233	230	54	59	56	60
	Poza Rica	7524	5.83	15	6.05	7.43	6.62	198	197	202	190	61	61	61	63
	Obregón	7524	3.67	24	3.73	5.84	5.35	224	222	227	223	62	62	61	63
	Across sites	7524	5.02	-	5.25	6.35	6.44	202	210	218	230	60	59	59	61
Antigua x Hep. Dominica 35	San Andres	7535	5.06	13	6.44	7.37	6.75	239	227	234	258	56	56	56	63
	Delhi	7535	2.30	23	2.39	3.15	3.42	144	142	147	180	58	57	58	63
	Poza Rica	7535	6.22	13	6.49	7.36	8.94	212	209	212	233	55	54	55	60

TABLE 3.1.11.- Summary of performance of full sib families developed from Advanced Unit Populations. Data from International Progeny Testing Trials, 1975.
TROPICAL YELLOW FLINT/DENT MATERIALS:

IPTT No.	Site & Exp.	Variety	Yield ton/ha Mean 250 fam.	C.V.	Mean Sel. fam.	Mean Expt. Var.	Best Check	Plant Height cm. Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Days to flower Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check
Amarillo Cristalino-1 27	CEIAT	7527	5.47	21	5.83	7.49	6.83	253	249	256	248	58	58	58	57
	Poza Rica	7527	6.22	11	6.54	7.77	7.04	249	247	254	243	61	60	60	61

TABLE 3.1.12.- Summary of performance of full sib families developed from Advanced Unit Populations. Data from International Progeny Testing Trials, 1975.
SUBTROPICAL AND TEMPERATE MATERIALS:

IPTT No.	Site & Exp.	Variety	Yield ton/ha Mean 250 fam.	C.V.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Plant Height cm. Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Days to flower Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check
Amarillo Subtropical 33	Obregón	7533	4.10	23	5.19	6.83	6.36	251	250	250	269	60	60	60	61
	Tlaltizapan	7533	8.52	12	9.69	11.35	8.64	273	274	272	275	59	60	60	66
	Chimaltenango	7533	1.78	23	1.40	2.68	6.22	179	140	186	228	90	71	89	93
	Across sites	7533	4.83	-	5.64	6.32	7.14	268	236	238	254	70	71	71	73
ITO x Illinois 42	Sids	7542	5.55	21	5.98	7.99	7.20	224	222	238	256	72	71	72	72
	Obregón	7542	4.14	22	4.67	6.26	6.16	238	237	237	245	60	59	60	69
	Tlaltizapan	7542	9.24	12	9.83	11.39	11.06	262	261	264	270	60	59	60	64
	Across sites	7542	6.31	-	7.06	7.71	6.15	241	262	245	257	64	65	64	65

TABLE 3.1.13.- Summary of performance of full sib families developed from Advanced Unit Populations. Data from International Progeny Testing Trials, 1975.
OPAQUE-2 MATERIALS:

IPTT No.	Site & Exp.	Variety	Yield ton/ha Mean 250 fam.	C.V.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Plant Height cm. Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check	Days to flower Mean 250 fam.	Mean Sel. fam.	Mean Exp. Var.	Best Check
Tuxpeño-2	Sids	7537	5.30	26	5.62	8.60	11.66	283	278	292	330	73	72	73	69
	Ferkessedougou	7537	7.73	12	7.98	8.52	10.18	234	229	227	254	62	62	63	65
	Poza Rica	7537	6.22	14	6.51	7.68	7.51	234	230	233	275	61	60	61	62
	Across sites	7537	6.07	-	6.33	7.35	8.80	252	245	253	267	63	62	62	62
Yellow H.E. O_2 39	La Máquina	7539	3.02	25	3.34	4.35	3.96	220	214	211	218	57	56	55	56
	Ferkessedougou	7539	6.40	17	6.60	7.87	8.79	256	250	250	250	60	59	60	61
	Poza Rica	7539	4.89	17	5.16	6.36	6.58	258	253	255	245	59	59	59	61
	Across sites	7539	4.77	-	4.84	5.84	5.44	245	243	240	237	59	57	58	59
White H.E. O_2 40	La Máquina	7540	3.20	23	3.54	4.56	5.60	230	[illegible]	228	235	56	56	56	56
	Poza Rica	7540	5.87	14	5.91	6.81	6.47	259	224	255	258	59	57	59	60

TABLE 3.2.1.- Populations merged during 1975 and number of families from each that were assembled in the same population.

Population Name 1975		Population Name 1974		No. families included
IPTT-28	Amarillo Dentado	IPTT-28	Amarillo Dentado-2	166
		IPTT-30	Amarillo Dentado-1	84
				250 families
IPTT-29	Tuxpeño Caribe	IPTT-29	Tuxpeño Caribe 2	150
		IPTT-32	Tuxpeño Caribe 1	100
				250 families
IPTT-30	Blanco Cristalino-2	Back Up Trial 104: (Tuxpeño x Nicarillo) x Sint. 10 lineas		130
		Back Up Trial 105: (Mix.1 x Col.Gpo.1) (ETO x Sint. 10 lineas)		47
		Back Up Trial 106: (ETO Blanco x Sint. 10 lineas)		46
		Pool 23 (Tropical late White Flint)		27
				250 families
IPTT-33	Amarillo Subtropical	IPTT-33	Amarillo Subtropical	174
		IPTT-46	Amarillo Pakistan	76
				250 families
IPTT-36	Cogollero	IPTT-30	Amarillo Dentado 1	8
		IPTT-35	IDRN	71
		IPTT-36	Cogollero	171
				250 families
IPTT-39	Yellow (H.E.) o_2	IPTT-38	(Ven. 181 x Ant.Gpo.2) Ven. 1 (H.E.)o_2	100
		IPTT-39	Yellow (H.E.)o_2	150
				250 families
IPTT-48	Comp. Hungary	IPTT-48	Comp. Hungary	228
		Lote 126	Mezcla Amarilla x Lineas Illinois	22
				250 families

Seed envelopes are put in CIP containers for shipment to collaborators. Field books and instruction sheets accompany the seed.

3.4 COMPANION NURSERIES

All families evaluated for yield performance, also are planted in Companion Nurseries to measure their potential value when: (1) planted thickly, and (2) inoculated artificially and uniformly with pathogens and infested with insects. Insect and disease nurseries are planted a few weeks ahead of the yield trials as a trap crop to attract insect vectors under natural conditions.

In the insect nursery, half-rows in the field are not treated with insecticide and are evaluated for budworm and stemborer damage. The other half of these rows is treated with insecticide and used for comparative evaluation of insect damage.

In the disease nursery, half-rows are inoculated with stalk rotting organisms, and the whole row inoculated with ear-rotting pathogens. At harvest time, stalks are split open and ear and stalk rots measured in the field.

The high density nursery is planted simultaneously with the yield trial with plantings at a density of 80,000 plants/ha. Yield trials are planted at densities of 53,000 plants/ha.

Tables 3.4.1; 3.4.2; and 3.4.3 summarize the results obtained in the 250 families from each population in Group 1 in the place where they were evaluated, Poza Rica or Tlaltizapan. The mean of the new selected families used for the regeneration of families also is included.

3.5 PROTEIN QUALITY

3.5.1 CONVERSION PROGRAM

All maize materials in the Advanced and Back-up stages of maize improvement program are included in the continuing program of conversion to high-quality protein varieties. During 1975 the work included:

3.5.1.1 Conversion of Advanced unit materials

At Poza Rica or Tlaltizapan, during the year 1974A, twenty-three normal materials were crossed with one or more sources of opaque-2 donors with hard endosperm texture. The F_1 crosses were advanced to F_2 during 1974B. The F_2 hard endosperm opaque-2 families produced by each of the Advanced Unit materials were planted on a family basis in 1975A. Intercrosses were made among F_2 families that had satisfactory protein and tryptophan levels in the endosperm. At harvest time, only ears with vitreous appearance were harvested. Table 3.5.1 shows the number of F_3 ears harvested during 1975A. The ears were shelled individually, and the best-looking segregates with hard endosperm texture were sorted from each ear separately. The selected segregates from F_3 ears were planted on family basis during 1975B. Intercrosses were made among selected families and again at harvest; only hard endosperm opaque-2 ears were selected for further selection and for making the first backcross with the selected families of the corresponding normal Advanced Unit population. Table 3.5.1 lists the number of families saved from each population during 1975B.

3.5.1.2 Conversion of Back-up materials

Pools now available are being converted to opaque-2. The F_2 segregates selected from Pools 19 to 26 were planted on family basis in 1975A. Intercrosses were made between families within each population. Modified endosperm type F_3 ears with the best appearance were selected at harvest time. The F_3 families were advanced to F_4 during 1975B. Table 3.5.2(A) shows the number of F_3 and F_4 families selected from each Pool. A total of 1943 F_4 families will be advanced further and also backcrossed to respective Pools during 1976A.

Table 3.5.2(B) shows the number of F_4 families from four temperate Pools. F_1 crosses of Highland Pools 1 through 14 (except Pool 6) were advanced to F_2 during 1975. Table 3.5.3 lists the number of segregating F_2 ears selected from each Pool. A total of 2,095 segregating ears from different Pools will be sorted for opaque-2 segregants and planted on a family basis in 1976.

3.5.1.3 Conversion of populations that are being selected for plant efficiency and adaptation

Table 3.5.4 lists the number of F_3 and F_4 hard endosperm opaque-2 families selected for plant efficiency and adaptation, from each of the populations. The selected segregates from each population will be backcrossed to corresponding normal populations during the year 1976.

3.5.2 POPULATION IMPROVEMENT PROGRAM

On the basis of 1974 data, five advanced opaque-2 populations were reduced to three:

- -- IPTT-37 and IPTT-40 remained unchanged;
- -- The two yellow opaque-2 populations (Ver.181-Ant.Gpo.2 x Ven. 1 o_2 and Yellow H.E.o_2) were merged and will continue as IPTT-39 under the name of Yellow H.E.o_2;
- -- IPTT-41 was dropped from the list.

On the basis of 1974 data, a new set of 250 full sib families was generated during 1975A at Poza Rica from each of the three populations. The progeny trials from these three populations were sent to six different sites, including one in Mexico (Table 3.5.5).

Table 3.5.6 summarizes results obtained from 1975 data. The mean of selected families was greater than the mean of tested families in all three populations. Increases were 4.3% for Tuxpeño opaque-2, 1.5% for Yellow H.E.o_2, and 6.5% for White H.E.o_2.

Major emphasis was on: yield and general performance over a range of environments, reduced ear rot incidence, satisfactory kernel hardness, and stability over environments. The data from disease-insect nursery also was considered, along with yield and other agronomic trials, to select families to be used for the regeneration of new set of 250 full sib families.

3.5.3 DEVELOPMENT OF EXPERIMENTAL VARIETIES

The 1975 data provided a basis for developing a number of site specific and across-site experimental varieties. A total of 11 experimental varieties were developed from three Advanced Unit Opaque-2 populations (Table 3.5.7). Table 3.5.8 lists the mean grain yield and other agronomic traits of experimental varieties developed by recombining the best ten families from three Advanced Unit opaque 2 populations (on the basis of 1975 data). The mean of experimental varieties developed from all three populations was greater than the mean of the population, and greater than the mean of the checks. The means of the experimental varieties ranged from 10.3 to 62.1% greater than the mean of the population, and were 4.5 to 40.9% greater than the mean of the checks. In days-to-flower, the experimental varieties equalled, or were one-two days earlier than, the mean of the population. Also, the mean height of the experimental varieties was 1-9 cms. shorter than the mean of the population.

3.5.4 DEVELOPMENT OF BROAD-BASED GERMPLASM SOURCES

Table 3.5.9 shows the broad-based germplasm sources that have been developed, which are now at different stages of improvement.

3.5.4.1 PD(MS)6 H.E.o_2: third and fourth cycles of recombination were achieved during 1975A and 1975B, respectively. After the fourth cycle, 467 ears with good vitreous appearance were selected to be planted during the year 1976A on a family basis. Reciprocal plant-to-plant crosses will be made among families and the full sibs developed are scheduled to be evaluated during 1977. (This material closely resembles normal maize in appearance, the kernels look good and it shows no segregation for soft opaque-2 kernels).

3.5.4.2 CIMMYT H.E.o_2: has undergone four cycles of selection. The kernel type in this material also has improved considerably during the last two cycles. From the harvest of 1975B, 402 half-sib ears were saved for planting on family basis during 1976A. Development of full sibs followed by evaluation of progenies will be done as for PD(MS)6 H.E.o_2.

3.5.4.3 Yellow opaque-2 Back-up Pool: the second and third cycles of recombination were completed in 1975, and 743 half-sib ears saved from 1975B harvest will be shelled and sorted individually for best modified opaque-2 segregates. The selected segregates will be planted in the following season to obtain the fourth cycle of recombination. Emphasis continues on the enhancement of frequency of favorable modifiers and of protein quality.

3.5.4.4 White opaque-2 Back-up Pool: two additional cycles of recombination were completed in 1975; 733 half-sib ears were selected from the third cycle of recombination. Modified opaque-2 kernels with greater hard fraction will be sorted on a glass screen and again planted in a half-sib recombination block to complete the fourth cycle of recombination.

3.5.4.5 Temperate x Tropical H.E.o_2: has undergone three cycles of recombination. 381 ears were saved from third cycle. An additional cycle of recombination will be achieved in this material before extracting families for the development of full sibs. This material looks fairly good and has good modified opaque-2 kernels, thus may be promoted to the Advanced Unit during 1976.

3.5.4.6 Highland Composites: four highland opaque-2 materials have achieved 3 cycles of recombination; all of these materials have soft endosperm texture. Table 3.5.9 shows the number of families saved from each material during 1975.

3.5.4.7 A number of other materials also are being converted to opaque-2 as shown in Table 3.5.10. A total of 1046 F_4 hard endosperm opaque-2 families with good kernel appearance were saved during 1975B. At a later stage, these materials will be merged with appropriate opaque-2 materials. Table 3.5.10 shows the number of families saved from each material.

3.5.5 SELECTION FOR HARD ENDOSPERM

Three major problems in opaques can be attributed directly or indirectly to the presence of soft endosperm. Major emphasis, therefore, is exerted on selection for kernel hardness at all stages of breeding for protein quality (in the conversion program, in development of germplasm

source population, and in the population improvement program).

In converting Advanced Unit materials, gene pools, and other materials in the Back-up stages of maize improvement, appropriate opaque-2 materials are used as donors. Opaque-2 donors that possess vitreous endosperm and have an acceptable appearance are used, except in the floury-1 conversion program. Also, in many instances, hard endosperm opaque-2 populations that have genetic modifiers accumulated from as many different sources as possible have been used as donors. To be on the safe side, more than one opaque-2 donor is used in converting any normal material.

In converting advanced and back-up materials to hard endosperm opaque-2, modified opaque-2 segregates are sorted very carefully from any segregating generation. The type and quality of hard endosperm opaque-2 segregants recovered in F_2 determines: (1) whether to go ahead with the first backcross, or (2) wait to advance the F_2 families to F_3 (or later generations) till favorable modifiers controlling kernel vitreousness have been accumulated to a high frequency. Also, hard endosperm opaque-2 families in any generation are analyzed for quality protein as a check on lysine and tryptophan in protein. Only families that are acceptable from a quality-protein point of view are used in pollinations.

The half-sib recombination system is usually used in the development of hard endosperm opaque-2 source populations. The modified ears with good phenotypic appearance are selected following each cycle of recombination. The selected ears are shelled individually followed by a selection of the best hard endosperm segregates from each ear for planting in the next season.

In the Advanced Unit opaque-2 materials, the frequency of favorable modifiers is being improved by: (1) selecting the best possible vitreous seed from each family for planting, and (2) when new families are generated through reciprocal plant to plant crosses, selecting only those pairs with two modified ears for further selection.

In the selection for hard endosperm, good progress has been made in all materials at different stages of the maize improvement program. Opaque-2 materials with very good modifiers and with more or less normal appearance have been developed for direct use and also as a good source of modifiers in converting new normal populations to hard endosperm opaque-2.

3.5.6 STABILIZING MODIFIERS CONTROLLING KERNEL HARDNESS

The full-sib families in each Advanced Unit opaque-2 population are studied at six different sites. This helps greatly in selecting only those families for recombination that are rather stable for hard endosperm opaque-2 character. Also, in the materials at the Back-up stages of the program, families are extracted after the frequency of desirable modifiers has been enhanced considerably. The families thus extracted are then subjected to systematic progeny testing trials over at least three locations within Mexico.

3.5.7 REDUCING EAR ROT INCIDENCE

Ear rot incidence in opaques can probably be reduced by selection for kernel hardness, and by the artificial inoculation (with ear rot organism) of the families from the Advanced opaque-2 populations and from the materials of the Back-up program. The resistant families can be identified, and through a continued selection process, resistance to ear rot organisms can be built up.

A total of 250 full sib families from three Advanced Unit populations (Tuxpeño Opaque-2, Yellow H.E.o_2 and White H.E.o_2) were inoculated artificially with ear rot organisms. The mean ear rot ratings of the selected families was a little lower than the mean of the populations; the differences were very small.

3.5.8 TRANSFER OF OPAQUE-2 GENE IN FLOURY-1 BACKGROUNDS

The opaque-2 gene is being transferred to a number of floury-1 materials with big seeded kernel type from the Andean region. Crosses of 21 materials from different countries with opaque-2 were advanced to F_2. In the segregating F_2 materials, the opaque-2 segregates were identified by Ninhydrin test performed on individual kernels. Selected kernels from these materials will be planted at Batan in 1976.

Two floury 1 pools (Pool 3 and Pool 8) were crossed with opaque-2 and advanced to F_2 in 1975. Opaque-2 segregates will be identified by Ninhydrin test for planting during next year.

The opaque-2/floury-1 versions of different materials, provided a base for a composite formed during 1974. The selected ears from this composite were shelled individually and big seeded kernels were sorted from each ear for planting during 1975 to obtain a second cycle of recombination. About 300 ears were saved from the 1975 harvest to continue the third cycle of recombination during 1976.

3.5.9 SUGARY-2/OPAQUE-2 DOUBLE MUTANT

Conversions of normal materials to the double mutant combination su_2o_2 are now underway During 1975, 72 materials from the Advanced, Back-up and opaque-2 improvement work were crosse

with sugary-2/opaque-2 source. The F_1 crosses will be advanced to F_2 during 1976A at Tlaltizapan. Some highland materials, where su_2o_2 segregates were recovered in F_3, will receive the first backcross. The segregates of the double mutant combination sugary-2/opaque-2 have very different appearances in different genetic backgrounds. Considerable variation in kernel size has been found. In developing this combination, considerable attention will be paid to selecting segregates that have acceptable appearance, with a kernel size comparable to that of the normal kernels.

3.5.10 EXPERIMENTAL VARIETY TRIAL

Trial No. 15 was formed from experimental varieties developed from five Advanced Unit opaque-2 populations (Tuxpeño o_2, Ver.181-Ant.Gpo.2 x Ven.1 o_2, Yellow H.E.o_2, White H.E.o_2 and Composite K). This trial consisted of 25 entries to be evaluated in 5 x 5 simple lattice with 4 replications, and was sent to 27 different locations in different countries of the world. Table 3.5.11 shows the distribution of the trials and the results are shown in Table 3.5.12.

The data in Table 3.5.12 indicate that:

The experimental varieties developed from five Advanced Unit opaque-2 populations were in general superior to the corresponding base populations from which these derived.

In Tuxpeño o_2 (IPTT-37), the across 7537 did very well in most of the locations. The performance of other experimental varieties from this population (Poza Rica 7437, Gemiza 7437, and Obregon 7437) also was fairly good in many locations.

In Ver. 181-Ant. Gpo.2 x Ven. 1 o_2, the three selections (Delhi 7438, Poza Rica 7438 and Rampur 7438) were about equal.

In Yellow H.E.o_2, both Delhi and Poza Rica selections did fairly well. The performance of these experimental varieties was somewhat better than the experimental varieties developed from IPTT-38.

In White H.E.o_2, the selection from El Salvador (San Andres 7440) was better than the site-specific selections.

In Composite K, the across selection again was better than the site-specific selection. Performance of the site-specific selections (Poza Rica 7441 and Cuyuta 7441) was equal to or better than the across selection in some locations.

Three other hard endosperm opaque-2 populations (Mezcla Amarilla, Mix.1-Col.Gpo.1 x Eto and Amarillo Dentado) also compared fairly well with some of the experimental varieties developed from the Advanced Unit populations.

At each location the performance of one or more experimental varieties either equaled or bettered that of check entries.

3.6 PHYSIOLOGY/PRODUCTION AGRONOMY

3.6.1 PHYSIOLOGY

Increase in the capacity of the grain-to-stover dry matter continues to be an objective in overcoming limitations to maize grain yields. Thus, as a part of the progeny testing programming, selection continues for materials with a low incidence of barren plants when grown at high populations. Emphasis is now being directed toward the identification of morphological characters that may further increase the storage capacity of the crop.

The last of the current series of trials designed to understand the control and development of grain storage of maize are described below. Sufficient data has now been collected from three sites in Mexico to evaluate how environmental factors control the number of ears per plant, grain per ear, and grain size. This data is now being analyzed.

3.6.1.1 Growth and Yield of Lowland Maize

At present, no further analyses are being made of the patterns of accumulation and distribution of dry matter in Tropical materials. Various materials currently undergoing special selection for morphological characters (see Special Projects) will be analyzed, when appropriate, to assess the changes in dry matter distribution that may have occurred.

3.6.1.2 Control and Developments of Grain Storage of the Crop

A series of trials was conducted in the 1975A cycle at Tlaltizapan to study how yield (and its components) would be affected by increased and decreased photosynthate supply during various developmental stages. Responses of tropical lowland material with a relatively low efficiency of conversion of dry matter to grain were compared to that of a more efficient type (Temperate hybrid).

Figure 3.6.1 shows how a 22-day period under 54 percent shade at various developmental stages affected grain yields of a tropical synthetic variety (Tuxpeño-1, C_{11}) and a temperate hybrid (Pioneer 3369A). The period 10 days before and after flowering seemed most sensitive to a reduction

in radiation input; the effect being more severe in the temperate material. The loss in grain dry matter was due to a reduction in grains per ear and ears per plant (increased barrenness). Table 3.6.1.

In another experiment using Tuxpeño-1, the radiation to individual plants was increased by removing neighboring plants at various developmental stages. The effect of increased radiation for discrete developmental stages was measured by the differences in response between two successive exposure treatments. Again, response was greatest to increased radiation, with around flowering, an increase in the number of grain per ear and ears per plant. Exposure treatments during the grain fill period resulted in an increase in the individual size (dry weight) of grain by 13 to 16 percent.

As shown in Figure 3.6.2, the development of the number of florets is completed approximately 15 days before silking in Tuxpeño-1, and 5 days before silking in Pioneer 3369A. The longer duration of primordial development in the temperate material resulted in a greater number of florets, and there was a greater loss due to shading. In both materials, the amount of photosynthate required for new growth at this developmental stage is small, thus it is difficult to explain the changes (increases from exposure, decreases from shading) in yield solely due to changes in total amount of crop photosynthate. For Tuxpeño-1, there would appear to be a reserve supply of soluble sugars in the stem (Figure 3.6.3). The effects of the distribution of radiation to plant parts(both the quantity and quality and its effects on the control and development of grain sink)need further basic research. The finding that mean grain size was influenced by changes in the radiation environment 16 days and more after silking also suggests further study of the mechanisms of transport to and storage in the grain.

In another trial, Tuxpeño-1 and Eto x Illinois populations were studied to determine how yields were affected by (1) tassel and partial leaf removal (reduction to half of leaf area by cutting each leaf longitudinally, (2) at two developmental stages (20 and 10 days, before flowering). These effects were observed on plants at: (1) 80,000 plant/ha; and (2) without competition (thinning of plants from 80,000 to 10,000 plant/ha at the time of treatment.

Tassel removal effectively increased grain yield (24 percent increase) only in Tuxpeño-1; when the plants were grown under competition (Table 3.6.2). Reduction in yield through early tassel removal, particularly in Eto x Illinois, may have been due to damage to other growing tissues.

Halving the total plant leaf area had no effect on the yield of Tuxpeño-1 grown under competition. However, there was a small (11%), but consistent, yield loss in Eto x Illinois.

These data suggest that, at least in the tropical germplasm (Tuxpeño-1), plant yield might be increased by selection for a reduced tassel size. Additional crop yield increases might be obtained by selections for reduced leaf area (thus enabling a higher density of planting). Changes in the distribution of light through the canopy may also be relevant in the improvement of the development of grain storage sinks in the crop.

Table 3.6.3 shows the variation among families (250) in three Advanced Unit Populations (Tuxpeño-1 (IPTT 21), Eto Blanco (IPTT 32) and Antigua x Dominican Republic (IPTT 35) for flowering delay (silking date minus date of pollen shed); "barrenness" (plants without ears); tassel branch number; ear leaf length, width, number, area, and density (area per height) above the ear; as well as an index of grain yield per leaf area above the ear.

Antigua x Dominican Republic showed greater production per unit leaf area (i.e. was more efficient) than either Tuxpeño or Eto Blanco. This increase was associated with a smaller leaf area and a lower leaf-area density above the ear, shortening of the interval between pollen shed and silking, and more ears per plant (less barrenness).

As compared to Tuxpeño-1 and Pioneer 3369A, the more efficient temperate material (Pioneer 3369A) showed a 20 percent reduction in leaf area above the ear; due mainly to a shorter leaf and a 34 percent reduction in density of leaf area (smaller leaves and a greater vertical separation between leaves).

There seem to be sufficient variations in each of the components of leaf area in the IPTT populations measured to warrant a selection program to reduce leaf area and density above the ear, as a means of increasing yield efficiency (see Special Project page 46).

Although tassel size, as measured by branch number (correlation coefficient of 0.71 between tassel branch number and dry weights),is not associated with differences in yield performance among these three populations, tropical materials show greater numbers (25 percent more tassel branches in Tuxpeño-1 compared with Pioneer 3369A). This finding,plus the evidence from the other experiments, suggests that selection for reduced tassel size also might be worthwhile as a criteria to increase yield efficiency (see Special Project page 46).

3.6.1.3 Genotype Comparison Under Simulated Drought

In studies reported in 1974, the performance of a number of varieties was compared under simulated drought, and the findings suggest that there is little change in relative performance

among varietal genotypes over a wide range of water stress conditions. However, the potential and strategy for genetic improvement in drought avoidance and tolerance characteristics continues under discussion and analysis. In 1975, a trial was conducted at CIMMYT experiment stations in Mexico (at 1,000 m elevation) during the dry season. A tropical maize genotype (Tuxpeño-1) was chosen because of its broad use and adaptation to the Lowland Tropics; this maize had undergone 11 cycles of selection for reduction in height and improvement in yield and disease resistance (under rainfed and irrigated conditions in the Gulf coast lowlands of Mexico (Veracruz). The population was structured into full-sib families (total 85) as in a conventional breeding program. To economize on seed, plots for each family were 2.5 m x 0.75 m. Each family was grown under three levels of water management: non-limiting, medium, and severe stress. These main treatments were replicated three times.

The water management treatments resulted in grain yields of 6.1 ton/ha (non-limiting; 4.4 ton/ha (medium stress), and 1.5 ton/ha (severe stress). For the medium stress (4.4 ton/ha), the first water application following germination was 10 days after flowering. (The crop had shown visible stress during the three week period before flowering and through flowering that resulted in a 20% reduction in height and some tissue death). There was no subsequent irrigation in the severe stress treatment (1.5 ton/ha), resulting in tissue and plant death during the grain-filling period.

Statistical analysis of the data suggests that there is genetic variation in grain yield at all three levels of moisture stress, and that the relative performance of some families differs between water treatments.

The overall level of reliability of data for the trial is reasonable (coefficient of variation of 23%) considering the limited plot size, but there is a large increase in experimental error as the stress level increases (coefficient of variation of 18, 19 and 45% for non-limited, medium and severe stress, respectively). This is an important factor in considering research effort necessary to detect genetic variation under stress conditions.

The implications of the data are best shown by Table 3.6.4, which lists probable performance of families selected under each of the drought treatments. The selection of the 10 best families based entirely on the information from the well-watered treatment (6.1 ton/ha) shows considerable selection differential in yield potential, with no change from the parent population at the intermediate and low yield levels. A selection of the 10 best families in yield based entirely on the information from the severe stress treatment indicates a large selection differential of (42%) over the mean, with little change at the other two environments. While the experimental error increases rapidly relative to the yield under severe stress, the performance of the selected 10 families would appear significantly better than the population mean. Thus, the data suggest that there are genetic differences in performance under limited moisture conditions.

Further, some of those families selected under non-limiting conditions will perform poorly under medium or high stress conditions. In the selections given in Tables 3.6.4, approximately 30 percent of the families selected under non-limiting conditions yielded significantly less than the mean of the parent population, with the selections performing around the mean under stress conditions.

Conclusive data for genetic variation and interaction for water stress can be obtained from the testing of "synthetic varieties" made from the intercrossing of the families within each of the selected groups, and tested in non-limiting and stressed environments in subsequent years.

3.6.2 AGRONOMY

Agronomy trials were conducted at the experiment stations and at off-station locations to support the genetic improvement program and provide a vehicle for the training of production agronomists. In the experiment station trials, varieties of different maturities and plant morphology were grown at different planting densities as a guide to the management of populations undergoing improvement, and for selection of plant densities for further varietal testing. Trials designed to examine the levels of, and interaction between, management factors of variety, plant density, insecticide application and fertility level were conducted at reasonably uniform sites outside the experimental station. No new series of International Agronomy Trials are planned. Where applicable, the influence of soil nutrient status (nitrogen, pH, water) on varietal interaction will be analyzed from the data of the International Varietal Testing Program.

3.6.2.1 Response of Highland Tropical Maize to Planting Density

Two trials, one at El Batan (2,249 m elevation) the other at Atizapan (2,640 m elevation) were grown in the 1975 summer. Composites of those "Highland Pools" which were more advanced in their improvement and which represented a range in maturity and plant type were selected for study along with locally available improved and unimproved varieties.

Table 3.6.5 shows the results of these trials. At El Batan, the HEWD yielded significantly more than the other two earlier materials, and was similar to HIYD, Puebla Opaque-2, and Hidalgo x Mex. Gpo. 1 (although earlier in maturity than the latter materials). The yield of Composite I (opaque) was not significantly different from H28 (local hybrid check), which was the highest yielding entry.

Yields increased significantly with density increase, and no variety x density interaction was noted. As in the Lowlands, the number of non-ear-bearing stalks contributed to a loss in crop efficiency. In these trials, there was insufficient data to precisely measure tiller contribution to yield. However, the ratio of ears to number of stalks (main stem plus tillers) per plants was 0.55 and 0.44 at the low and medium densities.

Data from this trial provide a predicted optimum density for yield of 65,000 plants/ha; a companion nursery to the IPTT Tropical Highland Advanced Unit will be grown at this density for selections for more efficient families.

The trial at Atizapan was damaged by frost-level night temperatures during the grain filling stage; the effects were more severe on the later maturing materials. The grain yields of some CIMMYT materials were similar to the local variety (Criollo Baraza) and were only a few days later. Yields of all materials increased with increasing plant density; predicted optimum planting density was approx. 68,000 plants/ha.

In drought resistance studies, water tension of the plant leaves was measured to determine stress.

TABLE 3.4.1.-Summary of performance of full sib families developed from Advanced Unit populations. Insect nursery data. MEXICO 1975B

IPTT No.	Testing site*	Mean of resistant lines** Population	Sel. Fam.	Mean of susceptible (rating 4-5) Population	Sel. Fam.
22	PR	3.1	3.2	3.5	3.4
23	PR	3.0	3.0	3.8	3.7
24	PR	3.3	3.2	3.9	3.9
27	PR	3.0	2.8	3.5	3.5
31	PR	3.3	3.2	2.8	2.8
32	PR	3.5	3.5	2.8	2.9
33	TL	3.2	3.0	3.2	3.4
35	PR	3.2	3.3	3.4	4.1
37	PR	4.0	3.9	3.9	3.9
39	PR	3.9	3.7	4.6	4.4
40	PR	4.2	4.1	4.6	4.7
42	TL	3.2	3.0	3.4	3.3
43	PR	3.2	3.2	3.6	3.7
44	PR	3.7	3.6	No data	3.7

* PR = Poza Rica, Mexico; TL = Tlaltizapan, Mexico
** Rating 1 = no disease; 5 = severely infected.

TABLE 3.4.2.-Summary of performance of full sib families developed from Advanced Unit populations (families grown in 5 m. plots without replications, under natural infestation). INSECT NURSERY DATA, POZA RICA, MEXICO 1975B.

IPTT No.	Budworm (Spodoptera frugiperda) Foliar damage rating* Population $\bar{x}$	Sel. Fam. $\bar{x}$	Stem borer (Diatraea spp.) (% damaged internodes) Population $\bar{x}$	Sel. Fam. $\bar{x}$
22	4.8	4.5	27.9	27.5
23	4.9	5.0	30.7	27.2
24	4.4	3.2	30.9	31.7
27	6.0	5.7	27.1	26.8
31	6.1	6.1	21.2	21.4
32	6.2	6.2	20.1	20.5
33	No data	-	No. data	-
35	4.2	4.1	21.9	21.7
37	5.2	5.1	23.8	23.6
39	4.5	4.2	28.6	27.6
40	4.7	4.6	26.3	26.4
42	No data	-	No data	-
43	6.3	6.1	18.5	20.1
44	6.3	6.2	18.4	24.3

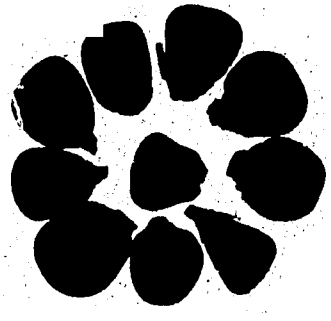
* Rating 1 - 9: 1 = resistant, no leaf damage
9 = highly susceptible.

TABLE 3.4.3. [illegible] Tests Produced from Advanced Test Populations*, [illegible], Mexico, 1978.

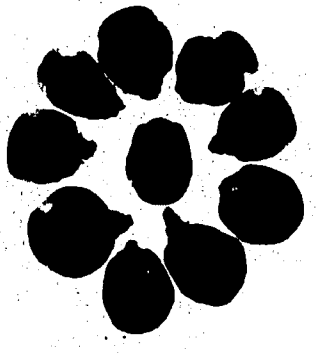
IPTT No.	Testing site**	[illegible] Pop.	[illegible] Mal.	[illegible] Pop.	[illegible] Mal.	[illegible] Pop.	[illegible] Mal.	[illegible] Pop.	[illegible] Mal.	[illegible] Pop.	[illegible] Mal.
22	PR	6955	[illegible]	[illegible]	[illegible]	[illegible]	23.4	0.7	0.8
23	PR	6281	[illegible]	[illegible]	[illegible]	31.7	53.9	0.7	0.7
24	PR	5837	[illegible]	[illegible]	5135	51.2	49.7	0.7	0.8
27	PR	6219	[illegible]	[illegible]	4867	30.2	31.7	0.8	0.8
31	PR	6156	[illegible]	4544	[illegible]	5.9	4.0	0.7	0.8
32	PR	6217	[illegible]	3787	3719	21.5	20.5	0.7	0.8
33	TL	5523	[illegible]	[illegible]	6552	48.3	55.8	0.8	0.9
35	PR	6621	[illegible]	5028	5344	31.9	26.2	0.9	0.9
37	PR	6325	[illegible]	4585	4049	12.4	10.3	0.8	0.8
40	PR	5270	5406	No data	-	58.6	63.9	No data	-
42	TL	9240	[illegible]	7747	8584	11.7	10.0	0.9	0.9
43	PR	6466	7007	3636	3804	61.9	62.4	0.6	0.6
44	TL	9216	[illegible]	No data	-	63.1	62.3	No data	-

* High Density Nursery = 80,000 ptas/ha., normal IPTT yields test = 50,000 ptas/ha.
** PR = Poza Rica, Mexico; TL = Tlaltizapan, Mexico.

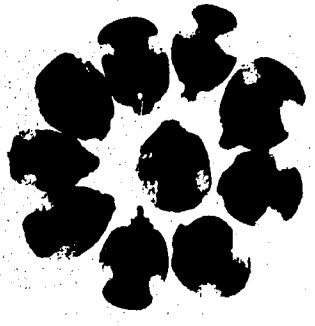
OPAQUE AND MODIFIED PHENOTYPE OPAQUE-2 KERNELS



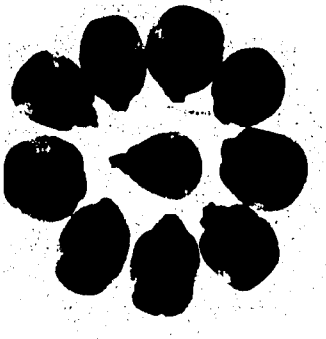
OPAQUE



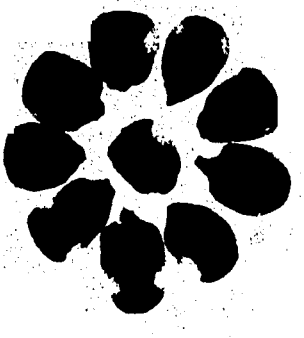
25% VITREOUS



50% VITREOUS



75% VITREOUS



MORE OR LESS NORMAL

TABLE 3.5.1. Conversion of advanced unit materials to opaque-2

IPTT No.	Population	No. of Ears saved F_3 - 1975A	F_4 - 1975B
21	Tuxpeño-1	19	50
22	Mezcla tropical blanca	110	265
23	Blanco Cristalino-1	98	249
24	Ant. x Ver.181	138	266
25	Mix.1- Col.Gpo.1 x Eto	280	250
26	Mezcla Amarilla	214	252
27	Amarillo Cristalino - 1	281	500
28	Amarillo Dentado	255	375
29	Tuxpeño Caribe	246	504
31	Braquíticos	133	247
32	Eto Blanco*	-	-
33	Amarillo Subtropical	25	68
34	Blanco subtropical	32	129
35	Ant. x Rep. Dominicána	-	-
36	Cogollero	38	21
42	Eto x Illinois	7	33
43	La Posta	100	243

* New advanced unit materials

TABLES 3.5.2A,& B.-Conversion of Tropical and Temperate gene pools to opaque-2.

Pool No.	Name	No. F_3 ears saved during 1975A	No. of F_4 ears saved during 1975B
A)	Tropical Pools		
19	Tropical intermediate white flint	182	230
20	Tropical intermediate white dent	148	230
21	Tropical intermediate yellow flint	331	280
22	Tropical intermediate yellow dent	254	280
23	Tropical late white flint	270	230
24	Tropical late white dent	144	185
25	Tropical late yellow flint	269	258
26	Tropical late yellow dent	407	250
	Total	2006	1943
B)	Temperate Pools		
27	Temperate early white flint	36	34
32	Temperate intermediate white dent	22	-
33	Temperate intermediate yellow flint	73	-
34	Temperate intermediate yellow dent	10	23
	Total	130	57

* Same as IPTT-24

** F_3 ears

TABLE 3.5.3. Conversion of Highland corn pools to opaque-2

Pool No.	Name	No. of opaque-2 donors used	No. of F_2 ears saved during 1974	No. of F_2 ears saved during 1975
1	Highland early white flint	3	58	147
2	Highland early white dent	4	68	198
3	Highland early white floury	4	79	205
4	Highland early yellow flint	3	86	270
5	Highland early yellow dent	3	135	292
7	Highland intermediate white dent	4	54	107
8	Highland intermediate white floury	4	180	238
9	Highland intermediate yellow flint	5	105	202
10	Highland intermediate yellow dent	5	230	273
11	Highland late white flint	3	17	24
12	Highland late white dent	4	40	55
13	Highland late yellow flint	3	36	71
14	Highland late yellow dent	1	6	13
	TOTAL		1092	2095

TABLE 3.5.4. Conversion of populations that are being selected for plant efficiency and adaptation.

Serial No.	Material	No. of F_2 ears saved 1975A	1975B
1	Amarillo Bajío	305	344
2	Amarillo Bajío x Varios templados	92	90
3	Amarillo Bajío x Mezcla tropical amarilla	99	112
4	Maíces tropicales selección de Batan	48	57
5	Mezcla Amarilla P.B. x Líneas Illinois	169*	113**
6	Planta Pequeña Mazorca Grande	14	27
	TOTAL	727	743

* F_2 families

** F_2 families

TABLE 3.5.5. CIMMYT'S INTERNATIONAL MAIZE TESTING PROGRAM, 1975

DISTRIBUTION OF IPTT

	POPULATION	SOUTH AMERICA				CENTRAL AMERICA						MEXICO					AFRICA				ASIA															TOTAL
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31				
																					INDIA						PAKISTAN			TURKEY						
		COLOMBIA	ECUADOR	PERU	VENEZUELA	COSTA RICA	EL SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	PANAMA	BATAN	POZA RICA	TLALTIZAPAN	OBREGON	MINIA	EGYPT	TANZANIA	IVORY COAST	NIGERIA	PHILIPPINES	THAILAND	DELHI	HYDERABAD	LUDHIANA	PANTNAGAR	PIRSABAK	YOUSAFWALA	NEPAL	KOAPAZARI	[illegible]	IRAN	
37	TUXPEÑO O_2												X			X	X		X	X	X															8
39	YELLOW H.E. O_2			X				X					X						X			X	X													8
40	WHITE H.E. O_2							X	X				X				X			X	X															8

TABLE 3.5.6.- Summary of performance of full sib families developed from Advanced Unit Populations Data from International Progeny Testing Trials, 1975.

IPTT No.	Site & Expt. Variety		Yield ton/ha.					Plant Height cm.				Days to flower			
			Mean 250 fam.	C.V.	Mean Sel. Fam.	Mean Exp. Var.	Best Check	Mean 250 fam.	Mean Sel. fam.	Mean Expt. Var.	Best Check	Mean 250 fam.	Mean Sel. Fam.	Mean Expt. Var.	Best Check
Tuxpeño-2 37	Sids	7537	5.30	26	5.52	8.60	11.66	283	278	292	330	73	72	73	69
	Perkessedougou	7537	7.73	12	7.98	8.52	10.18	234	229	227	254	62	62	63	65
	Poza Rica	7537	6.22	14	6.51	7.68	7.51	234	230	233	225	61	60	61	62
	Across sites	7537	6.07	-	6.33	7.35	8.80	252	245	253	267	63	62	62	65
Yellow H.E. O_2 39	La Máquina	7539	3.02	25	3.34	4.35	3.96	220	214	211	218	57	56	55	58
	Perkessedougou	7539	6.40	17	6.80	7.87	8.79	256	250	250	250	60	59	60	61
	Poza Rica	7539	4.89	17	5.16	6.36	6.58	258	253	255	245	59	59	59	61
	Across sites	7539	4.77	-	4.84	5.84	6.44	245	243	240	237	59	57	58	59
White H.E. O_2 40	La Máquina	7540	3.20	23	3.54	4.56	5.60	230	227	228	235	56	56	56	56
	Poza Rica	7540	5.27	14	5.61	6.51	8.47	259	234	255	258	59	57	59	60

TABLE 3.5.7.-Experimental varieties developed from three Advanced Unit opaque-2 populations on the basis of 1975 data.

IPTT No.	Population	Location	Exp. Variety
37	Tuxpeño opaque-2	Poza Rica, Mexico	Poza Rica 7537
		Ferkes, Ivory Coast	Ferkes 7537
		Sids, Egypt	Sids 7537
		INIA, Mexico	INIA 7537
			Across 7537
39	Yellow H.E.o_2	Poza Rica, Mexico	Poza Rica 7539
		Ferkes, Ivory Coast	Ferkes 7539
		La Máquina, Guat.	La Máquina 7539
			Across 7539
40	White H.E.o_2	Poza Rica, Mexico	Poza Rica 7540
		La Máquina, Guat.	La Maquina 7540

TABLE 3.5.9.-Opaque-2 materials in the Back-up stages of the program.

S.No.	Population	Cycle of recombination	No. of H.S. ear saved 1975A	1975B	Method of recombination
1	PD(MS)6 H.E.o_2	C_4	567	467	Half-sib
2	CIMMYT H.E.o_2	C_4	619	402	"
3	White opaque-2 Back-up pool	C_3	587	733	"
4	Yellow opaque-2 Back-up pool	C_3	833	743	"
5	Temperate x tropical H.E.o_2	C_3	441	381	"
6	Mat.o_2 Composite	C_3	132	104	"
7	High altitude opaque-2 Comp.	C_3	168	184	"
8	Composite I	C_3	180	245	"
9	Puebla opaque-2 Composite	C_3	144	143	"

TABLE 3.5.8.-Mean grain yield and other agronomic traits of experimental varieties developed by recombining best families from Advanced Unit-opaque-2 populations on the basis of IPTT data 1975.

IPTT No.	Population	Experimental Variety		Grain Yield kg/ha. Pop. $\bar{x}$	Sel. Fam. $\bar{x}$	Checks $\bar{x}$	% Superiority of sel. fam. over population $\bar{x}$	% Superiority of sel. fam. over Check $\bar{x}$	Days to flower Pop. $\bar{x}$	Sel. Fam. $\bar{x}$	Plt. Height in cms. Pop. $\bar{x}$	Sel. Fam. $\bar{x}$
37	Tuxpeño opaque-2	Sids	7537	5305	8602	9736	62.1	-11.6	73	73	283	292
		Ferkes	7537	7727	8521	7291	10.3	16.9	62	63	234	227
		Poza Rica	7537	6225	7681	5857	19.0	31.1	61	61	234	233
		Across	7537	6076	7355	7037	21.1	4.5	63	62	252	253
39	Yellow H.E.o_2	La Máquina	7539	3020	4349	3250	44.0	33.8	57	55	220	211
		Ferkes	7539	6405	7870	7238	22.9	8.7	60	60	256	250
		Poza Rica	7539	4891	6362	4535	30.1	40.3	59	59	258	255
		Across	7539	4773	5843	5086	22.4	14.9	59	58	220	215
40	White H.E.o_2	La Máquina	7540	3201	4561	3238	42.5	40.9	56	56	230	228
		Poza Rica	7540	5270	6511	4959	23.5	31.3	59	59	259	255

TABLE 3.5.10. Materials in the Back-Up stages that are being converted to opaque-2.

Serial No.	Material	No. of F_3 ears saved during 1975A	No. of F_4 ears saved during 1975B
1	Tuxpeño C_{11} x La Posta	296	230
2	Líneas El Salvador	115	93
3	Tuxpeño-Nicarillo x Sint. 10 líneas	56	61
4	Mezcla Amarilla x 8 materiales	19	48
5	(Mix. 1-Col. Gpo. 1 x Eto)x Sint. 10 líneas	89	125
6	Eto x Sint. 10 líneas	95	104
7	Tuxpeño C_7 x Sint. 10 líneas	29	45
8	Amarillo Bajío x Sint. 10 líneas	50	50
9	Amarillo Bajío x Maíces Argentina	55	36
10	Serie Cris.	138	51
11	Thai Composite # 1	126	131
12	Intercrosses among hard endosperm opaque-2 materials	148	72
	TOTAL	1216	1046

TABLE 3.5.11. CIMMYT'S INTERNATIONAL MAIZE TESTING PROGRAM, 1975
DISTRIBUTION OF EVT

TRIAL No.	GROUP OF EXPERIMENTAL VARIETIES	SOUTH AMERICA							CENTRAL AMERICA							CARIBE			MEXICO				AFRICA										ASIA										EUROPE		TOTAL
		ARGENTINA	BOLIVIA	BRAZIL	CHILE	COLOMBIA	ECUADOR	PERU	VENEZUELA	BELIZE	COSTA RICA	EL SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	PANAMA	HAITI	JAMAICA	CUBA	DOMINICAN REP.	GUADELOUPE	PUERTO RICO	TRINIDAD & TOBAGO	MALI	CHAD	EGYPT	ETHIOPIA	GHANA	IVORY COAST	KENYA	MADAGASCAR	MALAWI	MAURITIUS	NIGERIA	R.S. SOUTH AFRICA	SOUTH AFRICA	TANZANIA	UGANDA	ZAMBIA	INDIA	INDONESIA	IRAN	ISRAEL	JAPAN	NEPAL	PAKISTAN	PHILIPPINES	SOUTH VIETNAM	THAILAND	TURKEY	TURKISH A.R.	HUNGARY	YUGOSLAVIA	
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	
15	OPAQUE 2	2	1		1						1	1	1	1	1		1	1	1			1				1		1	1				1			1				1			1	1	1		1							27

TABLE 3.5.12.- Results of Experimental Variety Trial No. 15 during the year 1975

Entry No.	Populations	San Cristobal Bay, Dom. (kg/ha)	La Máquina Guatemala (kg/ha)	Chaparas Honduras (kg/ha)	CIEAT Panamá (kg/ha)	San Andrés El Salvador (kg/ha)	Portoscuela Gen. Ivory Coast (kg/ha)	Gemiza Egypt (kg/ha)	Khumaltar Nepal (kg/ha)	Poza Rica Mexico (kg/ha)	Chapingo Mexico (kg/ha)	Tlaltizapán Mexico (kg/ha)	Nyachipala China (kg/ha)	Bodles Jamaica (kg/ha)	Bowen, Thailand (kg/ha)	Texas/Puerto Rico (kg/ha)	Turrialba Costa Rica (kg/ha)	Rosario/Cruz Bolivia (kg/ha)	[illegible] (kg/ha)	Mean
1	Gemiza 7437	1011	1408	4512	6508	3841	5000	7461	3123	5534	4185	5635	2503	5513	4881	5512	3077	7320	[illegible]	[illegible]
2	Poza Rica 7437	1080	1935	5310	6232	4770	6065	6553	4001	6054	4227	5206	2771	5800	4005	5005	2965	[illegible]	[illegible]	[illegible]
3	Chapingo 7437	965	1672	4861	6720	3839	7288	6429	3865	5081	4246	5270	2956	4741	4856	5024	2905	[illegible]	[illegible]	[illegible]
4	Aurora 7437	1015	1435	5155	5004	4550	6431	5838	5241	5716	4332	5781	3431	4595	4517	5053	3070	[illegible]	[illegible]	[illegible]
5	Delhi 7438	1478	1306	5031	5638	3846	6340	5871	3930	4710	4183	5843	2522	4094	4406	4772	1879	[illegible]	[illegible]	[illegible]
6	Rampur 7438	1148	1319	5715	5736	3976	5800	5505	4005	4898	4321	7364	3583	4122	4683	4640	1511	[illegible]	[illegible]	[illegible]
7	Poza Rica 7438	900	900	5015	5583	3400	5653	6063	4542	4438	4243	7437	2821	3854	4323	5063	1587	[illegible]	[illegible]	[illegible]
8	Delhi 7439	1815	1452	5167	6000	3121	6009	6901	4480	5003	4896	7341	2658	4806	4061	4756	1370	[illegible]	[illegible]	[illegible]
9	Poza Rica 7439	1236	1406	5148	6741	4004	6491	6063	5227	4696	4183	7979	3085	4650	5538	4870	2400	[illegible]	[illegible]	[illegible]
10	San Andrés 7440	1186	1432	4523	6301	4322	6649	6070	5364	4717	4394	8309	2526	3769	4565	5636	2353	[illegible]	[illegible]	[illegible]
11	Rampur 7440	921	1267	4514	5789	3836	5820	6168	4382	4656	3915	6978	2254	4318	4400	5647	1848	[illegible]	[illegible]	[illegible]
12	Poza Rica 7440	1226	1112	4822	5585	3724	5484	6479	4834	4438	4261	7796	2517	4314	4843	5300	2180	[illegible]	[illegible]	[illegible]
13	Cayuta 7441	894	1861	5073	6497	3707	5000	7071	4323	4131	4558	7093	3245	5332	4653	5115	2250	[illegible]	[illegible]	[illegible]
14	Poza Rica 7441	1344	1259	5364	6546	4047	6335	6506	4349	4907	4296	8963	3257	4758	5276	5983	2170	[illegible]	[illegible]	[illegible]
15	Aurora 7441	1137	1482	4546	6330	4387	6510	5833	4697	5101	4109	8557	2963	4925	5444	5819	2400	[illegible]	[illegible]	[illegible]
16	Maíz. Amar. opaque-2	1731	913	4113	5062	4052	5830	7780	4383	4176	4343	7143	2896	4344	4480	4873	2074	[illegible]	[illegible]	[illegible]
17	Mix. 1 x Opa. 1 Rho o_2	1965	1170	5277	5682	4100	6196	6451	4586	4623	4592	7522	2687	4082	4900	5017	2679	[illegible]	[illegible]	[illegible]
18	Amar. Dent. opaque-2	1193	1244	4861	5791	4310	6547	5738	4645	5046	4429	7740	2881	4278	4873	5418	3347	[illegible]	[illegible]	[illegible]
19	Tuxpeño opaque-2	896	1136	4040	4667	3443	5752	4945	3603	3700	2305	6477	2373	3954	3170	5127	1277	[illegible]	[illegible]	[illegible]
20	Var. 181-Ant. 2 x Var. 1 o_2	1488	1272	3971	5324	3210	5346	4945	3468	3727	3321	5867	2650	3923	3219	4422	1394	[illegible]	[illegible]	[illegible]
21	Yellow H.E. o_2	714	927	4333	4339	3983	5078	4822	4615	3778	3213	6068	1733	3623	3897	4840	1655	[illegible]	[illegible]	[illegible]
22	White H.E. o_2	1074	898	4500	5506	3856	5635	3812	4656	4188	4345	6867	3301	3582	4712	5330	3147	[illegible]	[illegible]	[illegible]
23	Compuesto K (H.E.) o_2	1267	1138	4679	5430	3629	5365	5843	3438	4100	3590	7013	2438	3356	4502	4461	1313	[illegible]	[illegible]	[illegible]
24	Check 1 "	3568	850	4621	4867	5732	5329	8367	4880	4228	2802	8960	1803	5268	5358	4777	826	[illegible]	[illegible]	[illegible]
25	Check 2 "	3459	1266	5718	7044	5674	4754	7789	4266	3869	5212	4856	2820	4790	7404	5180	5251	[illegible]	[illegible]	[illegible]
	Means	1356.0	1346.4	4845.9	5913.2	3940.4	5978.4	6195.3	4391.3	4815.4	4090.8	7510.0	2705.8	4442.3	4741.9	5323.2	2199.2	5211.6	3712.2	[illegible]
	L.S.D. (.05)	480	734	1409	794	692	995	2454	889	864	1039	1230	1067	985	907	1289	1157	1298	[illegible]	
	C.V.	24.5	41.7	20.6	9.5	12.4	11.8	28.0	14.3	13.3	18.0	11.6	27.9	15.4	14.9	17.1	37.2	17.1	13.1	

TABLE 3.6.1.-Effect of a 22 day period of 54% shade and exposure to higher radiation at Various developmental stages on the components of yield for Tuxpeño-1 and a temperate hybrid (Pioneer 3369A) (exposure for Tuxpeño only) (Tlaltizapan).

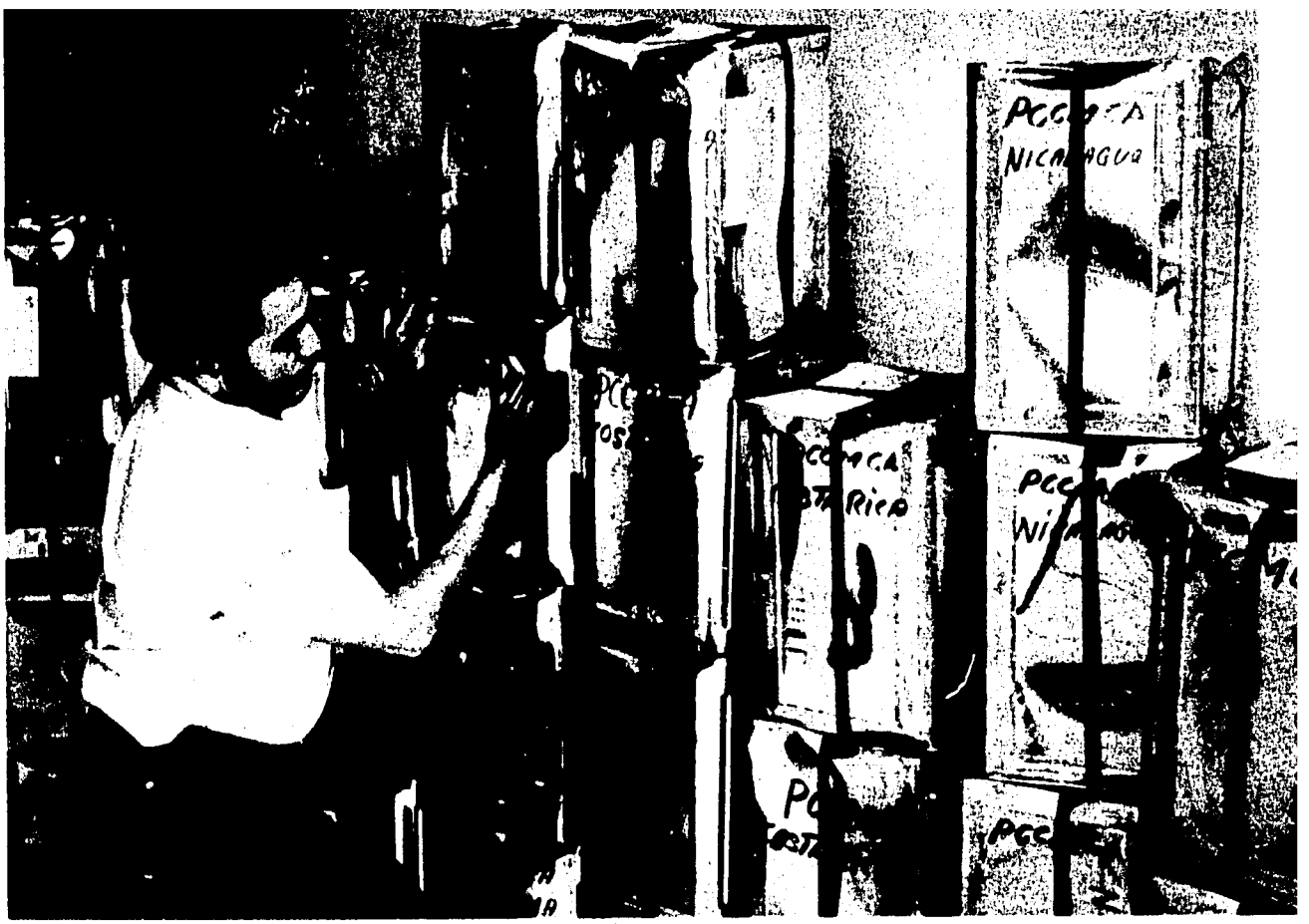
Treatment stage (Days around flowering)	Plant Yield (g)	Change relative to control (%)	Ear Plant Number	Change relative to control (%)	Grain per Ear Number	Change relative to control (%)	Grain Size mgm	Change relative to control (%)
(A) SHADING								
(i) Pioneer 3369A								
-24	103	- 3	1.09	5	407	13	234	9
-12	67	-37	0.97	- 7	270	32	256	0
- 1	40	-64	0.87	-17	171	57	270	5
10	91	-15	1.03	0	346	13	260	1
18	86	-19	1.01	- 3	308	23	277	8
30	87	-19	0.99	- 4	389	2	225	13
41	102	- 4	1.09	5	379	2	247	4
Control	106		1.04		396		257	
(ii) Tuxpeño-1								
-26	91	8	0.98	7	418	3	221	0
-15	73	-13	0.90	- 3	330	-19	241	8
- 4	54	-35	0.78	-16	301	-26	234	5
4	57	-32	0.81	-12	292	-28	243	8
16	60	-28	0.93	1	359	-12	214	4
27	72	-14	0.85	- 8	360	-12	194	13
38	79	- 5	1.03	11	383	- 6	203	9
Control	84		0.92		405		223	
(B) EXPOSURE								
Tuxpeño-1								
23	155	4	1.22	4	510	5	249	- 5
12	152	20	1.19	4	491	0	260	3
0	134	25	1.15	8	493	17	253	- 8
10	112	17	1.07	10	419	2	271	13
32	97	8	0.97	0	407	- 7	242	16
Control	89		0.97		435		209	

TABLE 3.6.2.-Effect of tassel and leaf removal at different growth stages on the grain yield per plant (g) of Tuxpeño-1 and Eto x Illinois grown at different plant densities (Tlaltizapan).

Manipulations	Final Plant Density (Plt./ha^{-1}) 80,000		10,000	
	Developmental stage of treatments (Days before flowering)			
	20	10	20	10
(A) Tuxpeño-1				
Control	78.0	86.1	131.9	124.6
Tassel removal	96.5	100.2	121.2	115.8
Leaf removal	87.3	87.3	115.1	127.4
(B) Eto x Illinois				
Control	84.2	86.8	111.7	104.5
Tassel removal	67.4	84.3	82.0	102.8
Leaf removal	71.0	78.4	105.3	89.0

TABLE 3.6.2.-Variation between and within populations of tropical maize for morphological characters probably associated with yield efficiency (Data for 250 families in each population) (Poza Rica).

Morphological character	Tuxpeño-1(IPTT-21)			Eto Blanco(IPTT-32)			Ant. x Dom. Rep. (IPTT-35)		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Manimum	Minimum	Mean
Flowering delay (days)	3.0	-0.5	1.12	4.0	0.0	1.38	3.0	-0.5	0.73
"Barrenness" (Ear per plant at 80,000 plt/ha-1)	1.28	0.20	0.69	1.13	0.32	0.69	1.28	0.40	0.89
Tassel Branch number	29.7	10.3	18.0	28.0	13.0	19.8	30.2	10.0	18.8
Leaf length (ear leaf) cm	110.0	84.2	96.5	110.1	88.2	99.0	101.1	79.7	91.0
Leaf width (ear leaf) mm	11.6	8.1	9.6	11.1	8.3	9.6	10.6	7.70	8.9
Leaf number above ear	7.4	5.4	6.2	7.7	5.3	6.3	6.8	4.6	5.8
Leaf area above ear (dm^2 per plant)	71.5	43.9	57.4	78.1	43.6	59.6	60.6	23.4	45.9
Density of foliage above ear ($cm^2 cm^{-1}$)	83.0	38.0	57.1	92.0	42.0	58.4	63.0	32.8	46.1
Grain yield per leaf area above the ear (g/dm^2)	2.93	0.94	1.88	2.59	0.91	1.83	4.25	1.14	2.33



Scientists in 45 countries cooperated in the international trials.

FIGURE 3.8.1. THE EFFECT OF A SINGLE FEMOR OF 20 DAYS WITH 20 PERCENT SHADING OF THE CROP AT DIFFERENT STAGES OF DEVELOPMENT ON THE GRAIN YIELD OF A TROPICAL LOWLAND VARIETY (TUXPEÑO-1) (SOLID SYMBOLS) AND A TEMPERATE HYBRID (OPEN SYMBOLS) GROWN AT TLALTIZAPAN, MORELOS DURING THE WINTER SEASON

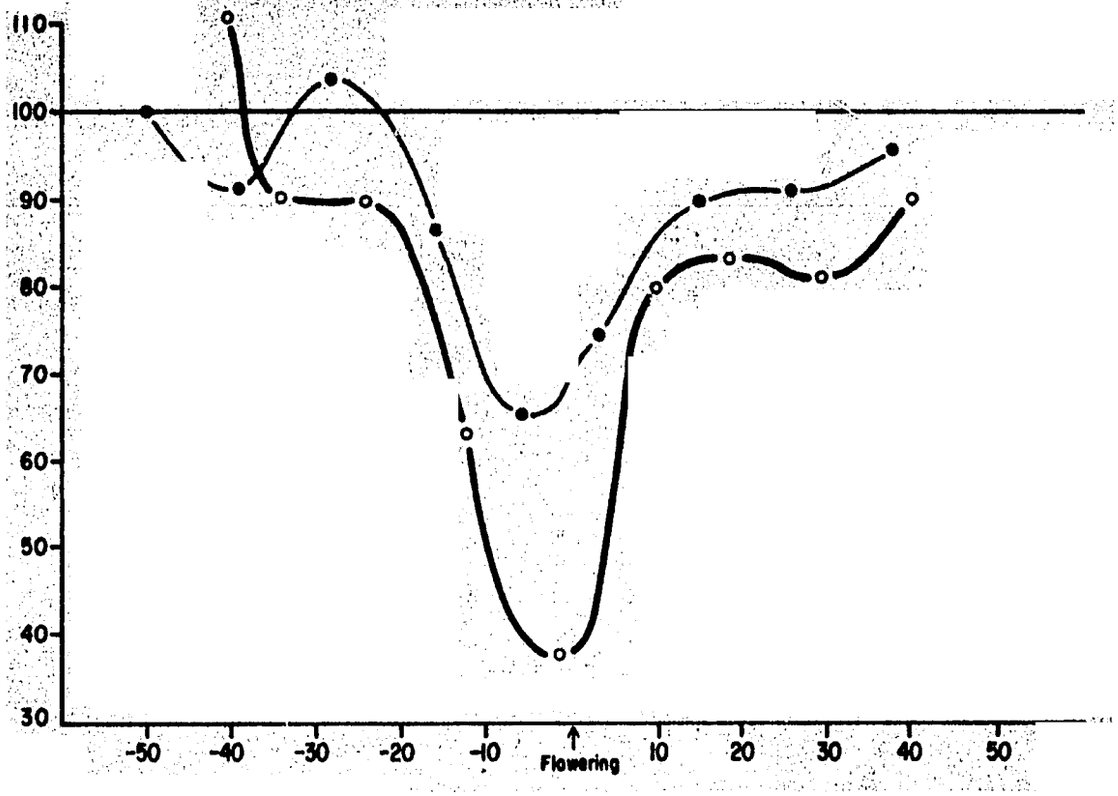


FIGURE 3.8.2. DEVELOPMENT OF GRAIN PRIMORDIA (TRIANGULAR SYMBOLS) AND EAR DRY WEIGHT (RECTANGULAR SYMBOLS) OF THE PRIMARY EAR IN A TROPICAL LOWLAND VARIETY (TUXPEÑO-1) (SOLID SYMBOLS) AND A TEMPERATE HYBRID (PIONEER 3388A) (OPEN SYMBOLS) GROWN AT TLALTIZAPAN DURING WINTER SEASON

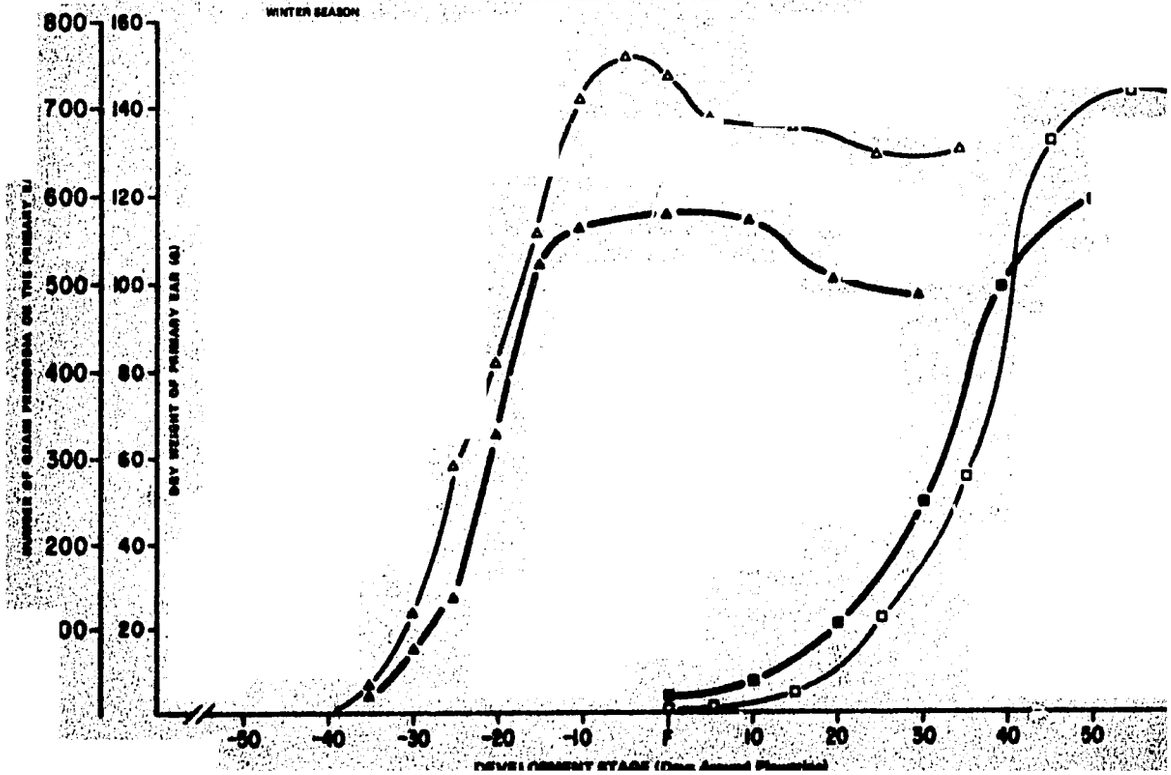


TABLE 3.6.3.

THE PATTERN OF SUGAR ACCUMULATION DURING THE GRAIN FILLING PERIOD IN THE STEMS OF A TROPICAL LOWLAND VARIETY (TUXPEÑO-1) GROWN AT TLALTIZAPAN DURING THE WINTER SEASON

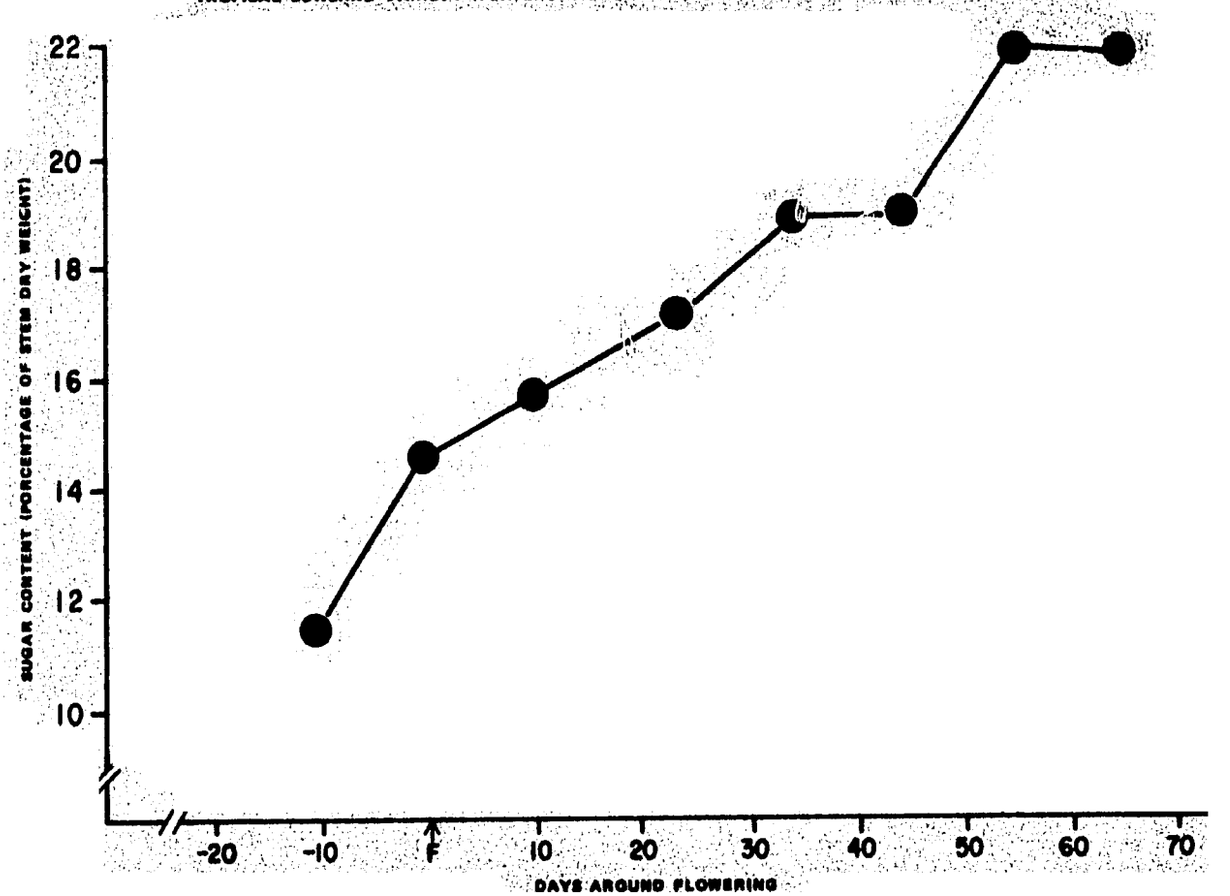


TABLE 3.6.4.-Performance of families selected under various levels of water stress.

Selected family	Yield (kg/ha^{-1}) No-stress	Medium stress	Severe stress
(i) Selection under no-stress			
25	7438	5014	1706
27	6428	4315	856*
28	7311	4383	830*
43	6676	3971*	1832
47	7120	3349*	1049
59	6819	4179	1550
63	6836	5376	1235
74	7904	5336	1933
81	6764	3572*	1320
83	6631	4835	1890
Selection $\bar{x}$	7010	4433	1419
Population $\bar{x}$	6120	4330	1557
Selection differential	14.5	0	-1.0
(ii) Selection under medium stress			
9	5635*	5035	1608
23	6515	5481	2341
25	7438	5014	1706
32	6213	5017	2332
62	5869	5064	1268
63	6836	5376	1235
67	6188	5026	1415
74	7904	5336	1933
76	6292	5021	1891
82	5619*	5066	1176
Selection $\bar{x}$	6450	5143	1690
Selection differential	5.0	19.0	8.6

TABLE [illegible] [illegible] selected water-[illegible]

Selected family	No stress	[illegible] stress	Severe stress
	(kg/ha⁻¹)		
(iii) Selection under severe stress			
13	[illegible]	[illegible]	2208
19	[illegible]	[illegible]	1777
26	6217	[illegible]	1877
30	[illegible]*	[illegible]	2150
32	6213	5017	2332
34	[illegible]*	4104	2456
54	[illegible]*	4906	1690
66	6443	4633	2032
74	7904	5336	1933
84	6596	4202	2654
Selection $\bar{x}$	6175	4423	2111
Selection differential	0	0	36.0

Selected family	No stress	[illegible] stress	Severe stress
(iv) Selection across all levels of stress			
13	5980	4683	2202
23	6515	5481	2341
26	6217	4555	1877
49	6643	4921	2036
60	6686	4584	1544
66	6443	4633	2032
67	6188	5026	1415
70	7003	4545	1196
74	7904	5336	1923
84	6596	4202	2654
Selection $\bar{x}$	6643	4796	1923
Selection differential	8.6	10.8	23.8

Significantly less than the population mean.

TABLE 3.6.5.A.- The performance of a number of Tropical Highland materials grown at three densities at El Batan.

Variety	Yield (ton/ha)	Days to Silking	Plant Ht. (cm)	Lodging %	Tillering No./plt.	Rotten Ears (%)	Ears per plant	Grain per ear	Grain size (mgm)
Variety	**	**	**	**	**	**	N.S.	**	**
HEWD (Pool 2 - IPTT 52)	6.50	79	237	7	1.0	12	1.20	300	287
HEWF (Pool 3 - IPTT 53)	5.78	84	253	7	1.4	15	1.26	246	493
HEYF (Pool 4 - IPTT 54)	5.88	80	235	7	1.2	18	1.37	359	287
HIYD (Pool 10 - IPTT 60)	6.47	87	245	3	1.5	16	1.33	431	265
Puebla Opaque-2	6.33	91	268	11	1.9	8	1.21	404	294
Composite I	6.71	96	280	18	2.5	3	1.42	522	223
Hidalgo 8 x Mex. Gpo.10	6.55	96	256	14	2.2	0	1.27	470	235
H28 (Local)	6.84	91	295	3	1.3	3	1.25	444	289
Pioneer 3369A	4.69	96	223	0	0.2	15	1.28	418	203
SE	0.20	2	4	1	0.2	2	-	15	7
Density (plants/ha^{-1})	**	*	**	N.S.	**	N.S.	**	**	N.S.
26,700	5.36	87	242	8	2.3	9	1.81	391	292
56,850	6.41	90	260	7	1.5	9	1.11	431	283
87,200	6.81	90	260	8	0.9	11	0.98	408	283
SE	0.12	1	3	-	0.1	-	0.05	8	-
Variety x Density	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

TABLE 3.6.5.B.- The performance of a number of Tropical Highland materials grown at three densities at Atizapan.

	Yield (ton/ha)	Days to Silking	Plant Ht. (cm)	Lodging %	Tillering No. per plant	Rotten ear (%)
Variety	**	**	**	**	**	**
HEWD (Pool 2 - IPTT 52)	4.98	108	208	20	1.52	13
HEWF (Pool 3 - IPTT 53)	5.50	107	211	31	1.55	10
HEYF (Pool 4 - IPTT 54)	5.30	110	202	33	1.18	15
HIYD (Pool 10 - IPTT 60)	3.92	119	215	25	1.31	23
Puebla Opaque-2	3.85	123	219	31	1.68	18
Composite I	3.65	135	223	34	2.00	11
Hidalgo 8 x Mex. Gpo.10	3.75	137	236	43	1.96	4
H 28 (Local)	5.52	121	214	7	0.85	8
Criollo Baraza (Local)	5.58	102	205	37	1.25	8
SE	0.27	3	5	10	0.08	2.0
Density (plants/ha^{-1})	**	N.S.	N.S.	**	**	**
27,500	3.89	116	215	10	1.67	9
50,000	4.81	117	219	45	1.50	14
74,200	5.31	120	210	60	1.10	13
SE	0.16	-	-	15	0.05	1
Variety x Density	N.S.	N.S.	*	N.S.	**	**
SE	-	-	8	-	0.15	3

4.0 Back-up Operations: 1975

4.1 INTRODUCTION

The Back-up unit brings together and develops germplasm complexes, or Pools, that meet the requirements of most maize-growing areas in the world (Table 4.1.1). Pools have been developed for Highland, Lowland, and Temperate regions, and are classified according to maturity (early, intermediate, and late), grain texture (flint, dent, and floury), and color (white and yellow). Introduction nurseries of germplasm from throughout the world, along with observation nurseries and yield trials of CIMMYT's germplasm bank accessions, are conducted each cycle in Mexico to identify materials for use in the Pools. After 3 to 4 cycles of recombination, Pools are evaluated to identify progenies for incorporation into the Advanced unit populations. Thus, there is a continuous flow of germplasm from the bank and national programs through the Back-up unit to the Advanced unit.

4.1.1 GERMPLASM BANK

In 1975, the maize germplasm bank continued the maintenance and evaluation of over 8,000 accessions and fulfilled requests for 5,250 items. Table 4.1.2 shows the populations and amounts of seed held in the bank at the end of 1975. Table 4.1.3 summarizes the shipments made during the year. Of the 2,602 samples shipped to the U.S.A. during the year, 2,032 were sent to the U.S. National Seed Storage Laboratory at Fort Collins, Colorado, for long term storage. The remaining were supplied to individual researchers upon request.

In 1975, the remaining data for the Maize Germplasm Bank catalog was keypunched and a preliminary working catalog was produced in October by the GR/CIDS group at the University of Colorado. The catalog requires some final adjustments, and will be updated as new information is available from evaluation trials and as new accessions are added to the bank. This catalog and the bank inventory listing, will be held at both Colorado and CIMMYT, where computer facilities will allow rapid and easy access to all information.

A total of 2,048 composites and groups were evaluated in four replicated trials at Poza Rica. Superior materials were improved further in the breeding nursery and will be included in the appropriate Lowland pools.

4.2 POOLS

During 1975, each of the 16 Lowland and Temperate pools was advanced through two more cycles of recombination and selection. The Highland pools complete only one cycle a year. Each pool consists of approximately 450 families planted in a half-sib recombination block. All of the family rows and substandard male plants are detasseled before pollen shed. At harvest, selection is made for plant height, and for high yield, early maturity, good standability, and increased insect and disease resistance. Initially, selection is on a family basis with a final selection of best plants within the selected families. Each selected ear is planted as a female row in the next cycle, but only the best selections are included in the next cycle's male composite. The present characteristics of the Pools are shown in Table 4.1.1.

In 1974, Pools 4,5,8, and 10 were represented in two locations. They were merged in 1975, but (like the other pools) they will continue to be tested at more than one location to maintain the wide adaptation.

Considerable gains have been made in developing earliness and short plant type in the early Lowland pools (15 and 18), but progress has been slower in increasing yield and disease resistance. To overcome such problems, these pools were crossed with selected families from the Advanced unit populations and other materials (Table 4.1.4). After a few cycles of recombination, selection will be made for all desirable attributes in these pools. Progress has been made in the formation of a brachytic-2 pool designed for areas where lodging is prevalent.

Pools 21 (TIYF), 22 (TIYD), 23 (TLWF), and 24 (TLWD) were tested in 1975 to identify families for use in the Advanced unit. Replicated yield trials were conducted at Poza Rica, Obregon and Tlaltizapan; with inoculated disease and insect trials at Poza Rica. The results are summarized in Table 4.1.5. The selected families from individual pools will be moved into appropriate Advanced unit populations in 1976. The broad range of climates and soils under which the yield trials were made should ensure that the selected families are widely adapted.

TABLE 4.1.- Back-Up Pools - 1975

No.	Name 1/	Abbreviation	No. of families	Days to 50% silking 2/	Plant Height (cm) 2/	Location Grown
	HIGHLAND					
1	Early White Flint	HEWF	212	76	199	Batan & Toluca
2	Early White Dent	HEWD	521	80	214	Batan & Toluca
3	Early White Floury	HEWfl	350	84	214	Batan & Toluca
4	Early Yellow Flint	HEYF	582	73	208	Batan & Toluca
5	Early Yellow Dent	HEYD	614	78	199	Batan & Toluca
6	Intermediate White Flint	HIWF		Not Formed Yet		
7	Intermediate White Dent	HIWD	484	88	231	Batan & Toluca
8	Intermediate White Floury	HIWfl	462	84	233	Batan & Toluca
9	Intermediate Yellow Flint	HIYF	314	87	218	Batan & Toluca
10	Intermediate Yellow Dent	HIYD	1267	84	209	Batan & Toluca
11	Late White Flint	HLWF	205	103	243	Batan & Toluca
12	Late White Dent	HLWD	388	98	243	Batan & Toluca
13	Late Yellow Flint	HLYF	296	100	238	Batan & Toluca
14	Late Yellow Dent	HLYD	287	97	235	Batan & Toluca
	TROPICAL					
15	Early White Flint	TEWF	244	52	-	Poza Rica
16	Early White Dent	TEWD	135	52	-	Poza Rica
17	Early Yellow Flint	TEYF	249	51	-	Poza Rica
18	Early Yellow Dent	TEYD	191	51	-	Poza Rica
19	Intermediate White Flint	TIWF	323	55	207	Poza Rica
20	Intermediate White Dent	TIWD	288	57	195	Poza Rica
21	Intermediate Yellow Flint	TIYF	249	55	216	Poza Rica
22	Intermediate Yellow Dent	TIYD	269	59	215	Poza Rica
23	Late White Flint	TLWF	790	58	213	Poza Rica
24	Late White Dent	TLWD	455	59	192	Poza Rica
25	Late Yellow Flint	TLYF	444	57	214	Poza Rica
26	Late Yellow Dent	TLYD	357	58	216	Poza Rica
	TEMPERATE					
27	Early White Flint	TmEWF	403	57	227	Tlaltizapan
28	Early White Dent	TmEWD		Not Formed Yet		
29	Early Yellow Flint	TmEYF		Not Formed Yet		
30	Early Yellow Dent	TmEYD		Not Formed Yet		
31	Intermediate White Flint	TmIWF		Not Formed Yet		
32	Intermediate White Dent	TmIWD	351	65	240	Tlaltizapan
33	Intermediate Yellow Flint	TmIYF	463	60	230	Tlaltizapan
34	Intermediate Yellow Dent	TmIYD	372	63	230	Tlaltizapan

1/ See 1973 Annual Report for germplasm used.
2/ Data presented on highland pools were collected at El Batan only and on the tropical and temperate pools on the indicated locations in 1975 summer season.

TABLE 4.2.- Populations held by the germplasm bank.

Species	Population	Number	Kg's Seed
Maize	Collections	7,300	34,210.03
	Groups	627	4,315.77
	Composites	172	788.28
	Total	8,099	39,314.08
Teosinte	Collections	86	196.68
	Total	8,185	39,510.76

TABLE 4.3.-Destination and number of seed shipments handled in 1975.

Destination	No. shipments	No. kinds
Argentina	1	631
Australia	2	56
Brazil	4	976
Bulgaria	1	56
Canada	2	2
Colombia	1	27
Costa Rica	2	61
Czechoslovakia	1	3
Dominican Republic	1	53
England	5	84
Finland	1	5
Ghana	1	107
Holland	2	201
India	1	8
Indonesia	1	1
Mexico	14	532
New Zealand	1	7
Nicaragua	2	65
Nigeria	3	234
Peru	1	2
Puerto Rico	1	40
Romania	1	131
Spain	1	4
Switzerland	1	11
Togo	1	16
USSR	1	25
USA	16	2002
TOTAL	71	5250

TABLE 4.4.-Materials used to improve the yield and disease resistance in tropical early pools (Posa Rica 1975 summer season).

Female: (selected families from) PB-75A	Male (Balanced composite of selected families from)
Pool 15 (TEWF)	Blanco Cristalino-1 Eto Blanco Comp. blanco Pfister x varios tropicales (Tuxp. x Nicarillo) Sint.10 Lin.(White flint segregates) (Mix.1 Col.Gpo.1) (Eto x Sint.10 Lin.)(White flint segreg.) Eto Blanco x Sint. 10 Lin. (White flint segregates).
Pool 16 (TEWD)	Tuxpeño-1 Mezcla Tropical Blanco Tuxpeño Caribe (Mix. 1 Col.Gpo.1) Eto
Pool 17 (TEYF)	Amarillo Cristalino-1 Mezcla Amarilla (Tuxp.x Nicarillo)Sint. 10 Lin.(Yellow flint segregates) (Mix.1 Col.Gpo.1)(Eto x Sint.10 Lin.)(Yellow flint segreg. Eto Blanco x Sint. 10 Lin.(Yellow flint segregates)
Pool 18 (TEYD)	Amarillo Dentado-1 Amarillo Dentado-2 Ant. x Rep. Dominicana Amarillo Dentado Sel. Misc. P.B.

TABLE 4.5.-Performance of four pools in yield, insect and disease trials in Mexico 1975 Summer Season

Material	Data Used	Posa Rica Yield 1/ (kg.)	Posa Rica Days to flower	Posa Rica Plant Ht.(cm)	Tlaltizapán Yield 1/ (kg.)	Tlaltizapán Days to flower	Tlaltizapán Plant Ht.(cm)	Obregón Yield 1/ (kg.)	Obregón Days to flower	Obregón Plant Ht.(cm)	Disease and Insect Nursery 1/ Fall army worm 2/ damage	Borer 3/ damage	Stalk 4/ rot	Ear 5/ rot	No. Sel. fams.
Pool 21	$\bar{x}$ Pop.	5680	58.6	234	8472	69.4	260	4372	63.2	254	2.6	22.1	4.4	3.1	18
	$\bar{x}$ Sel.Fam.	6400	58.6	221	8890	69.4	254	4674	62.9	248	2.3	19.0	4.6	3.0	
Pool 22	$\bar{x}$ Pop.	5906	59.5	234	7408	72.0	254	4064	63.5	258	3.8	22.3	4.1	3.7	19
	$\bar{x}$ Sel.Fam.	6583	59.1	230	8335	71.8	254	4529	62.0	256	3.6	19.5	4.1	3.4	
Pool 23	$\bar{x}$ Pop.	6450	60.0	230	7856	70.5	260	3793	65.2	251	4.6	19.9	4.0	3.8	18
	$\bar{x}$ Sel.Fam.	7163	59.2	226	9271	69.1	261	4610	63.7	244	3.8	15.6	3.9	3.4	
Pool 24	$\bar{x}$ Pop.	6424	61.0	229	7790	74.3	259	4610	65.0	258	4.2	20.4	3.8	4.3	15
	$\bar{x}$ Sel.Fam.	7172	60.4	223	9247	72.6	259	5471	63.0	253	3.8	17.4	3.7	4.1	
Tuxpeño 1		5758	62.0	223	7702	71.0	260	3585	63.0	236	4.6	15.0	3.8	4.5	Check 6/
Tuxpeño Caribe		6860	60.8	227	9171	72.0	259	3739	67.5	251	5.3	20.2	4.3	4.0	Check 6/
Mezcla Amarilla		4187	59.3	229	5849	69.3	254	3607	62.0	251	3.8	21.4	4.8	3.5	Check 6/
Amarillo Dentado		5475	60.0	229	7371	71.0	258	4900	63.5	258	3.5	22.7	4.1	3.3	Check 6/
H509		5331	62.8	218	--	--	-	--	--	--	3.5	16.5	4.3	4.5	Check 6/
H412		--	--	-	5729	76.5	241	2756	62.0	263	-	--	-	-	Check 6/

1/ Conducted at Posa Rica station only.
2/ 15% moisture
3/ Recorded on a 1 to 9 scale
4/ Recorded as percentage internodes damaged
5/ Recorded on a 1 to 5 scale.
6/ Performance averaged over the four pools.

4.3 FLOURY MAIZE

The development of cool climate (or high altitude) floury endosperm populations was emphasized in 1975. The only pools previously defined were: the early maturity white floury Pool 3, and intermediate maturity white floury Pool 8. Other basic germplasm complexes were assembled to make contributions to the production patterns in the higher mountain Andean Zone areas. These complexes included yellow kernel floury endosperm, and additional crosses of opaque-2 into the floury maize types.

Much of the soft endosperm floury maize grown in the Andean area is used directly as human food. A substantial part is eaten as green corn (roasting ears, boiled corn, soups, etc.), where the maize is handled primarily as a perishable vegetable, rather than as a cereal grain. Preferences vary for kernel size, shape, colors and flavor.

In 1975, work focused on providing yellow grain populations, and on enlarging the range of early maturity germplasm to be fed into the different preferred grain types. Since the crop is being grown as a perishable, and most of the varieties have relatively very long season maturities, there is limited flexibility in marketing over an extended period of the year. Maize varieties with substantially shorter growing cycles (early maturities) should be helpful in modifying the marketing season of such corn, and in providing additional alternatives in cropping patterns.

In seeking such varieties in 1975, the following materials were handled:

- Composite of Cacahuacintle race from Mexico.
- Broad mixture of the yellow kernels found in the floury 1 populations grown at Batan and Toluca during the last three years, including those from Mexico and the Andean Zone collections.
- Crosses of floury varieties with the very early maturity high altitude germplasm (examples: Precoz Titicaca-Bolivia. San Gerónimo-Perú. Group E Toluca 1974. Floury collections - Chihuahua).
- Large kernel varieties (including Hickory King from Zaire, Maiz Ancho from Morelos, Mexico, Cuzco and Chillos from the Andean Zone) were intercrossed as a kernel size component.
- Existing crosses of all the above materials with opaque-2 sources were advanced and additional crosses were made.

Approximately 2 ha. of these highland maizes were planted in collaboration with INIAP at the Santa Catalina Experiment Station, Ecuador, to begin selection for suitability in that area.

5.0 Collaborative Research for Pest Resistance: a Multicontinental Operation

Working in cooperation with national programs throughout the world, CIMMYT continues to improve plant resistance to maize pests of regional or world-wide importance. These pests include: Downy mildew (Sclerospora spp.) in Southeast Asia, now becoming a serious threat in Africa and America; corn stunt (Spiroplasm) disseminated by insect vectors (Dalbulus spp.) in Central America and the Caribbean Region; and maize streak (virus) also disseminated by insect vectors (Ciccadulina spp.), in Equatorial Africa.

Corn stunt has been known and studied for relatively few years; however, it is known that many of the common maize varieties in the Dominican Republic are reasonably tolerant to the causal agent, whereas most of the materials in Mexico and Central America are susceptible. One interpretation of this finding is that the disease has existed for a long time in the Dominican Republic, and natural selection has increased the levels of tolerance in the surviving materials. Similarly, downy mildew has existed for many years in the Philippines, and has forced the accumulation of genetic factors that provide sufficient field tolerance to permit continued cultivation of the varieties found there.

In both stunt and downy mildew, introduction of unselected, susceptible materials from other areas results in nearly complete loss of the materials. Studies made thus far suggest that a number of genes are involved in conferring resistance to both diseases. The downy mildew resistant Philippine sources, which have evolved for the most part under natural selection, have shown high levels of resistance to Sclerospora spp. in many countries where they have been tested; however, agronomically, they require considerable improvement.

Protection against maize streak virus in Africa usually has been obtained by planting the crop at dates that give lowest infection rates. It has been possible to utilize a form of natural escape phenomenon to continue growing the crop. Resistance to the virus has been reported; but as yet, little deliberate breeding for resistance has been done. Substantial restrictions exist in terms of times and areas of planting, as well as in direct yield loss as results of the disease.

Resistance sources to the causal agents and to the insect vectors are being examined for both stunt and streak. Attempts to introduce germplasm from other areas (that may have better yield potential or other desirable attributes) into the areas affected with these diseases will require development of acceptable levels of the appropriate disease resistance. After the genetic factors for the disease resistance and the other desired characters have been combined into a single population, recombination of the desired traits can be directed toward locating the individuals that carry all of the desired attributes.

Among the factors to be taken into account are: (1) resistance to these diseases appears to be quantitative; however, monogenic resistance is reported (in Taiwan) for streak virus, and also for downy mildew; (2) recovery of an acceptable level of disease resistance will require several cycles of selection under conditions of appropriate occurrence of the disease in the plantings under selection; and (3) large numbers of plants must be employed to assure reasonable chances of recovery of recombinant individuals having all of the desired attributes. Thus, during the 1975A season, the tropical and subtropical populations, pools and other materials undergoing improvement in CIMMYT's program were crossed to the Philippines downy mildew resistant sources. In addition, three Lowland Tropical materials, designated as base populations for this program were crossed to downy mildew and stunt resistant donors (Table 5.1). The base materials include: (1) a white dent population; (2) a white flint population, and (3) a yellow flint-dent population. In the 1975B season (August-September sowing), the following studies were underway:

- Downy mildew resistance was to be selected in cooperation with Kasetsart University, Thailand and the University of the Philippines.
- Resistance to corn stunt was being studied in cooperation with The Centro Nacional de Tecnología Agropecuaria, El Salvador; and The Centro Experimental Agropecuario "La Calera", Nicaragua.
- Resistance to maize streak was being sought in cooperation with The International Institute of Tropical Agriculture, Nigeria and The Ilonga Agricultural Experiment Station, Tanzania.

TABLE 1.1.- Maize materials undergoing evaluation and selection for Downy Mildew, Stem, Tassel resistance in El Salvador, Honduras, Nicaragua, Panamá, Paraguay, Guatemala and Venezuela.

Genealogy	Origin	No. of Rows
	TL-75-A	
1. Pool 16-TEWD x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-1	25
2. Pool 15-TEWF x Phil. DMR 2-4-6, Comp. 2.	Lote 129-132-2	25
3. Pool 20-TIWD x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-3	25
4. Pool 19-TIWF x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-4	25
5. Pool 24-TLWD x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-5	25
6. Pool 23-TLWF x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-6	25
7. IPTT-21, Tuxpeño 1 x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-7	25
8. IPTT-22, Tuxpeño Caribe 1 x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-8	25
9. IPTT-29, Tuxpeño Caribe 2 x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-9	25
10. IPTT-31, Braquíticos x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-10	25
11. IPTT-35, IDRN x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-11	25
12. IPTT-36, Cogollero x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-12	25
13. IPTT-43, La Posta x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-13	25
14. IPTT-44, AED-Tuxp. 1 x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-14	25
15. IPTT-22, Mes. Trop. H. x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-15	25
16. IPTT-23, Blanco Crist. 1 x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-16	25
17. IPTT-25, (Mix. 1 x Col. Gpo. 1) ETO x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-17	25
18. IPTT-32, ETO Blanco x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-18	25
19. Tuxpeño - 19 materials x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-19	25
20. (Tuxpeño 1 - La Posta x Inv.-Ver) x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-20	25
21. (Pfister Hybrids, S.S., Cuba, etc.) x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-21	25
22. Compuesto Caribe sel. bl. x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-22	25
23. (Kenya x Katanga) Tuxpeño 1 # x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-23	25
24. Cruzas familias selectas E-1 x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-24	25
25. Cruzas familias selectas E-512 x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-25	25
26. (Líneas E.S. x Varios) x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-26	25
27. (Tux. x Mic.) Sint. 10 líneas x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-27	25
28. (Mix. 1 x Col. Gpo. 1) x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-28	25
29. Cruzas Entre Crist. bl. x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-29	25
30. Selec. hojas Angostas x Phil. DMR 2-4-6, Comp. 2	Lote 129-132-30	25
31. Comp. bl. IACP-CA, bl x Comp. 2	Lote 129-132-31	25
32. Cruzas Material Zaire x Comp. 2	Lote 129-132-32	25
33. Rosacée largo del día x Comp. 2	Lote 129-132-33	25
34. (ETO x Sint. 10 líneas sel. bl.) x Comp. 2	Lote 129-132-34	25
35. (Tuxp. x Sint. 10 líneas sel. bl.) x Comp. 2	Lote 129-132-35	25
36. (Ph. 1. precoces x tardíos) x Comp. 2	Lote 129-132-36	25
37. Comp. bl. India y SE Asia x Comp. 2	Lote 129-132-37	25
38. IPTT 38, Blanco Sub. Trop. x Comp. 2	Lote 129-132-38	25
39. Compuesto Mundial (WC) x Comp. 2	Lote 129-132-40	25
40. Ilonga Comp. (Tanzania) x Comp. 2	Lote 129-132-44	25
41. Kitale 11 (Kenya) x Comp. 2	Lote 129-132-45	25
42. [illegible] x [illegible]/CTDMYT-Zaire x Comp. 2	Lote 129-132-61	25
43. (Mix. 1 x Col. Gpo. 1) ETO-Sint. 10 lin. x Comp. 2	Lote 129-132-63	25
44. (Tuxp. x Sint. 10 líneas) x Comp. 2	Lote 129-132-64	25
45. (Am. Sugh x Sint. 10 lin.) x Comp. 2	Lote 129-132-65	25
46. Mexican Sugar x Comp. 2	Lote 129-132-66	25
47. Pioneer Sorg. Sup. Dent. x Comp. 2	Lote 129-132-67	25

TABLE

	Genealogy	Origin	No. of Ro
		TL-75-A	
48.	Precoces blancos Indonesia x Comp. 2	Lote 120-132-[illegible]	25
49.	Pool 18, TEYD x Phil. DMR 1-3-5, Comp. 1	Lote 133-136-1	25
50.	Pool 17, TEYF x Comp. 1	Lote 133-136-2	25
51.	Pool 22, TIYD x Comp. 1	Lote 133-136-3	25
52.	Pool 21, TIYF x Comp. 1	Lote 133-136-4	25
53.	Pool 26, TLYD x Comp. 1	Lote 133-136-5	25
54.	Pool 25, TLYF x Comp. 1	Lote 133-136-6	25
55.	IPTT 27, Am.Cristalino 1 x Comp. 1	Lote 133-136-7	25
56.	Am. Crist. 1-Thai Comp. x Comp. 1	Lote 133-136-8	25
57.	IPTT 30, Am. Dentado 1 x Comp. 1	Lote 133-136-9	25
58.	IPTT 29, Am. Dentado 2 x Comp. 1	Lote 133-136-10	25
59.	IPTT 24, Antigua x Ver. 181 x Comp. 1	Lote 133-136-11	25
60.	IPTT 26, Mezcla Amarilla x Comp. 1	Lote 133-136-12	25
61.	(Mez.Amar. x Thai Comp.) x Comp. 1	Lote 133-136-13	25
62.	(Am.Crist. 1 x Mez.Am.Dent.) x Comp. 1	Lote 133-136-14	25
63.	(Am.Crist. 1 x Thai Comp.) x Comp. 1	Lote 133-136-15	25
64.	(Am. Dentado x Mez. Var. Am.) x Comp. 1	Lote 133-136-16	25
65.	(Am.Dentado x Thai Comp.) x Comp. 1	Lote 133-136-17	25
66.	(Am.Dent.2 x Mez. Misc.Dent.) x Comp. 1	Lote 133-136-18	25
67.	(Am.Dent.2 x Thai Comp.) x Comp. 1	Lote 133-136-19	25
68.	Am. Dent. tardío, Sel.Arg. x Comp. 1	Lote 133-136-20	25
69.	Serie Cris. P.L. x Comp. 1	Lote 133-136-21	25
70.	(Mez. Am. P.B. x 8 Mais). x Comp. 1	Lote 133-136-22	25
71.	Dent. Am. Misc. BU-102, 1974 x Comp. 1	Lote 133-136-23	25
72.	Dent. Am. Misc. BU-103, 1974 x Comp. 1	Lote 133-136-24	25
73.	Tuxp. x Mic. BU-104, 1974 x Comp. 1	Lote 133-136-25	25
74.	Mix. 1 x Col. Gpo. 1 x ETO-Sint. 10 lineas BU-105, 1974 x Comp. 1	Lote 133-136-26	25
75.	(Tuxp. 1 x Sint. 10 lineas) x Comp. 1	Lote 133-136-27	25
76.	IPTT 35, Ant. x Rep. Dom. x Comp. 1	Lote 133-136-28	25
77.	(Am. Bajio x Sint. 10 lineas) x Comp. 1	Lote 133-136-29	25
78.	(Am.Bajio x Misc. Trop.) x Comp. 1	Lote 133-136-30	25
79.	Puerto Rico Mez. de 3-11-20 x Comp. 1	Lote 133-136-31	25
80.	Rep. Dom. Frances largo x Comp. 1	Lote 133-136-32	25
81.	Rep. Dom. Mez. 9 Colec. x Comp. 1	Lote 133-136-33	25
82.	Comp. Colombia pisoc term. x Comp. 1	Lote 133-136-34	25
83.	Sint. 10 lineas-PD(MS)6-Cuba-Rep. Dom. x Comp. 1	Lote 133-136-35	25
84.	IPTT 34, Amarillo Subtrop. x Comp. 1	Lote 133-136-36	25
85.	Indonesia precoces Am. x Comp. 1	Lote 133-136-38	25
86.	(Maices Trop. sel. Batan 71 x Phil. DMR y otros) x Comp. 1	Lote 137-1-19	25
87.	(Maices Trop. sel. Batan 71 x Phil. DMR y otros) x Comp. 1	Lote 137-34-41	25
88.	(Phil. DMR1, x ETO, PD(MS)6 etc.) x Comp. 1	Lote 137- 51	10
89.	(Phil. DMR1 x Uruguay varios) x Comp. 1	Lote 137-56-58	135
90.	(Phil. DMR 2-3-5, x Mix-ETO) x Comp. 1	Lote 137-60-62	25
91.	(Tinigui B2 x ETO Mex.) x Comp. 1	Lote 137- 66	10
92.	(Minie x Uruguay 671) x Comp. 1	Lote 137- 70	10
93.	(Davao x ETO mixture) x Comp. 1	Lote 137- 73	10
		PR-75B	
94.	Tropical Late White Dent (TLWD)	Lote 26-1-440	440
	Phil. DMR Dentes x TLWD	Lote 26-441-[illegible]	249
	Sinst Rio. Dentes x TLWD	Lote 26-[illegible]-710	21
95.	Tropical Interm White Flint (TIWF)	Lote 27-1-[illegible]	400
	Sinst Rio. Dentes x TIWF	Lote 27-401-[illegible]	100
	Phil. DMR Dentes x TIWF	Lote 27-501-[illegible]	165
96.	Trop. Interm. Yellow Flint Dent	Lote 28-1-[illegible]	400
	Phil. DMR Dentes x TIYFD	Lote 28-401-[illegible]	264
	Sinst Rio. Dentes x TIYFD	Lote 28-[illegible]-[illegible]	40

Primary emphasis is being placed on the use of (apparently resistant) surviving plants from selected progenies. Selfed seeds are to be returned to Mexico for recombination (sowing in March) and development of the new set of progenies, which will be seeded at the several sites during August-September for the next cycle of selection. Initially, downy mildew and streak, and downy mildew and stunt combined resistant sources will be given special attention. As improved resistant sources are developed, they will be made available to national programs and will permeate all of CIMMYT's maize materials under improvement. Stunt and streak resistances will be sought under high natural incidence of the leaf hopper vectors. Artificial inoculations and spreader rows will be used to the extent possible in identifying downy mildew resistant plants.

Stem borers are another pest complex under consideration. In cooperation with Cornell University, CIMMYT is working to develop a maize population which carries resistance to Ostrinia nubilalis (European corn borer, a temperate species) and Diatraea saccharalis (sugar cane borer, a tropical species). During the summer, the progenies will be evaluated and selected at Ithaca, N.Y. and Tlaltizapan, Mor. During the winter the selected progenies (sibbed or selfed) from each site are to be recombined at Tlaltizapan, Mor. In addition, a disease nursery established at Poza Rica during the summer contributes resistant selections to common foliar disease. Some of the results obtained at Cornell University are shown in Table 5.2. Some of the tropical entries (lower portion of the table) seem to carry as high a level of resistance to the first generation as do the resistant Corn Belt inbreds, and also a high level of resistance to the second generation. Other resistant mechanisms seem to be involved in the tropical sources (as compared to the temperate inbreds) in which high Dimboa concentration restricts larval establishment. Presently this population is represented by 266 families, and is a mixture of Corn Belt European corn borer materials and tropical sources that have been less damaged by borer in different localities in Mexico in past years.

TABLE 5.2.- Average DIMBOA content and visual European Corn Borer ratings - Cornell University, Ithaca, N.Y.

Maize Material	DIMBOA 1/	First Generation 2/	Second Generation 3/
B49 (Res. 1st. gen.)	305	2.0	12
B68 (Res. 1st. gen.)	79	2.5	12
B37 (Susc. 1st. gen.)	36	4.1	-
WF9 (Susc. 1st. gen.)	8	7.5	37
B52 (Res. 2nd. gen.)	38	6.3	10
Lagunero 3 meses x Antigua 8D	3	2.0	0
Nicaragua Synthetic 1 x Antigua 8D	0	3.7	3
Puerto Rico Gpo. 1 x Antigua Gpo.2	1	1.7	2
Comp. Res. Pud. Maz. x Antigua Gpo.2	1	2.2	0
(Azteca x Varios) x Antigua 8D	7	1.0	0

1/ Expressed in micrograms/gram of fresh weight 52 days after planting.
2/ Foliar damage, rating scale 1 = no damage; 9 = severe damage.
3/ Stem damage, number of tunnels.

6.0 Special Projects

The Advanced Unit develops and delivers commercially improved varieties to national programs; however, its routine procedures allow little time to follow up on what appear to be new leads, or on intriguing possibilities that may show up in the development of varieties. Three such areas -- selections for yield efficiency, for early maturity, and for wide adaptation -- are now being studied in the Special Projects work. Findings should serve to guide selection procedures in the main breeding programs.

6.1 SELECTION FOR YIELD EFFICIENCY

Tropical maize, generally is characterized by an almost uniform background of "too much foliage and too little grain" (when compared to maize types developed in temperate latitudes). One of the basic concerns of the Special Projects is to devise a means of producing more grain in proportion to total dry matter.

Evidence is accumulating to describe various aspects of the fundamental problems. Many reports indicate the tendency of the tropical maizes to produce great amounts of total dry matter, with a relatively small proportion of grain. Measurements of sugar content in the sap and stalks of tropical maize show that: (1) levels of such sugars are far higher than is the case with temperate zone maize types, and (2) that these sugars are not transferred so completely to the ears upon maturity. Why is this? Is this a measure of an inefficient genotype? What can be done about it? (Are these measurements only a reflection of the enormously greater need for resistance to the many foliage and stalk diseases in tropical areas?) What are the real relationships among these several characteristics of tropical maize? As progress is made toward the development of a better grain-to-stover ratio and lesser sugar content in mature tropical maize plants, will there be a corresponding susceptibility to diseases and insect pests?

Modest studies continue to shed light on these questions. The systematic recurrent selection for shorter plants is now a standard selection criterion in all the CIMMYT maize populations under development. The benefits of this are obvious in terms of better standability of the plants, and more dependable recovery of the harvest actually produced. Its implication is clear regarding the relative efficiency of smaller plants compared to larger ones. Yet this selection procedure is based on a visible morphological plant configuration and does not include measurements of sugar concentrations, root development, or actual foliage determinations.

A number of materials are undergoing special selections to determine the potential for improving yield efficiency by breeding; and the ultimate effects, both direct and indirect that such selections may have on the performance of the crop.

6.1.1 YIELD EFFICIENCY WITHIN TROPICAL GERMPLASM

6.1.1.1 Short Plants

The population - Tuxpeño Planta Baja has been chosen to determine the ultimate effects of selection for extreme shortness of plant. The original composite population of selected varieties from within the race Tuxpeño has now undergone 12 cycles of selection for shorter plants and has been released for commercial production in several countries (Mexico as V-524 "Tuxpeñito", Honduras as Honduras Planta Baja; and Zaire as Salongo).

This population still has far too much foliage relative to temperate type maize plant architecture, and very probably can be further reduced in plant height. It has been chosen for study in an intensified selection effort. Full sib families were generated in the first planting season at Poza Rica and planted for a second cycle of selection at the same station. During the second (summer) planting cycles, there was a heavy infection of sorghum downy mildew. Thus, shorter-plant selection was possible only as mildew infection permitted (those families that had been heavily infected with mildew could not be used to generate progeny, as they did not produce any grain). Thus the short-plant selection procedure of continuous full sib mating among selected families was modified somewhat, as dictated by the disease in the field: some of the very shortest families were not included. In spite of this, a reasonably good selection differential was obtained.

This selection for shorter plant height will be continued to determine the total effects. Measurements will be made of: root development (to see if roots also are reduced); sugar content; yield; leaf number; maturity; disease reactions; etc. The information obtained should be valuable

as a guideline for selection criteria in the other CIMMYT populations.

6.1.2 CHARACTERS OTHER THAN YIELD

The evidence to date suggests that, although shorter plant selection has contributed to increased crop yields (through a change in management practice), the efficiency of individual plants measured as harvest index has not changed considerably (for tall and short selections of Tuxpeño). In view of this, and the evidence of the importance of morphological characters other than yield (see Agronomy/Physiology), two other projects are being initiated.

6.1.2.1 Reduced Foliage

The genetic variation in three of the Advanced unit populations (leaf length, width, number above the ear, foliage density above the ear, and yield per leaf area) has been reported (Section 3.6). Three populations are being formed for which reduced leaf area will be the primary selection criteria. Within the crossing block of the Advanced unit populations, Tuxpeño-1 (IPTT-21), Eto Blanco (IPTT-32), and Antigua x Dominican Republic (IPTT-35), families will be selected with leaf areas equal to or below the mean of the respective population. These will be handled as full sibs, and a crossing block and an earlier planted observation nursery at high density will be grown each cycle at Poza Rica Station. These populations represent a typical widely grown Tropical lowland material (Tuxpeño-1); moderately shorter tropical material with good combining ability and with a tendency to barrenness at higher densities (Eto Blanco); and an early, short, relatively efficient tropical material (Antigua x Dominican Rep.).

6.1.2.2 Reduced Tassel Size

The same populations (chosen for the same reasons) are being selected for reduced tassel branch sizes in the manner described for reduced foliage. After some progress in the changes of both leaf area and tassel size, the special populations will be yield tested with the original population and their Advanced unit equivalent. On the basis of this evidence, the leaf area and tassel selection might be merged, with concurrent selection of both to see what changes may occur. In view of the possible need to have small tassels combined with reduced leaf area and height (to obtain maximum changes in yield efficiency), the Eto Blanco population will be managed to obtain a simultaneous reduction in tassel branches and leaf area.

6.1.3 YIELD EFFICIENCY IN TROPICAL x TEMPERATE GERMPLASM

The descriptions of the tendencies of tropical maize types to produce relatively small ears (or low grain yields) in relation to the total dry matter production might suggest that the temperate maize varieties should be moved to the tropics to replace the "inefficient" types. From a practical standpoint, this is simply not possible, because of the resulting disease and insect attacks. Temperate climate maize varieties are much too susceptible to a whole range of tropical diseases and insects. Thus, the temperate maize plant architecture is being combined with the appropriate [illegible] and disease tolerance from tropical types.

Several of these combinations are under mixing and selection in the CIMMYT program. A combination from the Eto x Illinois lines has been assigned IPTT No. 42, and is in the routine selection program. Others of the combinations are being subjected to successive selection under drastically different environments. Thus far, only descriptive identifications for purposes of selection have been provided, with no permanent variety name or population number assignments (with the possible exception of "Amarillo Bajío"). The selections were advanced in 1975 under the usual visual selection procedure in different environments. It is expected that progress will be gradual and that extreme selection pressure should not be exerted until thorough mixings have been achieved.

6.2 ADAPTATION

The 1974 CIMMYT Annual Report included a brief section on the general subject of adaptation, with primary focus on how this characteristic might be achieved. Development of maize varieties that are superior over a reasonably broad range of conditions is an essential part of the CIMMYT variety development effort. Obviously, it would be impossible to produce a specific genotype for each of the countless micro-climates in the tropics around the world. The native types that have been developed under extremes of temperature regimes provide evidence that very different environments produce results that vary widely in predictability.

In light of the general behavior patterns and observations listed below, it is obvious that systematic recombination of genes must be achieved to meet these varying requirements, if broadly adapted varieties are to result. For example:

Growth under cooler growing conditions (particularly during the early formative stages of the plant) tends to produce shorter plants.

Growth of lowland tropical types under cool highland mountain conditions produces very slow growth; abnormal, pale color of foliage; and little, if any, grain formation (frost usually kills the plants before full maturity). The Corn Belt maize from the U.S. tend to follow the same pattern, indicating that their temperature response more closely

resembles that of tropical types than that of highland maize.

Lowland tropical maize is generally susceptible to the cool highland diseases (Puccinia sorghi and Helminthosporium turcicum, for example).

Highland maize subjected to high temperature conditions of the lowlands usually grow much more rapidly to flowering than they do under the cool conditions, but begin to collapse at that time and rarely show evidence of grain formation. Is the ability to grow under cool conditions associated with (or the same as) an excessive metabolic loss under high temperatures?

Plants grown under cooler conditions tend to be stronger, with heavier stems (as well as shorter), than those grown under higher temperatures.

Systematic testing of the Advanced unit under varying environments reflects the need to identify genotypes that perform well under environments like the above, to recombine the appropriate genotypes (as progenies). Continued selection and recombination under widely different environments (in what is being called "Estudio Reacción Largo del Dfa") is an attempt to gradually build the gene frequencies required to grow well over an extreme range of conditions into a single population. Findings over the next few years should indicate the feasibility of this process (See 1974 Report).

Combinations of different germplasms are limited by the length of growing season in higher altitudes and higher latitudes; long season types cannot be used because of limited growing seasons. Certain germplasms that are sensitive to photoperiod represent a special kind of problem. For example, in Indonesia, maizes are generally very small in size and early to maturity. When these are moved to higher latitudes, however, they behave as very tall, late maturing types. By following the crosses of these to very early maturity northern temperate zone types, it should be possible to assess the complexity of inheritance of such photoperiod responses. Earliness to flowering, photoperiod response, response to temperature and many other agronomic traits appear to be genetically independent (separate from the day length). A series of the early maize types is now being studied under different temperature and day length conditions.

6.3 EARLY MATURITY

The characteristic of relative maturity is inextricably mixed with adaptation. Obviously, the earlier maturity types are less likely to be limited by length of season than are late maturity types. Quite apart from this, is the well-known association between extreme earliness to maturity and low yields. Most of the work in tropical maize breeding has been directed at obtaining higher yields. Upon examining the results, it quickly becomes apparent that (for the most part) improved yields obtained in these efforts are also associated with later maturity. Thus, the need for higher yields in truly early maturity types has never been met.

As a matter of initial priority, the very early types were not given the same attention in the CIMMYT program as were intermediate and later maturity categories. However, the earliest available types were gradually being built up as broad-base populations. Recently, the program has begun to intercross a series of what were considered better yielding genotypes of later maturity, with subsequent selection for earliness in this composite of types; rather than concentrating only on the composite of early maturity genotypes. The intent is to concentrate on the development of early and very early genotypes with good yield characteristics for hot tropical conditions. Two initial cycles of recombination were completed in 1975 with plantings at Poza Rica and at Obregon. Selection pressure for earliness will gradually be intensified as recombination cycles progress. At Obregon, a fairly heavy incidence of stunt virus permitted substantial selection for tolerance to this disease among the several hundred families planted. Modified mass selection (ear-to-row with selection among and within half-sib families) is being used at the present stage of population development.

The potential level of yield as related to maturity in this recently formed base population is not known; the assumption is that relatively greater change can be achieved in maturity of the plants than in their production of grain. Along with the maturity change, a foliage reduction effect is expected; since the materials intercrossed not only are later and produce larger ears, but also have more and larger leaves.

6.4 WIDE CROSSES

In the thousands of crosses made between maize and tripsacum in 1975, particular attention was paid to the success of different populations and genotypes as male and/or female parents. More seed was obtained from tetraploid maize than from diploid populations; but no superior maternal genotype was identified in tripsacum.

Successful pollinators of both maize and tripsacum were identified. The maize population Amarillo Bajío stimulated seed set on all tripsacums pollinated (each of eight genotypes belonging to four different species). All seed development was followed by embryo breakdown beginning twelve days after pollination. In 1976, Amarillo Bajío will be used on more species and genotypes of tripsacum to test the universality of the stimulation; and embryo culture will be used to obtain more hybrid plants.

Pollinators of tripsacum that gave hybrid seed with maize were increased. Replicate clones of these plants have been planted in the tripsacum garden at Tlaltizapan for more intensive use of the successful genotypes in 1976.

F_1 progeny have been obtained from several combinations of maize and tripsacum. In each case, maize was the female parent. All hybrids were male sterile and had only a low degree of female fertility. Chromosome counts showed that all F_1 plants examined had the gametic number of maize chromosomes, as expected. However, it appears that some tripsacum chromosomes were lost before seed germination. The number of tripsacum chromosomes retained by the hybrid was not consistent, and differed even between progeny from the same cross.

F_1 plants were pollinated with maize pollen, and backcross progeny have been obtained. Unfortunately, all such progeny have been non-viable. Chromosome counts were made on two plants before they died; each plant had received chromosomes from both parents, but chromosome loss had occurred.

With intensive use of previously successful parents, CIMMYT anticipates the production of a greater number of hybrids in succeeding cycles. These plants will be screened and selected for desirable characteristics, and backcrossed with maize for the production of good agronomic types.

Dr. Willy Villena (left), maize breeder in CIMMYT's Regional Program in Central America and the Caribbean, works here with Professor Carlos Salas F., of the University of Costa Rica Agronomy Department in measuring moisture content at harvest of an international trial.

7.0 Maize Training Program

7.1 INTRODUCTION

CIMMYT training program is designed to provide first-hand learning experiences for breeders, production agronomists, chemists, pathologists, entomologists, and experiment station managers.

In 1975, a total of 56 in-service trainees began their training in Mexico. These trainees came from 22 countries: Belize, Bolivia, Costa Rica, Dominican Republic, Ecuador, Egypt, Guatemala, Haiti, Honduras, Ivory Coast, Kenya, Malawi, México, Nepal, Nicaragua, Nigeria, Pakistan, Perú, Philippines, El Salvador, Yemen and Zaire.

The fields of specialization represented were: 35 trainees in Maize Production, 18 in Breedings, 2 in Protein Evaluation, and 1 in Plant Protection. Training consists of a combination of practical and theoretical sessions which are systematically provided specialized learning experiences. The field work is done at CIMMYT's stations in Mexico and in farmers' fields.

Trainees were sponsored by A.I.D., B.I.D., CENTA/CIMMYT, CIMMYT, F.A.O., F.F., I.C.T.A., I.D.A., I.I.T.A., P.N.M.-Zaire and U.N.D.P.

7.2 BREEDING

Breeding trainees learn the procedures that are used in the formation of superior maize varieties, and at the same time become acquainted with germplasm that may later be of interest in their countries. These trainees work as part of the CIMMYT team of geneticists, entomologists, pathologists, agronomists, physiologists, etc. This team integrates efforts, knowledge, and experience to select appropriate genotypes for different parts of the world. Through the application of suitable selection systems (mainly full-sib and modified half-sib selection), the trainees are involved directly in the maize improvement process -- in modifying the architecture of the maize plant for production of more efficient types that are resistant to pests, diseases, and lodging.

7.3 MAIZE PRODUCTION

Maize production training is of particular importance, because transfer of "knowhow" and of improved varieties to the farmer is a crucial step. This training seeks to complement the professional development of agricultural technicians dedicated to the production of maize, showing them the most appropriate technology to obtain optimum economic yields under a wide range of environments. Such technology has changed greatly in recent years, due to a better knowledge of the environmental factors that affect maize development, the availability of more genotypes capable of producing high yields, advances in the understanding and use of fertilizers and pesticides, and the development of more efficient equipment and machinery. Trainees are shown a simple 4-step system of research trials and demonstrations that can be readily modified to develop and implement a package of recommendations in their own countries.

Step one: is based on the experiment station work, and consists of variety development, preliminary screening of pesticides, and the identification of the major limiting factors to production.

Step two: involves intensified research station management techniques that have been transferred to a conveniently located site within a neighboring farmer's field.

Step three: identifies the most important factors for continual study and these are examined in more detail at several locations in farmers' fields near the experimental station. These are simple trials, testing different levels of each factor and the interactions between factors. In this 3rd. stage the trainees actively participate with the farmers and extension agents with a 3-way exchange of problems and ideas.

Step four: the trainees learn to manage the information obtained in the three preceding steps and develop a production package for the area based on sound economic principles. The trainees assist the extension agents in verifying these packages on 4 or 5 "diamond" plots at as many sites as possible, with the active participation of large numbers of farmers throughout the cropping cycle. This 4th. stage may also include multiplication plots, each of about one hectare, where farmers can increase seed of the recommended variety, using the recommended management.

7.3 PLANT PROTECTION

Training in Plant Protection adds to that given in Breeding. Experience is gained in the identification and assessment of principal diseases and insects affecting maize, and in the techniques used in artificial inoculation, infestation, and evaluation of materials for resistance.

7.4 PROTEIN EVALUATION

In the Protein Quality Laboratory, trainees learn proven techniques for identifying genetic materials with superior quality.

7.5 ADDITIONAL TRAINING

CIMMYT recognizes that the training capacity at the International Center in Mexico is insufficient to cope with the demand for qualified maize production agronomists. For this reason, a very limited number of potential trainers receive more comprehensive experience and knowledge that will enable them, in turn, to train other agronomists within their countries, thus achieving a multiplication effect. Three trainees from El Salvador and one from Pakistan were in this program in 1975.

CIMMYT Training staff also collaborated directly in national training programs in Pakistan and Tanzania. In Pakistan, 90 agronomists from Punjab, N.W.F.P. and Sind attended a course in maize and sorghum production given jointly by the Maize & Millets Research Institute, February 2 to March 7, 1975.

In August 1975, a CIMMYT maize training scientist organized and conducted a maize production course for 21 trainees from 13 regions on behalf of the Ministry of Agriculture of Tanzania. In turn, these trainees will train 540 agricultural officers of the new Tanzanian National Maize Production Project.

Trainees at CIMMYT learn first-hand operations in planting, agronomic observations, laboratory research, harvesting and analysis of on-station research – and in demonstration and experimental plots in farmers' fields.

8.0 Regional Programs

8.1 CENTRAL AMERICA AND CARIBBEAN REGION

8.1.1 FINDINGS: 1975 TRIALS

A total of 62 international progeny trials and experimental variety trials were grown successfully in the Central American Region. Five of the experiments were lost due to severe drought and to a virulent infection of corn stunt (achaparramiento) in Honduras. The experiments were well conducted, and the data collected are highly reliable. All experiments were visited several times by the Regional coordinators and other CIMMYT staff members.

The process of harvesting trials has been systematized in all countries. The breeders have found that the experiments can be easily harvested and more accurate data taken with a minimum of error, if the process is properly organized. For the first time, plant pathologists and breeders (and often the directors of Agronomy Departments) work together in the harvesting operation.

Among problems that remain: some countries are unable to measure trial results on metric scales, and are using inadequate moisture-testing machines. The Regional Program will provide two scales (in kilograms) for each country. Moisture-testing machines can be bought with local funds or donations from other institutions.

Experimental variety trials provided many valuable results. Several experimental varieties have shown performance superior to that of local varieties (and of some commercial hybrids). Experimental varieties have been requested in 15 kilogram lots by Guatemala, Honduras, Nicaragua, El Salvador, Costa Rica, and Panamá. This seed will be used for seed increase and distribution among the farmers. Honduras, Guatemala, Salvador and Nicaragua are increasing seed of Tuxpeño-1 for commercial use.

Although there is still a high rate of job transfer among breeders, disruption has been lessened, because:

1. The local programs have gone through a process of systematization with very clear and well defined objectives.
2. The regional coordinator for breeding helps in keeping the breeding program on track.

8.1.1.1 Summary of Findings

In 1975, no off-station trial results were received from Nicaragua, Panama and the Caribbean countries. Guatemala is analyzing results independently since their trials are somewhat different from the rest of the countries.

Data from 87 trials (Fig. 8.1; Table 8.1) indicate:

(1) Improved variety was (on average) approximately 10% better than the local variety. In El Salvador, the local variety was not included in these trials, since most of the farmers are planting improved varieties.

(2) Grain yield produced from Complete Technology was (on average) 24% higher than that obtained with the Farmer's Method; and Minimum Cost Technology produced only 4% more grain yield than Farmer's Method. The actual average yield of maize of the Central American Region is about 1,100 kg/ha ; however, yields from Farmer's Method were far higher than this average. This seems due to several factors: off-station trials were planted in low risk areas during the first year. Many farmers considered these trials as a competition (with their production method competing with other production technologies). These farmers took better care of their plots than they normally do on their commercial fields.

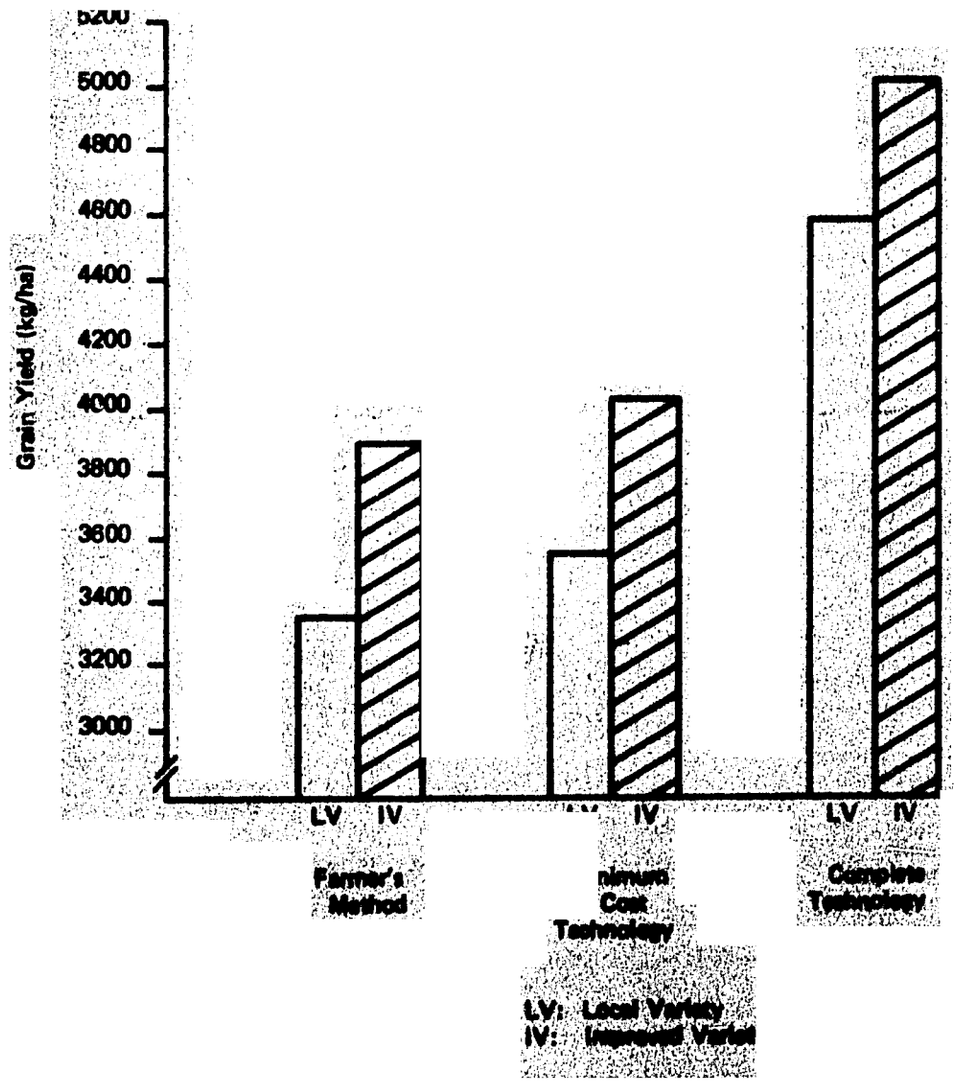
(3) Complete Technology showed the high grain yield (over 5,000 kg/ha) potential on the farmer's land.

TABLE 8.1. - Average grain yield of off-station trials on private farms of Central America Region 1975.

	Farmer's method		Minimum Cost Technology		Complete Technology		
	Local variety	Improved variety	Local variety	Improved variety	Local variety	Improved variety	No. of trial
Grain yield(kg/ha)	3378	3905	3571	4018	4598	5008	87
Average (kg/ha)	3642		3794		4802		

FIGURE 1.

AVERAGE GRAIN YIELD OF 87 OFF-STATION TRIALS 1975



8.1.2 GENERAL COMMENTS ON THE PRODUCTION PROGRAM

8.1.2.1 Quality Protein Maize

CIMMYT's Opaque-2 Experimental Variety Trial has indicated several good opaque-2 varieties. The Central American countries will be increasing these for distribution. Honduras is increasing seed of PD(MS)6 H.E. opaque-2. A total of 40 kilograms of this variety was sent to San Pedro Sula for seed increase. This high-quality protein maize will be used for human consumption, as well as for hog feeding by farmers' cooperatives. Guatemala has developed two opaque-2 varieties from CIMMYT materials. The national institution, ICTA, has a program for producing 200 tons of opaque-2 maize each year for human consumption. Guatemala and El Salvador are generating opaque-2 progenies. The Guatemalan program is trying to complete three cycles of selection per year in this opaque population.

8.1.2.2 Resistance to Stunt Virus

El Salvador and Nicaragua have grown the first cycle of selection for resistance to corn stunt. This is part of CIMMYT's special project for developing disease and insect resistance materials. Reasonably resistant materials have been identified among some Caribbean varieties and their crosses mainly in the Dominican Republic and Cuban collections. The local programs have developed a system that will permit two cycles of selection per year with relatively little effort. This system was developed by the regional coordinator for breeding varieties with resistance to corn stunt. Seventy kilograms of NA-2 from Nicaragua were sent to Panamá for seed increase. CIMMYT also sent to Panamá about 15 kilograms of Sintético de 10 líneas; both are derived from PD(MS)6, a variety with good adaptation to Central America. This seed will be used commercially in Rio Hatos, an area in Panamá where corn stunt appears to be endemic.

8.1.2.3 Economic Studies

A series of studies in economic aspects of maize production were initiated. Dr. Dick Perrin visited El Salvador and Honduras at request of the Governments of these two countries. Dr. Perrin talked to the breeders and maize production specialists and gave a series of recommendations to determine production cost of maize grown under different technological packages. El Salvador has formed a group of 5 economists that will work at the national level in all economic aspects of maize production. The directors of the local institutions have requested that economists of CIMMYT visit them and cooperate with them in the organization of these programs.

8.1.2.4 Networks

The breeding and production networks have been strengthened this year thanks to several regional meetings, and to the reciprocal short visits of scientists of Central America.

8.1.2.5 Training Strategy

CIMMYT's interest in training trainers has been welcomed by the Central American and Caribbean countries. El Salvador will be the first country to initiate national training programs. CENTA, the national institution, has requested CIMMYT to prepare a national training program for maize production. Drs. Violić, Villena and Soza visited the country recently, to set up the basis for this program.

PLANS FOR OFF-STATION RESEARCH TRIALS: 1976

Regional plans for 1976 call for simple trials to be conducted on private farms. Production technologies, elite varieties, fertilizer x density effects, and insecticides and herbicides are among the variables to be studied.

Central America	No. of Trials
Costa Rica	Not defined
El Salvador	400
Guatemala	450
Honduras	200
Nicaragua	250
Panama	Not defined
Caribbean	
Dominican Republic	Not defined
Haiti	188
Jamaica	6

Field books are being prepared for these trials, for standardized and improved recording of data.

9.0 Inter - Center Collaboration

9.1 CIMMYT-IDRC HIGHLAND COLD-TOLERANT SORGHUM PROJECT

Sorghum (Sorghum bicolor (L.) Moench) ranks among the five major cereals of the world in acreage and production. Over 95% of the crop is grown in relatively warm, humid, sub-humid, and semi-arid tropical and sub-tropical parts of the world. However, a substantial amount of sorghum has been grown for centuries in highlands of some East African countries; this sorghum seems to possess a varying degree of tolerance to cold (but above freezing) temperatures.

Millions of people use sorghum grain in various forms (injera in East Africa; chapati or roti in parts of Asia; tortilla en Latin America, etc.) as a staple food, as feed for animals, and as an industrial raw material. Also in some parts it is used for brewing, distilling, and preparation of local drinks (chicha in Central America). Its stalk is used for fodder, fuel, shelter, syrup, sugar, and broom production.

Grown for centuries in Africa and Asia, sorghum is an introduced crop (less than 200 year old) to the American continent. But its cultivation has been expanding rapidly for the past 15-20 years, and now more than 50% world's total grain is produced in the Americas. The United States is by far the largest producer, but acreage and production is increasing in Mexico, El Salvador, Guatemala, Colombia, Argentina, Brazil and other Latin American countries.

Although sorghum performs best under favorable moisture, temperature, and humidity conditions, it possesses a high degree of tolerance to drought conditions. Research is underway to incorporate an acceptable degree of cold-tolerance and relative insensitivity to photoperiod in the otherwise agronomically desirable sorghum cultivars and populations. This could help expand cultivation into high altitude and other areas of the world that are characterized by scarce and erratic rainfall. There are large tracts in Mexico, Central and South America, Tropical Africa, and Southern and Eastern Asia, where cold-tolerant sorghum could play an important role in increasing food supply.

Most Latin American countries do not have a national sorghum program at present and/or do not have qualified personnel working on sorghum improvement. Their access to a wider range of useful germplasm also is very limited. Thus, there is an urgent need for a regional sorghum program to assist these countries with improved germplasm and technology of production. Cold tolerant (CT) sorghums being developed at CIMMYT should make significant contribution to agricultural production in highlands and temperate zones -- not only in Latin America, but in other parts of the world where rainfall is erratic and scant. These also seem to be adapted to lowland areas as well. At present, cultivation of cold tolerant sorghum is limited to highlands of Ethiopia, Uganda, Kenya, and the Yemen Arab Republic. When local varieties introduced from these countries are grown on the American continent, they are usually tall, photoperiod sensitive, and require longer to grow. But by judicious breeding efforts, these lines are being utilized in development of sorghums adapted to highlands of Mexico and other parts of the world. (See 1974 CIMMYT Report).

9.1.1 SOME ADVANTAGES OF COLD TOLERANT SORGHUM

Sorghum outperforms other major cereals in its ability to withstand moderate drought and perform better in marginal areas, because of its deep fibrous root system and xerophytic leaf. Adding cold tolerance to sorghum cultivars will:

Extend sorghum adaptation to highland and temperate zones to intensify land usage, and bring millions of hectares of new arable land under cultivation.

Stabilize grain sorghum production in fringe areas where severe losses occur due to occasional low temperatures during growing season.

Serve as an alternative crop in frost-free mild winter areas, especially in the tropics.

Be suitable for early spring plantings, where low soil temperature limits good germination and stand.

Serve as mediator component in development of widely-adapted, broad-base germplasm and source populations.

9.1.2 MAJOR OBJECTIVES

The highland sorghum program was reorganized around the following objectives in January 1974:

9.1.2.1 Short Term Objectives

Selection and use of CT lines from the existing pool.

Improvement of CT lines for grain type, grain yield, protein quality, disease and insect resistance, etc.

9.1.2.2 Long Term Objectives

Search for and use of new and better sources of cold tolerance.

Study of cold tolerance inheritance.

Ascertain possible development differences between cold tolerant and susceptible groups of genotypes under comparable environments.

9.1.3 SELECTION AND USE OF CT LINES

Figure 9.1.1 shows a general overview of highland sorghum improvement program underway at CIMMYT. Approximately 1,500 individual plants were visually selected from the cold tolerant pool at El Batan (2,200 m) during summer of 1974. Their progenies were evaluated at Poza Rica (50 m) and Tlaltizapan (1,000 m) the following season. Some 380 promising selections were included into the first International Cold Tolerance Sorghum Adaptation Nursery (ICTSAN). They were grown at four locations in Mexico last summer. Also complete or partial sets had been distributed to 25 locations outside of Mexico (Table 9.1) for evaluation. So far, outside data have been received from only three locations. These nurseries also were observed during the growing season in Canada, the U.S.A., and in the highlands of Ethiopia, Honduras, and Guatemala. Cold tolerant selections from Mexico, in general, seem to be performing well in varying environments from tropical lowland (sea level) to highland (2,300 meters) and temperate zones (> 45°N latitude) in different countries. Based on ICTSAN data, approximately 100 lines will be selected for yield trial (ICTSYT) next year.

9.1.4 IMPROVEMENT OF COLD TOLERANT LINES

Each season at Poza Rica, a wide range of germplasm selected for various desirable traits is being hybridized with elite cold tolerant lines. Nearly 3,000 hand crosses are made between cold tolerant and susceptible groups, and among cold tolerant groups.

9.1.4.1 Disease Resistance

Among sorghum diseases, Foma and bacterial spot (both tentative identification) have been found in Mexican highlands (El Batan, Huamantla, and Toluca). But many other diseases are found in the highlands of East African countries, where sorghum has grown for centuries. Therefore, emphasis on breeding for disease resistance continues as a means of coping with possible future hazards. The entire breeding nursery is evaluated for all naturally occurring pathogens at Poza Rica in both seasons each year. The diseases found at the Poza Rica experiment station so far are: gray leaf spot (Cercospora sorghi); leaf rust (Puccinia purpurea), an unknown leaf spot caused by an imperfect fungus similar to Diplodia; zonate leaf spot (Gleocercospora sorghi); leaf blight (Helminthosporium turcicum); sorghum downy mildew (Sclerospora sorghi); bacterial stripe (Pseudomonas andropagan); maize dwarf mosaic virus; seed molds; fusarium stalk rot; fusarium head blight; and anthracnose (Colletotrichum graminicolum). However, only the first three have been of any economic significance. Considerable tolerance or resistance for each of these diseases exists in both cold tolerant and susceptible materials. Also, attempts are being made to introduce additional sources of resistance. CIMMYT works closely with Texas A&M University in evaluating their International Disease Nursery. In 1976, cold tolerant selections will be sent to Texas for screening against anthracnose, downy mildew, and head smut.

9.1.4.2 Insect Resistance

Corn leaf aphid (Rhopalosiphum maydis) has been seen occasionally on sorghum at El Batan and Toluca. However, at Poza Rica, midge (Catarinia sorghicola) and fall armyworm (Spodoptera frugiperda) cause substantial damage. Lines and populations resistant to midge and green bug (Schizaphis graminum) recently have been obtained from Texas and the resistance is being incorporated into cold tolerant germplasm.

9.1.4.3 Protein Quality

Protein quality improvement in sorghum began in January 1974. Seed of six high-lysine lines were supplied by Dr. J.D. Axtell of Purdue University. These lines were tall, photoperiod sensitive, and had dented grains. He also furnished seed of the opaque mutant "P721" in February, 1975.

Because of the apparent drawbacks of high-lysine lines, CIMMYT's primary objective has been to cross them with selected early, dwarf, normal endosperm lines. Sixteen such crosses were

TABLE 9.1. Locations of First International Cold Tolerance Sorghum Adaptation Nursery (ICTSAN) - 1978.

Zone	Country	Location
Africa	Ethiopia	1
	Ivory Coast	1
Asia	India	1
	Pakistan	1
Middle East	Israel	1
	Lebanon	1
	Yemen	1
Europe	England	1
	France	1
	West Germany	1
North America	Canada	2
	U.S.A.	7
	Mexico	4
Central America	Guatemala	2
	Honduras	1
	El Salvador	1
South America	Bolivia	1
	Venezuela	1
TOTAL	18	29

TABLE 9.2 Percent protein and lysine of whole kernels for some selected F_3 segregates between normal and high lysine sorghum crosses.

Pedigree	Grain Type*	Protein	Lysine in sample	Lysine in protein
(SC120-14 x IS16210)-1-G-1	M	6.9	0.225	3.3
-2	M	6.6	0.225	3.4
-3	M	6.5	0.205	3.1
-4	M	7.5	0.221	2.9
-5	OP	7.0	0.217	3.1
-6	OD	9.6	0.395	4.1
(SC120-14 x IS16210)-2	M	7.8	0.245	3.1
(SC423-14 x IS16210)-1	M	7.6	0.213	2.8
-3	M	6.4	0.195	3.0
-4	M	6.5	0.195	3.0
SC170-5-17 x IS16210	M	9.9	0.218	2.2
P74A-5424 x IS16210	M	13.5	0.278	2.0
P74A-5454 x IS16210	M	12.0	0.226	1.9
P74A-5461 x IS16210	M	6.8	0.226	3.3
(P74A-5463 x IS16210)-2	OP	7.3	0.226	3.1
-3	OP	7.1	0.228	3.2
-5	OP	7.2	0.233	3.2
-6	OP	8.5	0.260	2.9
High lysine+		15.1	0.481	3.2
Normal sorghum‡		12.1	0.241	2.0

* M = modified, OP = opaque plump, and OD = opaque dented.
\+ Average of four high lysine lines.
‡ Average of three normal lines.

Figure 9.1 [illegible] BREEDING PROGRAM

General Overview

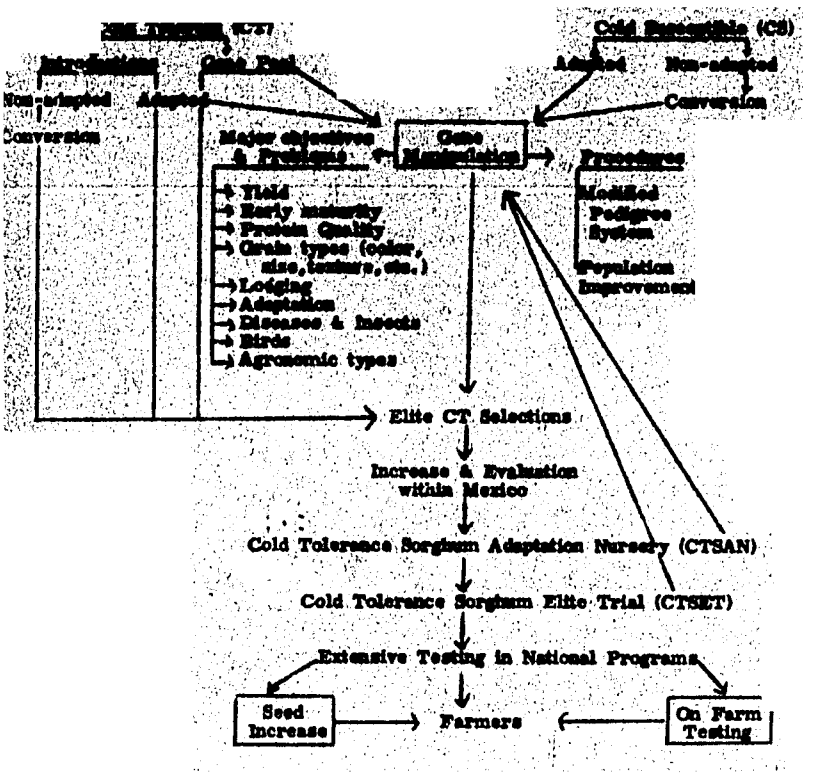


Figure 9.2- Conversion of alien highland sorghums utilizing summer (S) and winter (W) seasons

Site and season	Generation	Procedure
Lowland (S)	Parents	Source Population (cold susceptible, photoperiod insensitive, dwarf and male-sterile) x Highland introduction (HI) (photoperiod ensitive)
Lowland (S)	F_1	Self-pollinate→Intermating sub-pool 1
Lowland (S) & Highland	F_2	-- Select dwarf, early HI-like male-sterile plants and backcross with bulk pollen from HI. -- Test & select in highlands for cold tolerance.
Lowland (W)	I BC F_1	Self-pollinate→Intermating sub-pool 2
Lowlands (S) & Highlands	I BC F_2	-- Select dwarf, early HI-like male-sterile plants and backcross with bulk pollen from HI. -- Test & select in highlands for cold tolerance. Repeat until BC_3
Lowland (W)	III BC F_3	-- Grow plant-to-progeny rows. - Select HI-like fertile progeny row(s) and bulk harvest.

Breeding program | Evaluation and utilization in national programs

made at Poza Rica, Mexico during the 1974 winter season. The resulting F_1 hybrids were grown at Tlaltizapan, Mexico the following season. All of the hybrids were nearly as tall and late as their high-lysine parents. At harvest of the F_1 hybrids, selection for grain types was easily done by visual inspection of unthreshed heads. A few heads had been damaged by webworm (Celama sp.).

After threshing, four grain types --opaque dented, opaque plump, normal vitreous and modified --were separated on a glass screen over a fluorescent lamp. Light did not pass through dented and plump opaque grains, and passed differentially through modified types (i.e. a portion of each modified grain was opaque and the rest translucent). Normal grains were completely translucent. Dissection with a fine blade revealed that opaque dented and plump grains had floury endosperm, and normal translucent kernels had vitreous endosperm. The translucent fractions of modified grains were vitreous and the opaque fractions were floury.

All selected F_2 segregates of each cross were planted at two locations, Poza Rica and Tlaltizapan, during 1974/1975 winter season. Relatively short and early plants were harvested and threshed individually. Later, except for a few homozygous opaque plump and dented types, only seed from plants with modified types was saved and sorted over a fluorescent glass screen. Approximately 8 to 10 grams of seed of each selection was sent to the laboratory for protein and lysine determinations. Data for some samples are presented in Table 9.2. The results suggest that good quality protein exists in the modified types, although a relatively lower protein content can be expected in early stages of the breeding program.

Some crosses had more numerous modified segregates than others, and some produced none at all. The degree of modification of grain vitreosity varied. Since not all modified selections have good quality protein, chemical analyses will be essential in any protein quality improvement program.

The F_3 progenies of selected plants have been planted at Tlaltizapan and Poza Rica. Also new crosses have been made between selected cold tolerant lines and P721. CIMMYT discontinued use of Ethiopian high lysine lines in its crossing program.

Main objectives in protein quality for the future are:

Further selecting and improvement of cool temperature tolerant modified grain types with good quality protein.

Obtaining information regarding genetic nature of grain modification in order to adapt more efficient and effective breeding procedure.

Studying the usefulness of opaque mutant P721.

Studying the usefulness of "opaque" and high lysine gene combinations.

9.1.5 BREEDING FOR COLD TOLERANCE

Addition of new sources of genetic variability for grain color, type and yield, protein quality, diseases and insect resistance, etc., simultaneously reintroduces the lack of tolerance to cool temperature and, therefore, warrants selection under appropriate conditions to recover the desired combinants. The following two breeding methods are used.

9.1.5.1 Pedigree system

All crosses are made at Poza Rica where both cold tolerant and susceptible lines grow successfully. Each season nearly 1,500 crosses are made between selected parents. The F_1 hybrids are also evaluated at Poza Rica. From the first set of crosses made in 1974, 178 F_2 and 500 F_3 families were grown at El Batan and Huamantla. Although frequency of cold tolerant segregates varied between families but in general it was low ($<$ 5%). Moreover, a large proportion of families did not have any CT segregates. Over 150 individual plant selections were made for further evaluation.

9.1.5.2 Population Improvement

To bring a large range of genetic variability together and facilitate recombination, CIMMYT recently started using genetic male sterility to form intermating populations. Cold tolerance (BP_1) and disease resistance (BP_2) populations were formed during winter of 1974/75. Their F_1 crosses were grown at Poza Rica last season. Hopefully, one population each for insect resistance and drought tolerance will be formed early next year. Each of these populations will be recombined for 4 to 5 cycles before starting selection.

9.1.6 NEW SOURCES OF COLD TOLERANCE

Present sources of cold tolerance trace back to East Africa, and little is known about their inheritance. To improve upon available sources of cold tolerance and also to avoid any inherent danger of genetic vulnerability, it is believed that all possible sources of cold tolerance from highlands of Africa and other parts of the world should be screened. Of four lines brought from Ethiopia in 1973, at least one seems to possess cold tolerance. This is probably a local variety from the Harar region; it has a small, compact, goose neck type head with large white grains. In the past 1-1/2 years

CIMMYT has introduced 106 sorghum lines. Table 9.3 shows that 77 of these lines from highlands of Ethiopia have potential as sources of cold tolerance. But all lines are tall and photoperiod sensitive, and would not fit in the normal growing season of El Batan or similar areas in Mexico. Therefore, a conversion program (Figure 9.1) was begun this last season at Poza Rica, to shorten the height and maturity period of these Ethiopian lines.

TABLE 9.3.- New cold tolerant sorghum lines screened at El Batan, Mexico, 1975.

1	Aba Lacha	EGD -	9
2	Aklambol		15
3	Djengawol		20
4	Gumbila		10
5	Kaye Shurre		19
6	Mugad		16
7	Mugra Bitcha		21
8	Red Durabab		12
9	Wagareb		1
10	Zenga		7
11	73 ALV	Ethiopia	
12	Adugri 149	74ESL-	13
13	AL 70		38
14	AL 100		20
15	AL 477		11
16	Asao 122		21
17	Asbeteferi 332		5
18	Awash 1050		10
19	Debesso 356		37
20	Dedessa 36		36
21	Dedessa 1057		3
22	Erwegere 935		35
23	Gambella 1107		8
24	Gato 994		18
25	Gato 1001		9
26	Hirna 305		31
27	Harar Market Sample B		45-1
28	Jijwegere 935		41
29	Leoti 696		19
30	Netch Shurre		17
31	Woldya 157		34
32	WS 1297		4
33	WS 1509		29
34	WS 1520		15
35	WS 1521		12
36	WS 1584		28
37	WS 1641		23
38	WS 1763		16
39	WS 1767		6
40	ET 0077		46
41	ET 232		50
42	ET 601		52
43	ET 608		53
44	ET 717		54
45	ET 916		56
46	ET 2167		61
47	ET 2168		62
48	ET 2169		63
49	ET 2171		65
50	ET 2173		67
51	ET 2174		68
52	2175		69
53	2176		70
54	2177		71
55	2178		72
56	2179		73
57	2212		78
58	2396		83
59	2410		85
60	2422		87
61	2425		88
62	2451		90
63	2452		91
64	2453		92
65	2454		93
66	2462		94
67	2465		95
68	2466		96
69	2467		97
70	2468		98
71	2469		99
72	2471		100
73	2480		101
74	2482		102
75	2485		103
76	2486		104
77	2509		105

10.0 Related Maize Improvement Information

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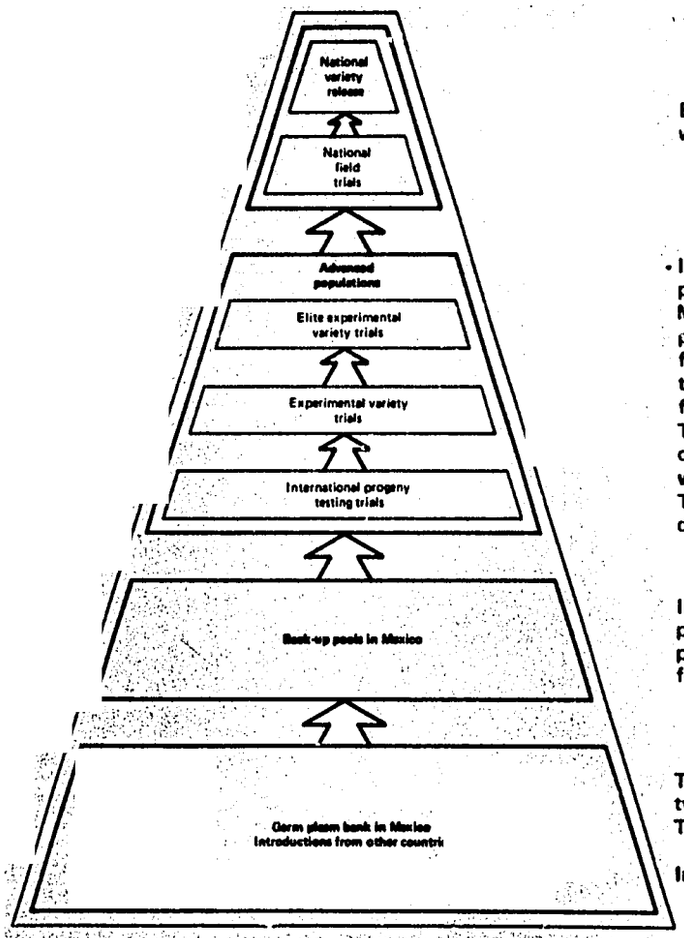
APPENDIX



Stages in the development of maize varieties at CIMMYT.

Based on **trials in farmers fields** and on international trials in competition with their best local varieties, **national agencies release new varieties.**

- In the **advanced unit,** all families in all populations (250 families per population) are grown in the **International Progeny Testing Trials** in Mexico and five other locations. Ten superior families from each population become **experimental varieties.** About 100 best performing families in each population are intercrossed and regenerated to form the 250 families in each population in the next IPTT. In addition, any families advanced from the back-up pools are integrated at this time. The experimental varieties are tested at 25 to 30 locations and the best one or two varieties in each population become **elite experimental varieties.** Elite experimental varieties are tested at 100 to 125 locations. The best performing elites in each country are moved into national demonstration trials and considered for possible national release.

In the **back-up unit** materials are classified into 34 pools. There are 14 pools for the highland tropics, 12 pools for the lowland tropics and 8 pools for the temperate zone. Two cycles are grown a year. Superior families move to the advanced unit.

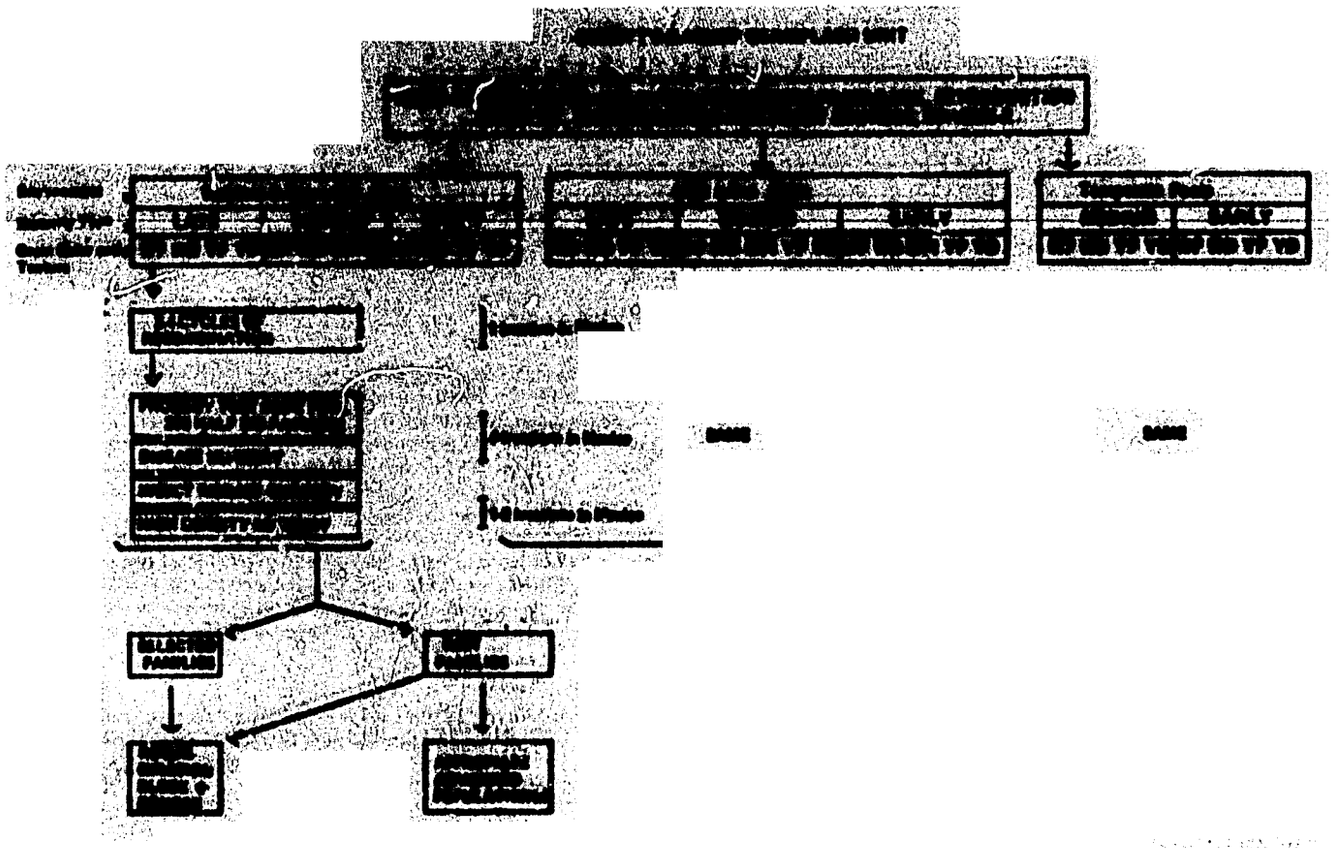
The **germ plasm bank** contains 12,000 accessions (varieties, lines, wild types) which are being classified according to economic characteristics. The best accessions are integrated into the appropriate back-up pools.

Introductions from other countries move directly to the back-up pools.

Agro-climatic characteristics considered in classifying maize gene pools.

Maturity range	Altitude meters	Latitude	Temperature a/	Days to silking	Duration of crop growth days
			Tropical-Subtropical lowland		
early	0-1600	0-30°N–S	25-28°C	Up to 50	90-100
medium	0-1600	0-30°N–S	25-28°C	50-60	100-110
late	0-1600	0-30°N–S	25-28°C	60 +	110-120
			Tropical highland		
early	1600 +	0-30°N–S	15-17°C	Up to 70	Less than 130
medium	1600 +	0-30°N–S	15-17°C	70-95	130-190
late	1600 +	0-30°N–S	15-17°C	95-120	190-240
			Temperate		
early	0-1600	30-40°N–S	20-22°C	Up to 60	100-120
medium	0-1600	30-40°N–S	20-22°C	60-75	120-150
late	0-1600	30-40°N–S	20-22°C	75 +	150 +

a/ Mean of main growing season.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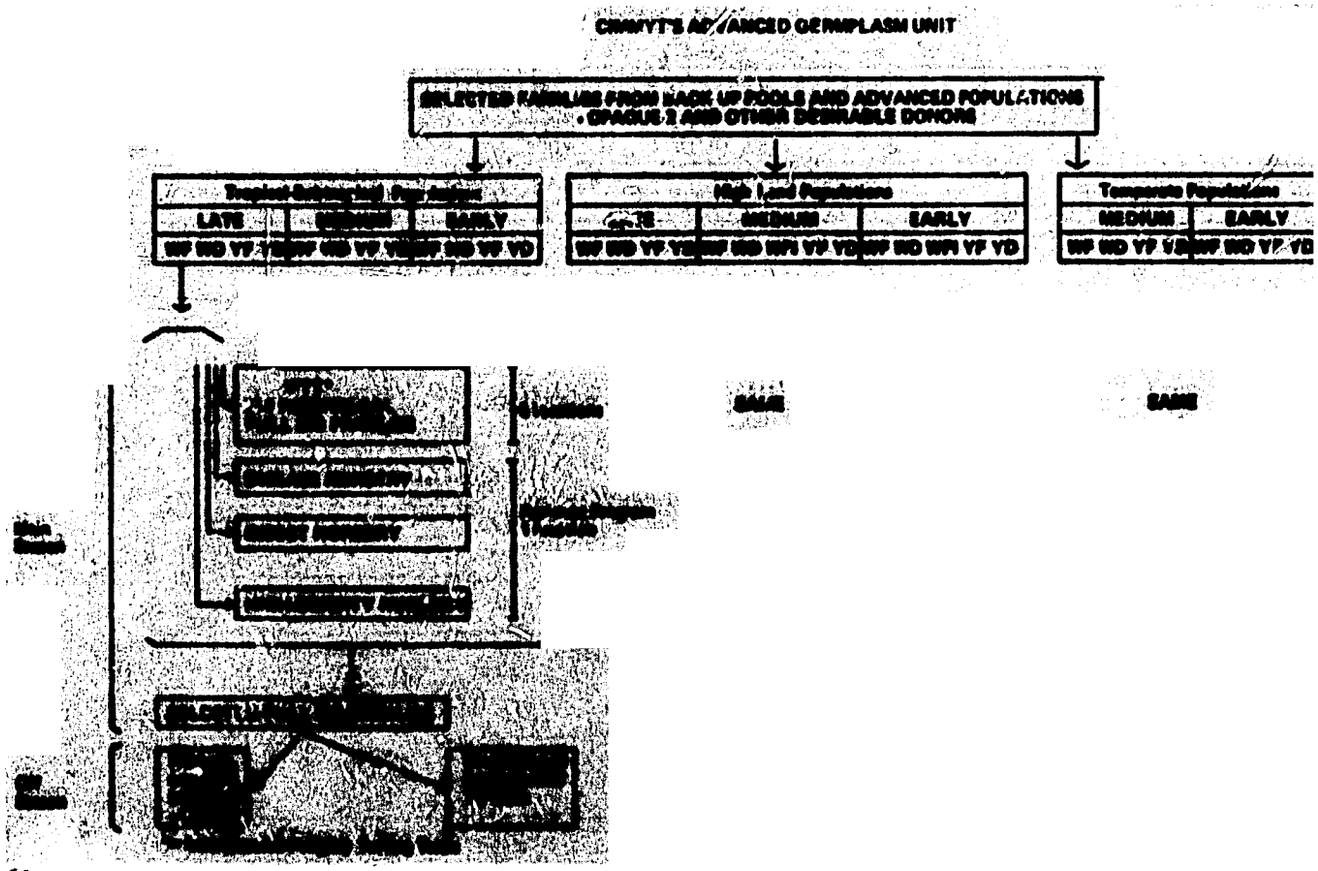
CIMMYT'S ADVANCED GERMPLASM UNIT
SELECTED FAMILIES FROM MADE UP POOLS AND ADVANCED POPULATIONS
• OPAQUE 2 AND OTHER DESIRABLE DONORS
Tropical Intermediate Populations
LATE
MEDIUM
EARLY
WF WD VF VD WF WD VF VD WF WD VF VD
High Land Populations
LATE
MEDIUM
EARLY
WF WD VF VD WF WD WF VF VD WF WD WF VF VD
Temperate Populations
MEDIUM
EARLY
WF WD VF VD WF WD VF VD
SAME
SAME

Se dio término a la impresión de este libro el 8 de noviembre de 1977 en los talleres de Ediciones Las Américas. Tiro: 2,000 Ejemplares. Impreso en México.