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9. ABSTRACT

A detailed and technical progress report of CIMMYT's maize improvement program in 1974. The program is aimed at developing appropriate technology as a joint venture with various public and private groups so that new varieties or practices are tested as part of the development and delivery process. Training stresses on-the-farm experience, with instruction and use of improved practices under conditions found in the trainee's home countries. Operations of the maize program have been divided into several stages, with two major divisions, the Back-up Unit and the Advanced Unit. The Back-up Unit covers introductions, testing of combinations, and building population complexes. The Advanced Unit is primarily the delivery vehicle into national programs; the materials here are much more homogeneous and thus nearer commercial use. Simultaneous progeny evaluation at several sites provides abundant information in the gradual improvement of populations, and materials can be multiplied immediately at any stage of development with knowledge of the performance accumulated during the selection of the progenies over previous cycles.

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CIMMYT: 1974
Maize Improvement

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

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International Maize and Wheat Improvement Center
Apdo Postal 6-641, Mexico 6, D.F., Mexico

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1.0 Introduction

CIMMYT's maize program--which in 1974 included 154 separate progeny trials in 22 countries, and 84 experimental variety trials in 35 countries--was begun as a cooperative venture of the Government of Mexico and the Rockefeller Foundation. Although program emphasis and geographical scope have evolved progressively, the origins of many of today's trials reach back over 30 years to the work of the program founders.

In the early years, hybrids were developed to meet the production needs of Mexico. Later, program scientists began putting together some genetically diverse maize populations, or composites, to set the stage for a concentrated effort on population improvement.

By 1970, there were many such populations in the CIMMYT program: still very heterogeneous, but excellent breeding populations. At that time, CIMMYT began to direct these populations (and others) toward the major genotype requirements of the maize-growing countries of the world. We have often referred to the program operations as a sort of funnel--with the germplasm bank serving as a source of genes to feed into the top. These materials would sift down through funnel populations of more distinct identity, evolving as experimental varieties that emerged as specific crosses directed at a farm-level use in a particular maize-producing area.

In 1973, CIMMYT decided that 28 populations have been defined well enough to move into an international progeny testing program, and that the resultant experimental varieties could be used directly in crosses, or for production in many countries. Our 1973 maize progress report detailed the various functions and systems that have carried the flow of materials from the germplasm bank and introductions, through the "funnel" of development and testing, to the testing of elite experimental varieties. (A brief summary of this process is provided in the Appendix CIMMYT's funnel concept is now capable of delivering progeny, experimental varieties, and elite experimental varieties to the many cooperating programs.

Thus, in 1974, reporting emphasis can be given to the results of the first year of systematic international testing. The international cooperation that is so crucial to CIMMYT's operations is highlighted first, with subsequent sections devoted to the supporting activities that provide the basic structure for our maize improvement work.

1.1 EDITORIAL NOTE:

Modifications in the content and format of the CIMMYT maize program report for 1974 stem directly from maize improvement progress and expansion in recent years. These adaptations allow documentation of a program in action, with direct and detailed reporting from national programs and farmers' fields throughout the world.

Specifically:

Data from the first complete year of international testing are highlighted in the lead section. Subsequent sections reflect the progressive stages of the maize improvement progress that support these worldwide trials. Primary focus is on research payoff for farm production.

Style, organization, and layout are designed for readers with a technical background, strongly weighted for scientists in national programs. The aim is for quicker delivery of results in a straight-

forward, heavily tabular format--organized for field and reference use.

It is hoped that these adaptations will further streamline the travel of maize improvement results to--and from--collaborating scientists and farmers. As worldwide agricultural information networks become operational, accommodations can be made rapidly to meet storage and retrieval demands, with report-year results keyed and indexed for smoother tracking of year-to-year progress.

Readers seeking a general survey of CIMMYT's operations are referred to the: CIMMYT REVIEW 1975. Reference data on other maize program technical reports for 1974 are found in Section 10)

1.2 ABOUT THIS REPORT

1.21 FLOOD AT POZA RICA

A flood at the Poza Rica station during September 1974 resulted in serious losses of material and in damage to the station itself. The yield trials associated with the Advanced Unit Progenies were all harvested prior to the flood, as were the Back-Up Pools 15, 16, 17, 18, 22; the Amarillo Bajío population; plus seed of Experimental Varieties from the previous cycle selections. Complete losses were recorded for: plantings of 7 other Back-Up pools; all of the Back-Up yield trials; the germplasm bank trials; the high density plantings, the Opaque-2 nursery, the seed increase of Tuxpeño 1; 3 isolation plantings; and 3 materials being advanced for south of the Equator locations. These plantings must be repeated from reserve seed; thus there will be a setback of one growing season in the development of the materials involved.

1.22 FROSTS AT TOLUCA AND EL BATAN

An unseasonal early frost in the highlands of Mexico killed the maize plantings at Toluca and El Batán in early September, 1974. Those materials which were already mature (the very early types) were unaffected, while the intermediate and later maturity types were progressively damaged, depending on their stages of maturity. This resulted in a delay of one year in the development of those materials which had not formed grain, and in a relatively poor job of selection in those materials frozen with the grain only partially filled. Major parts of these populations will need to be replanted in 1975.

CIMMYT's Maize Improvement process now delivers improved varietal material to cooperators in most of the tropical areas of the world.

2.0 Overview of Maize Improvement Process

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 or other independent groups or associations; and (3) with groups that have no formal designation. Our materials and information are freely available to all.

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.

Our training stresses on-the-farm experience, with instruction and use of improved practices under conditions that are found in the trainees' home countries.

The organization and function of the maize improvement process were reported in detail in the 1973 Maize Improvement Report. A quick summary of the general flow of materials in this process--from introduction to their delivery as improved varieties in national programs is shown in the Appendix. The program is seen as a continuous flow, with operations occurring simultaneously, rather than in a series of rigid steps.

If the new varieties are to contribute substantially to total production, they must be accepted by local farmers and placed in widespread use. Any characteristic or requirement that interferes with this acceptance and use is likely to limit the contribution of a new variety or practice.

This reasoning has suggested that the major thrust of our variety development program be toward open pollinated varieties that do not require a sophisticated hybrid seed production and distribution facility for their increase. This decision recognizes that there is little prospect for massive use of hybrids in many tropical areas of the world, even if greatly superior hybrids were available.

Most maize-growing areas are affected by factors of a very practical nature that tend to diminish the advantages that a hybrid may have. For example, in many areas where good hybrids <u>are</u> available, it is the practice of a relatively large proportion of the farmers who do purchase hybrid seed to plant back the resulting seed from one to several generations. These practices often produce the same net result as would the use of open pollinated varieties.

Other limitations of hybrids include the complex and precise logistics of producing good seed and getting them to the farmer. Availability and costs of fertilizers and other inputs also must be considered along with hazards of nature such as limited and erratic moisture supplies, floods, storms, and uncertain harvest returns.

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. Looked at in this way, the use of hybrids presumes a whole series of conditions that must be met for effective contributions to a national program. Further, any long range hybrid development program must be backed by a continuing population improvement program that will permit the derivation of pro-

gressively better hybrids. Hence, CIMMYT emphasizes population improvement in its breeding work, with the hybrid spin-off intended for use by national programs or other scientists in developing hybrids for local [illegible].

The variety development program at CIMMYT attempts to provide the range of maturities, grain [illegible] textures, and colors, that are needed to meet both the highland and lowland ecological conditions of [illegible] areas of the world. A constant stream of germ plasm flows into the basic complexes from the [illegible] germ plasm bank, as well as from other bank resources, national programs, and wherever other [illegible] valuable traits may be identified.

For convenience in the general management of the maize improvement process, the operations [illegible] program have been divided into several stages, with the two major divisions called the Back-up [illegible] Advanced Unit.

The Back-up Unit involves new introductions, testing of combinations, and building population [illegible]. The Advanced Unit is primarily the delivery vehicle into national programs; the materials are [illegible] 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 [illegible] stage of development, with knowledge of the performance accumulated during the selection of the progenies over previous cycles.

The remainder of this report provides a documentation of this process in action during 1974.

Young scientists from throughout the world participate in CIMMYT's operations in Mexico; in-service training emphasizes first-hand experience with practices that can be adapted for use in their home countries.

3.0 Advanced Unit Operations: 1974

3.1 INTERNATIONAL TESTING AND DISTRIBUTION - 1974

Three separate phases are involved in the international testing and distribution of materials. Phase one: consists of variety tests to identify which varieties (or populations) are most suitable for a given location. Phase two: after identification, progeny trials of the indicated materials are made. Phase three selected superior progenies are then recombined as judgment indicates to provide the experimental varieties, these are decided upon in collaboration with the local program that would use the variety for production.

The Advanced-Unit materials are arbitrarily handled in progeny sets of approximately 250 each. Thus, progeny trials are conducted in 16 x 16 lattice design trials, with the practical limitation of two replications at each of six different environmental sites. The six sites are chosen with one at a CIMMYT station in Mexico and each of the other five in a different country. The intent is to conduct the progeny trials of a given population simultaneously in six different countries.

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.

To conduct progeny trials of this type, adequate seed must be provided. This seed is generated by means of reciprocal hand pollinations of selected individual plants. From 250 to 300 families in progeny trials are selected, and the pollinations are made among these families (replicate seed is dominant seed from the previous cycle). Several plants in each family are thus individually crossed to other plants in other families (each with a different family).

Advanced materials have been assigned population numbers 21 through 48, inclusive. (Numbers 1 through 20 are reserved for experimental variety trials, bank entry combinations, etc.). As a start, progenies are being generated in Mexico during the winter (December-April) period 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 seasons of the year to provide the same service to locations on the other side of the equator).

A few rows of an opaque counterpart is planted adjacent to each Advanced population. This is back-crossed to the parent population during the progeny generating cycle. These crosses are sub-mated during the progeny trial period in the summer, and the opaque-2 segregate kernels is again planted adjacent to the recurrent parent for the next back-cross. In this way, each Advanced population is simultaneously converted to its opaque-2 equivalent.

In 1974, 34 progeny lattice sets of 16 x 16 were sent to one or more locations in countries other than Mexico. The number of sites varied from one to six for each of these materials. Data available was used to select the families for intercrossing to produce the progenies to be used in 1974 plantings at the several international sites.

As noted earlier, the Advanced stage materials are not only those that are relatively most uniform and homogeneous in characteristics (so that they are suitable for immediate increase as varieties), they are also systematically distributed to several countries simultaneously, so that they are widely and continuously

available to national programs.

The progeny and varietal testings are conducted in conjunction with regional and national programs as 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 germ plasm represented. Reserve seed is maintained in order to permit several options as a follow-up.

An additional level of evaluation of materials is contemplated in further tests of the experimental varieties. As the experimental varieties are developed, they in turn are organized into variety trials that will be grown over a much larger range of sites than at present. These are projected for about 25 sites with four row plots and four replications. Such testing allows an opportunity for more precise comparisons of experimental varieties themselves, and also provides a means for the identification of the most suitable materials for individual sites. Based on such varietal evaluations, a given site might select a different material than that which was originally used in progeny testing; whereas other sites, without progeny trials, could choose the materials to be established as progeny trials from the varietal trials.

Thus, Elite Experimental Varieties can be identified, both for use as commercial varieties at specific sites and for further study in relation to dependability of production over ranges of varied environments. As quickly as Elite Experimental Varieties are determined, on-farm trials will follow to verify their suitability for production.

3.11 EXPERIMENTAL VARIETY TRIALS: 1974 FINDINGS

3.111 National Programs

An array of diverse germplasm in the form of a variety yield trial can be a valuable adjunct to national programs: the performance of the varieties in these programs can be compared with other materials, and, upon request, a choice of new germplasm can be made available to complement the program's materials. Variety tests provide first-hand information about the available populations and their suitability for national programs.

In 1974, CIMMYT distributed variety trials representing a cross-section of the germplasm in the more Advanced populations under selection to provide: (1) a general evaluation, and (2) a basis for selection whereby individual countries might select and request suitable types for subsequent progeny trials. Table 3.11 shows the list of varieties distributed, with a preliminary summary of performance for yield, maturity and plant height.

Previous observations regarding the relative suitability of different types of germplasm were reconfirmed. Compuesto Hungria is almost all U.S. Corn Belt type in origin and has been shown to be totally unsuitable in lowland tropical areas, and thus has fallen to the bottom of the list. Amarillos Pakistan and Blancos Pakistan also are composed largely of U.S. Corn Belt germplasm, combined with the temperate latitude materials from Pakistan; whereas ETO x Illinois contains one-half Corn Belt germplasm and one-half intermediate altitude tropical material. The (Ant. 2D x AED) Kitale composite from Egypt is based on the Kitale II variety from Kenya (fairly cool climate) and on the cross of Antigua 2-D (Caribbean) with American Early Dent (Egypt); it essentially behaved as a temperate climate variety unsuited to lowland tropical areas.

The several opaque-2 varieties tended to occupy the portion of the list just above that of the poorly adapted types and below that of most of the normal kernel types, regardless of relative maturity or plant heights.

Despite the inclusion of such a diverse array of materials in the trial, the mean yield of the trial over 14 sites was 3,567 kg/ha, and the general precision of the trials was reasonably good. Trials were organized as 6 x 6 lattice designs, with four replications, and included six local check varieties for each site. Plots consisted of four rows; however, only the two center rows were harvested to reduce the effects of dissimilar maturities and plant heights on adjacent plots. Even with this precaution, some of these effects were included, suggesting that temperate-type materials should be restricted to non-tropical regions in such trials.

All of these materials tended to grow tall in Egypt and Nepal, countries which probably should not be classified as lying within tropical regions. Plant height varied widely in response to a series of environmental factors (of which day length has been reported to be extremely important). Temperature also is of critical importance in the development of the maize plant. The interaction of day length and sequences of

TABLE 3.1.1 Preliminary Results of Experimental Variety Trial 1974. Variety Means. Across 20 locations *.

Entry	Pedigree	Rank	Yield kg/ha.	Days to flower	Plant height
1	Tuxpeño 1	4	4274	67	216
2	Mezcla Tropical Blanco	2	4469	67	237
3	Blanco Cristalino	12	4020	64	222
4	Antigua x Ver. 181	16	3677	66	220
5	(Mix. 1 x Col. Gpo. 1)ETO	10	4101	68	240
6	Braquíticos	15	3754	70	208
7	IDRN	14	3785	64	242
8	Cogollero	9	4103	66	250
9	Tuxpeño x La Posta o_2	23	3355	67	220
10	(Ver. 181 x Ant. Gpo. 2)Ven. 1 o_2	26	2976	65	230
11	Y.H.E. o_2	22	3407	65	240
12	W.H.E. o_2	21	3414	65	233
13	Compuesto K (H.E.) o_2	25	3249	65	238
14	La Posta C_2	3	4336	69	249
15	Mezcla Amarilla	17	3595	64	234
16	Amarillo Cristalino 1	13	3863	66	236
17	Amarillo Dentado 2	11	4068	66	233
18	Tuxpeño Caribe 2	6	4220	67	228
19	Amarillo Dentado 1	5	4225	67	251
20	Tuxpeño Caribe 1	7	4145	66	240
21	Amarillo Subtropical	18	3590	64	234
22	Blanco Subtropical	20	3420	64	238
23	ETO x Illinois	24	3315	63	232
24	AED x Tuxpeño P.B.	19	3453	63	236
25	(Ant. 2D x AED) Kitale	27	2795	66	233
26	Amarillos Pakistan	28	2510	65	219
27	Blancos Pakistan	29	2305	59	214
28	Compuesto Hungría	30	1738	57	194
29	(Tuxp. x La Posta x Tuxp. Inv. Ver.)	1	4527	67	237
30	(Cuba x Rep. Dom.)x(Mez. Am. Ant. x Ver. 181) F_3	8	4118	65	243
31	Checks		4387	65	238
32	"		4141	65	233
33	"		3877	64	237
34	"		4337	66	236
35	"		4007	65	236
36	"		3956	65	239

* Panamá (3), Barbados (2), Peru (1), Bolivia (1), Egypt (1), Ghana (1), Guatemala (1), Mexico (3), El Salvador (1), Thailand (1), Ecuador (1), Nepal (2), Costa Rica (2).

Precise records of dates, plots, and plants are essential in the formation of experimental varieties; superior families selected from progeny trials on the basis of their performance are intercrossed in this process.

TABLE 3.1.2 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	BELIZE	COSTA RICA	EL SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	PANAMA	HAITI	JAMAICA	REP. DOMINICANA	BATAN	OBREGON	POZA RICA	TLALTIZAPAN	TOLUCA	IMIA	ALGERIA	EGYPT	ETHIOPIA	GHANA	IVORY COAST	KENYA	MOÇAMBIQUE	NIGERIA	REP. CENTRAFR.	SOUTH AFRICA	TANZANIA	ZAIRE	BANGLADESH	INDIA	INDONESIA	IRAN	KHMER 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			2	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									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	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							27
16	TEMPERATE	1	2	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	1	4	6	1	9	4	5	2	1	4	8	6	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	180

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.

In the progeny trials, 250 reciprocal full-sib families, plus six checks, make up the trials that are tested simultaneously in 6 countries.

varying temperatures was not well defined. Maize varieties of lowland tropical origin, when planted at Toluca, Mexico, (8,600 feet elevation) under very cool growing conditions, develop very slowly, have a semi-chlorotic appearance, and do not become very tall (never mature) so that temperature may be much more important than day length in many cases.

Table 3.11 indicates that the adapted materials are performing well over a wide range of conditions. Twelve of the entries were above 4 tons/hectare, as measured as an average over the 20 sites; they were fully equal to or better than the local checks.

An indication of the effect of the emphasis placed on short plant selection is reflected by Entry 1, Tuxpeño 1 (Table 3.11). This variety was only 8 centimeters taller than the brachytic 2 version of essentially the same genetic background (Entry 6, Braquíticos). It is being increased and distributed commercially in several countries. (Mexico reports more than 2,000 hectares of seed production to be ready for sale in 1975.

Preliminary results also show that among the types adapted to lowland tropical conditions, the white dent variety called "Tuxpeño 1 x La Posta & Inv.-Ver" performed well. This is a complex derived from the Tuxpeño race that was originally selected as three different varieties: (1) La Posta, a synthetic formed from 15 selected inbred lines; (2) Tuxpeño "Invierno-Verano", a mass selection for yield version of Tuxpeño Crema 1; and (3) Tuxpeño 1, a short plant (planta baja) selection from the original "Tuxpeño Crema 1", or selected Tuxpeño Composite. The Tuxpeño Crema 1 and La Posta are both very tall-growing varieties, while the Tuxpeño 1 (or planta baja) has been drastically reduced in plant height through recurrent selection. The two tall varieties were crossed with the short plant selection, and the resulting cross carried to F_3 and increased for inclusion in the variety trial as one of the entries. The resulting variety is much shorter than the two tall parents and only slightly taller than the short plant parent used in reducing plant height. It seems that the use of quantitatively selected short plant populations can be a very useful device to reduce the plant height of other materials.

Because of the difficulties inherent in interpreting data from trials with diverse types of materials the variety trials have been sub-divided into a series of different trials for 1975. Tropical, temperate, highland and opaque materials will be handled in distinctly separate trials, as will materials with widely different maturities. This will permit the inclusion of more homogeneous entries in particular trials, as well as the distribution of materials that are in better accord with their areas of ecological adaptation. Proposed distribution of the experimental variety trials for 1975 is shown in Table 3.12. Reports are compiled as soon as the data is computed. For 1974, variety trial data have been summarized in a report titled Maize Program Preliminary Report - International Experimental Variety Trials, 1974, and distributed to cooperators and other interested scientists. An example of the results from an individual site is given in Table 3.13 for La Molina, Peru, and is provided in similar form for all sites to each cooperator. When results have been completed for the year, the additional data recovered will be compiled in a supplement and similarly distributed.

3.112 Mexico Trials

3.1121 Experimental Variety Trials: 1974A

Twenty-five experimental varieties were compared at three sites in the winter season 1973-74: Poza Rica, Tlaltizapán, and Buena Vista, a site near Poza Rica. In addition, five opaque-2 varieties were compared in separate (adjacent) trials at the same sites. The results of these two sets of trials are shown in Tables 3.14 and 3.15.

Fourteen of the twenty-five normal varieties and all five of the opaque-2 varieties were subsequently included in the advanced unit populations that were tested internationally in progeny trials and experimental variety trials in 1974.

3.11211 Grain yields: were larger at Tlaltizapán than at the other two sites. The mean yields over sites of the individual varieties (from 3858 to 5290 kg/ha) do not deviate very widely from the overall mean (4754 kg/ha), indicating the similarity in the origin of most of these entries. A fairly clear exception is the lowest yielding entry, Eto x Illinois.

The opaque-2 varieties gave yields that were, on average, 670 kg/ha lower than the mean yield of the normal varieties at the same sites.

TABLE 3.1.3 VARIETY EXPERIMENTS: 1974
STATION AND LOCATION: Programa Cooperativo de Investigaciones en Maíz --Universidad Nacional Agraria-- La Molina, Perú
COOPERATOR: F. Scheuch H.

No.	Variety (Variedad)	Kg/Ha.	Days Flower (Días flor.)	Plant Ht. (Alt. plant.)	Ear Ht. (Alt. mz.)	No. Plts. (No. plants)	Ears/ Plant (Maíz plant)	Rotten Ears (Pudr. mz. PC)
31	Check	12875	102	273	170	40.7	1.4	9.5
33	Check	11715	104	305	173	41.5	1.2	11.0
32	Check	11677	101	295	159	41.7	1.3	9.6
29	Tuxp. x La Pos. x Tuxp. I.V.	11086	106	250	125	39.0	1.4	9.0
34	Check	10978	103	305	165	38.7	1.3	6.6
1	Tuxpeño 1	10804	101	223	98	40.5	1.2	5.0
14	La Posta C2	10618	107	264	140	41.2	1.1	6.7
35	Check	10295	103	288	154	39.5	1.2	8.7
2	Mezcla Tropical Blanco	10266	102	240	114	40.5	1.2	9.2
5	(Mix. 1 x Col. Gpo. 1) Eto	10264	104	253	125	40.5	1.3	11.8
20	Tuxpeño Caribe 1	10096	102	240	116	41.7	1.2	8.2
18	Tuxpeño Caribe 2	10083	102	234	109	43.0	1.2	9.6
19	Amarillo Dentado 1	9689	102	251	122	41.5	1.2	5.1
11	Y.H.E. 02	9475	98	244	120	40.2	1.5	7.0
6	Braquiticos	9373	108	203	86	40.7	1.1	10.3
23	Eto x Illinois	9343	94	223	102	40.7	1.1	14.1
8	Cogollero	9340	101	254	129	41.2	1.2	7.1
17	Amarillo Dentado 2	9332	101	238	111	39.0	1.3	7.3
21	Amarillo Subtropical	9293	97	229	114	40.5	1.3	12.4
22	Blanco Subtropical	9182	96	222	110	40.2	1.2	16.1
16	Amarillo Cristalino 1	9178	101	239	111	39.5	1.2	3.8
30	(CxRD) (MaxAnt. x V 181)	9054	102	246	123	40.7	1.3	5.5
24	AED x Tuxpeño P.B.	8932	101	230	122	40.5	1.1	20.8
36	Check	8925	103	268	143	39.5	1.3	9.3
7	IDRN	8815	98	226	112	40.7	1.2	7.5
9	Tuxpeño x La Posta 02	8790	101	226	104	37.5	1.2	13.4
4	Antigua x Ver. 181	8759	102	230	119	41.5	1.2	5.9
12	W.H.E. 02	8689	99	239	116	40.2	1.3	7.3
3	Blanco Cristalino	8597	99	206	91	41.2	1.2	8.0
13	Compuesto K (H.E.) 02	7751	100	234	117	39.7	1.1	9.2
25	(Ant. 2 D x AED) Kitale	7697	99	228	117	40.7	1.0	26.0
15	Mezcla Amarilla	7689	99	204	90	41.2	1.2	5.9
10	(Ver. 181 x Ant. Gpo. 2) Ven. 1	7617	98	228	116	37.7	1.2	12.0
26	Amarillos Pakistan	5998	93	222	99	40.0	0.8	29.5
28	Compuesto Hungria	5786	83	196	78	40.7	0.9	50.3
27	Blancos Pakistan	5419	85	199	91	40.0	1.1	25.1
	Means $\bar{x}$	9266	100	240	119	40.4	1.2	11.8
	LSD (DMS) .05	1081						
	C.V.	8.3						

TABLE 3.1.4 Grain yield of the 25 experimental varieties grown at Poza Rica, Buena Vista (Veracruz), and Tlaltizapan in the 1974 A cycle.

Experimental Variety		Grain Yield (Kg/ha.) Poza Rica	Buena Vista	Tlaltizapan	Variety Mean
* 1	Tuxpeño Caribe 2	3982	5184	6703	5290
* 2	La Posta C-4	4816	4635	6308	5253
3	Tuxpeño PB x Sint. 10 lin.	4888	4464	6399	5250
* 4	Tuxpeño - 1	4739	4474	6412	5208
5	Mezcla Amarilla x 8 Mat.	4831	4586	6150	5189
1 6	Familias Selectas	4199	4455	6794	5149
* 7	Amarillo Dentado 2	4363	4971	5488	4941
1 8	Lineas E.S. x Varios	4700	5074	4978	4917
9	Tuxpeño PB x 19 Mat.	4458	4838	5442	4913
10	(Mix. 1 x Col. Gpo. 1) x Eto x Sint. 10 lin.	4615	4056	6037	4903
* 11	Tuxpeño Caribe 1	4131	4212	6231	4858
1 12	Cruz de Familias Selectas BL	4896	4255	5412	4854
13	Tuxpeño x Nic. x Sint. 10 lin. S.B.	4915	4553	5026	4831
* 14	Compuesto Blanco Cristalino	3662	4008	6486	4719
15	Eto PB. x Sint. 10 lin.	4091	3994	5883	4656
* 16	IDRN	4532	3668	5626	4609
17	(Cuba x Rep. Dom.) x Ant. x Ver. 181	4129	4229	5464	4607
18	Amarillo del Bajio x Sint. 10 lin.	3654	4391	5688	4578
* 19	(Mix. 1 x Col. Gpo. 1) x Eto	3730	3938	6005	4558
* 20	Amarillo Dentado 1	4285	4113	5245	4548
* 21	Mezcla Amarilla	3705	4046	5754	4502
* 22	Amarillo Cristalino 1	3579	4455	5205	4413
* 23	Ant. x Ver. 181	3493	4059	4978	4177
* 24	Braquiticos	3509	4184	4580	4091
* 25	Eto x Illinois	2687	3679	5209	3858
	LSD .05	530	660	1257	
	C.V.	11.2%	11.0%	15.8%	
	Mean of Location	4183	4341	5740	

* Advanced Unit Population
1 Materials that were recombined to form "Mezcla Tropical Blanco"

TABLE 3.1.5 Grain yield of 5 experimental O_2 varieties grown at Poza Rica, Buena Vista (Veracruz), and Tlaltizapan in the 1974 A cycle.

Experimental Variety		Grain Yield (Kg/ha.) Poza Rica	Buena Vista	Tlaltizapan	Variety Mean
* 1	Tuxpeño x La Posta 02	4461	3881	5550	4631
* 2	Compuesto K (H.E.) 02	3469	3621	5116	4069
* 3	W.H.E. 02	3597	3517	5075	4063
* 4	Y.H.E. 02	3270	3532	5113	3972
* 5	(Ver. 181 x Ant. Gpo. 2) x Ven. 10_2	3181	3165	4703	3683
	LSD .05	677	473	702	
	C.V.	16.7%	9.6%	10.7%	
	Mean of Location	3596	3543	5111	

* Advanced Unit Populations.

The range of yields within each location was not very large and a large proportion of the varieties at each location gave yields that were not significantly different from one another. The close similarity of many of these materials justified combining some of them in 1974, as indicated in the table.

3.11212 Days to flowering: most of the varieties in this trial take a similar time from sowing to silking. The earliest entries (Eto x Illinois and IDRN Cornell) took 70 days to 50 per cent silking at Poza Rica, and 98 days in Tlaltizapán. The corresponding times for the Braquíticos, the latest entry, were 82 and 107 days. For the five opaque-2 varieties the time to silking was similar to that of most of the normal entries, namely 74 days at Poza Rica and 99 days in Tlaltizapán.

3.11213 Plant Height: for the 25 normal varieties and the 5 opaque-2 varieties the mean plant height was 194 cm in Poza Rica and 240 cm in Tlaltizapán. Apart from the Braquíticos, Mezcla Amarilla is the shortest variety in this set (167 cm at Poza Rica and 211 cm at Tlaltizapán). La Posta C_4 was the tallest (229 cm at Poza Rica and 277 cm at Tlaltizapán).

3.11214 Lodging: more plants lodged at Tlaltizapán (42 percent) than at the other sites (18 percent). This was associated with the difference in plant height at the two locations, and strong winds in March at Tlaltizapán. Of the varieties that are now in the advanced unit only Amarillo Dentado 1 and Ant. x Ver.181 showed above average susceptibility to lodging. There was rather more lodging in the opaque-2 varieties at Tlaltizapán than in the normal varieties.

3.11215 Diseases: the incidence of disease was fairly low at all three sites and almost entirely absent at Tlaltizapán. The only significant observation was a slightly higher incidence of ear rot in the five opaque-2 varieties (index 2.1) than in the normal population (index 1.3).

3.1122 Experimental Variety Trials: 1974B

The experimental variety trials sent out in 1974 consisted of 6 x 6 lattice designs with four replications at each site. The results for fourteen of these trials were summarized in a preliminary report that was circulated to co-operators who conducted the trials (March 1975) A more complete analysis of the combined data is planned when results from an additional ten or twelve trials are available.

Table 3.11 shows a summary of the yield data available. The mean yield over the twenty sites was 3626 kg/ha and the precision of the trials was, with a few exceptions, satisfactory. With the exception of entries No. 29 (Tuxpeño x La Posta I.V.) and No. 25 (Antigua x AED) Kitale, the varieties represent the advanced unit populations that were tested internationally in progeny trials in 1974. A description of the populations from which these progenies were generated can be found in the preliminary report of the progeny trials (CIMMYT Feb. 1975). Of the thirty-six entries in each trial, six were check varieties chosen locally and they were, therefore, different at each site.

3.12 PROGENY TRIALS

3.121 National Programs

Progeny trials were expanded in 1974, with systematic distribution to obtain: (1) quicker delivery of materials to national programs, and (2) information on the performance of the several advanced materials over a series of diverse environments. These trials are preceeded by comparative variety trials or other observations that serve to identify the types of populations most suitable for the needs of a given area. This simultaneous evaluation of a series of genotypes over differing production conditions increases the reliability of the results as compared to single site trials.

A total of 154 "IPTT" trials were distributed from CIMMYT during 1974 as shown in Table 3.16 "International Progeny Testing Trials, 1974". Data were received from 70 of these trials in time to make winter plantings and form experimental varieties from selected progenies. These experimental varieties are being organized into "Experimental Variety Trials" in the spring of 1975 (See Table 3.12). Of these experimental varieties, 84 are being formed on the basis of specific requests from individual sites, with an additional 9 varieties being formed on the basis of progeny performances over all sites at which they were tested.

TABLE 3.16 CIMMYT'S INTERNATIONAL MAIZE TESTING PROGRAM, 1975
DISTRIBUTION OF IPTT

IPTT No.	POPULATIONS	SOUTH AMERICA		CENTRAL AMERICA							MEXICO					AFRICA				ASIA						INDIA				U.S.A.	
		COLOMBIA	ECUADOR	COSTA RICA	EL SALVADOR	GUATEMALA	HONDURAS	NICARAGUA	PANAMA	REPLUBLICA DOMINICANA	POZA RICA	TLALTIZAPAN	OBREGON	BATAN	COTAXTLA	EGYPT	NIGERIA	TANZANIA	KENYA	PHILIPPINES	THAILAND	NEPAL	INDONESIA	PAKISTAN	TURKEY	DELHI	HYDERABAD	PANTNAGAR	LUDHIANA	CORNELL	TOTAL
21	Tuxpeño 1					1					1				1	1	1											1			6
22	Mezcla Tropical Blanco	1				1					1				1		1	1													6
23	Blanco Cristalino 1	1			1			1			1							1		1											6
24	Antigua x Ver. 181		1				1				1										1	1						1			6
25	(Mix.1 x Col.Gpo.1) x ETO	1		1							1								1			1						1			6
26	Mezcla Amarilla							1	1		1									1			1			1					6
27	Amarillo Cristalino 1					1			1		1		1											1		1					6
28	Amarillo Dentado 2								1	1	1				1									1			1				6
29	Tuxpeño Caribe 2	1	1			1	1				1				1																6
30	Amarillo Dentado 1					1				1			1								1			1		1					6
31	Braquiticos	1									1		1		1																4
32	Tuxpeño Caribe 1							1			1	1	1		1		1														6
33	Amarillo Subtropical	1					1					1										1		1				1			6
34	Blanco Subtropical	1										1	1									1		1				1			6
35	IDRN	1									1											1		1					1	1	6
36	Cogollero	1									1							1			1			1		1					6
37	Tuxpeño x La Posta O_2			1							1		1		1	1	1														6
38	(Ver.181 x Ant. Gpo.2) x Venz.1 O_2	1					1				1											1	1			1					6
39	Yellow H.E. O_2	1	1								1				1						1					1					6
40	White H. E. O_2	1			1						1						1					1						1			6
41	Composite K (H.E.) O_2	1				1					1							1		1								1			6
42	ETO x Illinois						1						1			1		1						1	1						6
43	La Posta	1									1	1	1		1	1															6
44	AED x Tuxpeño										1	1				1															3
45	Amarillos Pakistan											1	1	1										1		1					5
46	Blancos Pakistan											1	1	1										1		1					5
47	Compuesto de Hungary												1	1										1	2						5
	Total Distributed :	14	3	2	2	6	5	3	3	2	20	7	11	3	9	5	5	5	1	3	4	7	2	11	3	8	1	7	1	1	154

(Of the 154 trials distributed, 109 had been returned by July 1, 1975).

TABLE 3.1 7 Summary of performance of full sib families developed from Advanced Unit populations. Data from International Progeny Testing Trials: 1974 TROPICAL LATE WHITE DENT MATERIALS (TLWD)

			Yield ton/ha.					Plant Height cm.			
Population	IPTT No.	Testing Site*	Mean 250 fam.	C.V.	Mean Sel. fam.	Mean Exp. var.	Best Check	Mean 250	Mean Sel. fam.	Mean Exp. var.	Best Check
Tuxpeño 1	21	Gemiza (Egy)	2.91	54	3.48	5.67	6.10	195	196	207	196
		Cuyuta (G)	5.90	23	6.45	7.78	7.70	195	194	201	221
		Cotaxtla (M)	3.59	34	3.78	4.93	5.64	132	132	136	178
		Poza Rica (M)	6.53	16	6.98	8.20	7.36	210	211	215	230
Mezcla Tropical Blanco	22	Poza Rica (M)	6.59	21	7.26	8.29	6.98	226	227	227	222
		Cuyuta (G)	5.98	20	6.52	7.44	7.04	235	230	227	218
Tuxpeño Caribe 2	29	Cuyuta (G)	6.38	21	7.06	8.49	7.36	221	220	222	209
		Poza Rica (M)	6.01	19	6.49	7.69	6.62	226	225	231	232
		Cotaxtla (M)	4.03	27	4.13	5.35	6.41	163	162	163	200
Braquíticos	31	Cotaxtla (M)	4.53	29	4.83	6.49	5.83	160	162	160	195
		Obregon (M)	3.48	26	4.07	4.97	4.51	182	184	181	197
		Poza Rica (M)	5.76	21	6.61	7.37	8.44	199	204	201	221
Tuxpeño Caribe 1	32	Obregon (M)	3.48	24	3.98	4.79	4.02	205	204	200	224
		Tlaltizapan (M)	7.88	25	8.71	10.09	10.09	234	236	238	240
		Poza Rica (M)	6.03	17	6.59	7.51	6.56	231	231	232	228
		Managua (Nic)	3.72	33	4.51	4.80	4.91	180	181	187	208
		Across	5.28	-	5.95	6.34	6.40	212	213	212	225
La Posta	43	Sids (Egy)	5.25	35	6.14	7.76	7.65	318	319	320	324
		Tlaltizapan (M)	8.01	27	9.15	10.86	8.66	257	258	260	265
		Obregon (M)	3.64	28	4.19	4.95	4.45	235	235	231	255
		Poza Rica (M)	6.28	20	6.94	7.90	8.04	263	263	263	275
		Across	5.79	-	6.60	6.76	7.20	268	269	269	280
AED x Tuxpeño	44	Sids (Egy)	6.05	31	6.78	8.48	9.6	299	297	294	331
		Tlaltizapan (M)	7.20	29	7.98	9.87	6.5	225	226	233	205
		Poza Rica (M)	5.36	22	5.93	7.27	7.8	239	239	245	268
		Across	6.20	-	6.89	7.84	8.0	254	254	259	268

* M = Mexico; G = Guatemala; Nic. = Nicaragua; Egy = Egypt

Because of late arrival of seed in certain cases, and of substantial variation in planting season dates in others, data were not available to develop indicated specific experimental varieties for a number of locations during the 1974-5 winter planting season in Mexico. Nevertheless, upon request, such varieties will be developed for those locations as soon as feasible. Floods, drouths and other natural calamities also took their toll, causing unavoidable losses of a number of plantings.

3.1211 Testing Operations: An Example

Data obtained at the test sites is evaluated jointly by the collaborators and by CIMMYT on the basis of the several sites so that the most suitable progenies are selected in terms of the needs of the national programs. Thus, apparent yield, as well as plant height, maturity, grain texture, grain color and other traits, are considered in the selection by the national program: the collaborator's participation is crucial. As an example of how the system operates: Mezcla Amarilla (IPTT-26) was grown in identical progeny set trials in Delhi (India), Managua (Nicaragua), Tocumen (Panamá), Los Baños (Philippines) and Poza Rica (Mexico). Each location then selected the 10 superior progenies at that site. Reserve seed from the selected progenies was planted in Mexico, and was later intercrossed and multiplied. Identity for the following year's experimental variety trials was maintained as follows:

Variety Name		Test Location
Delhi	7426	Delhi, India
Managua	7426	Managua, Nicaragua
Tocumen	7426	Tocumen, Panamá
Los Baños	7426	Los Baños, Philippines
Poza Rica	7426	Poza Rica, Mexico
Across	7426	Across (mean) locations

The first word in the variety name describes the station where the progeny trial was conducted; the first two digits of the number indicate the year of test, while the last two digits represent the population number (IPTT-26 in the example). This designation is for testing purposes only--it is not intended as a substitute for the naming of varieties within national programs for their own use. National programs are urged to use names appropriate to their own needs.

Tables 3.17 through 3.111 contain an abbreviated summary of the results of the progeny trials (grouped by material type) for 1974 (Complete results have been reported in: Maize Program Preliminary Report International Progeny Tests, 1974). These tables list the populations included in the progeny trials, the sites at which each was grown, plus statistics on yield performance (in tons-of-grain-per-hectare), and plant height (in centimeters). For each site, the tables show the mean performance of all 250 progenies, the mean of the progenies selected to be recombined to derive the next generation of progenies for the 1975 trials, and the mean of the few (about 10) progenies chosen to develop the experimental variety for each site, and the best check.

3.2 COMPANION NURSERIES

The Companion Nurseries grown in Mexico provide a systematic evaluation of resistance to insect and disease pathogens when materials are placed under uniform and severe attacks. Performance is also tested in thick plantings.

In the insect-resistance nurseries, budworms and stem borers are multiplied in the laboratory; then half of each row in the field is infested (first with budworms, followed by stem borers). The other half of each of these rows is treated with insecticide. Each row represents one of the 250 families making up each advanced population, and is rated for insect damage several times during each growing season.

In the disease-resistance nursery, one-half of each row is inoculated with stalk rot pathogens, and the entire row inoculated with ear rot pathogens.

Insect and disease nurseries are planted before the yield trials and the high density nursery so that a high incidence of stunt disease can be obtained under natural conditions. These early plantings tend to attract large numbers of insects that are vectors of stunt.

TABLE 3.1.8 Summary of performance of full sib families developed from Advanced Unit populations. Data from International Progeny Testing Trials: 1974
TROPICAL YELLOW FLINT/DENT MATERIALS

			Yield ton/ha.					Plant Height cm.			
Population	IPTT No.	Testing Site*	Mean 250 fam.	C.V.	Mean sel. fam.	Mean exp. var.	Best Check	Mean 250	Mean sel. fam.	Mean exp. var.	Best Check
Amarillo Cristalino	27	Obregon (M)	2.70	25	3.16	3.84	3.64	219	222	217	230
		Delhi (I)	4.24	39	4.84	6.05	6.48	232	237	229	220
		La Maquina (G)	5.22	19	5.86	6.38	8.01	238	239	230	245
		Poza Rica (M)	5.62	17	6.25	6.96	8.91	246	250	247	245
		Panama (Pa)	4.64	27	5.25	6.60	6.31	247	249	250	258
		Yousafwala (Pk)	No data		-	-	-	-	-	-	-
		Across sites	4.50	-	5.07	5.31	6.67	236	239	238	240
Amarillo Dentado 2	28	Yousafwala (Pk)	No data		-	-	-	-	-	-	-
		Poza Rica (M)	5.49	20	6.25	6.97	6.73	237	238	238	241
		Panama (Pa)	5.90	24	6.66	8.28	6.99	255	255	264	260
Amarillo Dentado 1	30	Yousafwala (Pk)	No data		-	-	-	-	-	-	-
		La Maquina (G)	4.85	22	5.35	6.49	6.30	245	243	243	240
		Delhi (I)	4.67	33	5.06	6.23	6.60	242	239	230	265
		Obregon (M)	3.07	29	3.51	4.52	3.56	226	223	221	172
		Across sites	4.20	-	4.64	5.18	5.49	237	235	240	225
Cogollero	36	Poza Rica (M)	5.37	20	6.16	6.87	5.33	249	248	247	232

* M = Mexico; I = India; G = Guatemala; Pa = Panama; Pk = Pakistan

TABLE 3.1.9 Summary of performance of full sib families developed from Advanced Unit populations. Data from International Progeny Testing Trials: 1974
TROPICAL INTERMEDIATE MATERIALS

			Yield ton/ha.					Plant Height cm.			
Population	IPTT No.	Testing Site*	Mean 250 fam.	C.V.	Mean[1] sel. fam.	Mean[2] exp. var.	Best Check	Mean 250	Mean sel. fam.	Mean exp. var.	Best Check
Blanco Cristalino	23	Poza Rica (M)	6.33	16	6.92	7.59	7.43	213	213	216	220
		Los Baños (Ph)	4.67	30	5.15	6.44	3.94	228	230	230	246
		El Salvador (Sal)	2.70	26	3.03	4.03	3.54	222	223	222	234
		Across sites	4.57	-	4.87	5.27	4.97	221	223	229	233
Antigua Gpo. 2 x Ver. 181	24	Poza Rica (M)	5.72	11	6.26	7.11	8.41	210	209	212	209
Mix. 1 x Col. Gpo. 1) ETO	25	Poza Rica (M)	6.23	17	6.98	7.83	8.03	212	211	216	224
Mezcla Amarilla	26	Delhi (I)	4.21	31	4.60	5.85	7.21	210	210	203	265
		Poza Rica (M)	6.48	16	6.93	8.00	9.76	213	213	216	234
		Managua (Nic)	3.46	29	3.91	4.63	4.31	142	145	140	175
		Panama (Pa)	5.29	22	5.80	7.24	8.72	231	231	231	260
		Los Baños (Ph)	3.96	36	4.44	3.42	3.06	211	212	218	223
		Across sites	4.68	-	5.13	5.67	6.61	201	202	204	231
IDRN	35	Poza Rica (M)	4.52	25	5.30	6.184	5.750	238	232	237	223
		Yousafwala (Pk)	No data		-	-	-	-	-	-	-

* M = Mexico; Ph = Phillippines; Sal = Salvador; Nic = Nicaragua; Pa = Panama; Pk = Pakistan; I = India

1 Mean of the progenies selected for deriving the next set of progenies.
2 Mean of the progenies selected for developing the experimental variety.

TABLE 3.1.10 Summary of performance of full sib families developed from Advance Unit populations. Data from International Testing Trials: 1974
OPAQUE MATERIALS

Population	IPTT No.	Testing Site*	Yield ton/ha. Mean 250 fam.	C.V.	Mean sel. fam.	Mean exp. var.	Best Check	Plant Height cm. Mean 250	Mean sel. fam.	Mean exp. var.	Best Check
Tuxpeño x La Posta O_2	37	Poza Rica (M)	4.83	22	5.24	6.10	6.55	234	233	237	264
		Obregon (M)	3.10	26	3.57	4.44	3.70	199	206	194	210
		Cotaxtla (M)	3.28	36	3.72	5.06	4.40	181	180	178	195
		Gemiza (Egy)	1.47	86	3.65	3.65	5.67	188	220	220	236
		Across sites	3.14	-	3.57	3.94	5.08	200	200	209	226
(Ver. 181 x Ant. Gpo. 2) Venez. 1 O_2	38	Poza Rica (M)	4.48	24	5.10	6.08	7.95	243	245	248	242
		Delhi (I)	2.93	38	3.45	4.18	5.68	206	210	207	190
		Rampur (Nep)	No data		-	-	-	-	-	-	-
Yellow HE O_2	39	Poza Rica (M)	4.54	21	4.96	6.03	5.29	245	242	243	241
		Cotaxtla (M)	3.18	28	3.42	5.70	4.98	214	211	206	226
		Delhi (I)	3.14	42	3.36	4.79	6.23	231	228	235	245
		Rampur (Nep)	No data		-	-	-	-	-	-	-
White HE O_2	40	Poza Rica (M)	4.83	18	5.28	6.09	7.08	254	251	251	230
		El Salvador (Sal)	1.85	30	2.11	2.66	1.98	237	234	239	244
Composite K HE O_2	41	Poza Rica (M)	4.66	20	5.15	5.97	8.38	237	236	238	212
		Cuyuta (G)	4.31	22	4.76	5.58	5.65	233	233	230	202
		Across sites	4.48	-	4.96	5.61	7.01	235	234	237	207

* M = Mexico; Egy = Egypt; I = India; Nep = Nepal; Sal = Salvador; G = Guatemala

TABLE 3.1.11 Summary of performance of full sib families developed from Advance Unit populations. Data from International Progeny Testing Trials: 1974
SUBTROPICAL AND TEMPERATE MATERIALS

Population	IPTT No.	Testing Site*	Yield ton/ha Mean 250 fam.	C.V.	Mean sel. fam.	Mean exp. var.	Best Check	Plant Height cm. Mean 250	Mean sel. fam.	Mean exp. var.	Best Check
Amarillo Subtropical	33	Tlaltizapan (M)	5.89	43	6.87	8.88	5.97	204	-	209	237
		Rampur (Nep)	No data		-	-	-	-	-	-	-
		Pirsabak (Pk)	No data		-	-	-	-	-	-	-
Blanco Subtropical	34	Rampur (Nep)	No data		-	-	-	-	-	-	-
		Pirsabak (Pk)	No data		-	-	-	-	-	-	-
		Obregon (M)	2.55	35	3.01	4.09	4.39	212	209	210	182
		Tlaltizapan (M)	6.56	27	7.18	9.08	7.31	234	229	234	195
Eto x Illinois	42	Pirsabak (Pk)	No data		-	-	-	-	-	-	-
		Gemiza (Egy)	2.23	60	2.53	5.40	5.71	203	202	238	235
		Adapazari (Tk)	4.41	29	4.83	6.13	5.56	217	217	210	170
		Obregon (M)	2.89	29	3.19	4.06	4.56	208	205	205	212
	46	Pirsabak (Pk)	No data		-	-	-	-	-	-	-
		Tlaltizapan (M)	4.49	42	5.52	7.10	7.99	192	196	204	195
		Obregon (M)	2.30	29	2.67	3.36	4.48	205	205	201	217
	47	Pirsabak (Pk)	No data		-	-	-	-	-	-	-
		Tlaltizapan (M)	4.06	45	4.96	6.49	7.38	177	178	175	185
		Obregon (M)	2.30	36	2.70	3.82	4.24	195	193	205	212
Compuesto Hungary	48	Pirsabak (Pk)	No data		-	-	-	-	-	-	-
		Adapazari (Tk)	5.34	25	5.67	7.31	6.18	221	219	217	220
		Obregon (M)	1.60	45	1.82	2.41	6.56	174	173	163	148

* M = Mexico; Nep = Nepal; Pk = Pakistan; Tk = Turkey

The high-density nursery is planted at 80,000 plants per hectare compared with 53,300 plants used in the yield trials.

Tables 3.21; 3.22; and 3.23 are summaries of the notes taken for disease and insect ratings at Tlaltizapán and Poza Rica, as well as for some high density nursery plantings grown at Tlaltizapán.

3.3 POPULATION CHANGES FOR 1975

In the improvement of the Advanced Unit progeny populations, several materials were merged (combined) on the basis of data accumulated during 1974 (Table 3.31). Amarillo Dentado 1 (IPTT-30) and Amarillo Dentado 2 (IPTT-28) were merged to form Amarillo Dentado as IPTT-28 for 1975. Similarly, Tuxpeño Caribe 2 (IPTT-29) were merged to form IPTT-29. Amarillo Subtropical (IPTT-33) was combined with Amarillo Pakistan (IPTT-36) to form Amarillo Subtropical IPTT-33. Banco Subtropical (IPTT-34) and Blanco Pakistan (IPTT-47) were combined to form Blanco Subtropical (IPTT-34). BDRN (IPTT-35) and Cogollero (IPTT-36) were combined into Cogollero (IPTT-36). The three opaque populations (Ver.181-Ant.Gpo.2) Ven.1 o_2 (IPTT-38), Yellow Hard Endosperm o_2 (IPTT-39) and Composite K (IPTT-41) were merged to form Yellow Hard Endosperm (IPTT-39).

Two populations from the Back-up Unit were advanced intact to form part of the Advanced Unit, with ETO Blanco becoming IPTT-32 and Ant. Gpo.2 - Rep. Dominicana becoming IPTT-35. A third Advanced Unit population was formed from progenies generated from white flint segregants as follows: (Tuxpeño x Nicarillo) Sint. 10 lines - 69 progenies; (Mix. 1-Col. Gpo.1) ETO-Sint. 10 lines - 36 progenies; and ETO Blanco Sint. 10 lines - 33 progenies.

3.4 HIGH-QUALITY PROTEIN MAIZE

The amino acid balance in all cereals is below the optimum for efficient human nutrition and growth. Lysine is the first limiting amino acid in all the cereals. The second limiting amino acid is tryptophan in maize, and thereonine in most other cereals. Traditional maize, whether grown in the tropics or in the temperate climates, contains 9-11% protein in the whole grain. However, the balance of amino acid in the protein is poor: ordinary maize contains 1.8-2.3% lysine and about 0.3-0.4% tryptophan in protein. In 1963, however, a Purdue University team discovered the importance of opaque-2 gene in enhancing the levels of two limiting amino acids in the maize endosperm protein. The two amino acids register a two-fold increase in opaques, as compared to the normal maize types.

The opaque-2 mutant opened the way for improving the quality of protein in maize through genetic manipulation. A number of other mutants, such as floury-2 and opaque-7 also have been identified and have resulted in an increase in the levels of lysine and tryptophan. The mechanism for biochemical enhancement of lysine and tryptophan in all these mutants is the same: the boost in lysine and tryptophan levels is a result of a reduction in zein fraction lacking in lysine; while increasing other fractions, such as the albumins, globulins and glutenins that are higher in lysine content.

Opaque-2 has been used much more extensively than the other mutant and its use in maize improvement process continues in the same pattern. Use of the other mutants have been restricted to the experimental stages and have shown no advantage over the opaque-2. Recently, however, a double mutant combination involving opaque-2 and sugary-2 has shown some promise and may be considered as another major research achievement of the Purdue group.

After a decade of opaque-2 maize breeding, it seems important to review and ask relevant questions about the findings. Opaque-2 versions of normal maize varieties and hybrids have been obtained and are available in many countries. Commercial production and utilization, however, are restricted (the U.S.A., U.S.S.R., Brazil and a few others) and the area devoted to quality protein materials in these few countries is only a small fraction of total maize grown. A critical analysis results over the last ten years reveals that the lack of widespread adoption of opaque-2 maize stems from a set of complex and inter-related problems including: comparative low yield, non-acceptability of kernel phenotype, and more vulnerability to ear rot organisms and insect damage during storage. The cumulative evidence suggests, however, that such problems can now be overcome by: (1) materials that have now become available, (2) new and better breeding approaches, (3) better understanding of how to identify and deal with o_2 maize problems, (4) expanded emphasis on opaque-2

TABLE 3.2.1 Summary of performance of full sib families developed from Advanced Unit populations.
DISEASE NURSERY DATA: MEXICO, 1974 B

IPTT No.	Testing** Site	Ear rots (rating 1-5)* Pop. $\bar{x}$	Sel. fam $\bar{x}$	Stalk rots (% infect) Pop. $\bar{x}$	Sel. fam $\bar{x}$	Stunt (% infect) Pop. $\bar{x}$	Sel. fam $\bar{x}$
21	PR	3.72	3.69	66.5	65.9	23.5	22.8
22	PR	3.76	3.59	68.6	71.2	26.9	17.7
23	PR	2.89	2.90	72.5	73.2	11.9	10.7
24	PR	3.00	2.90	74.6	74.1	17.4	16.6
25	PR	3.29	3.40	57.5	60.7	16.3	15.6
26	PR	2.70	2.60	58.4	57.6	10.2	10.2
27	PR	3.17	3.18	41.0	42.0	20.5	14.9
28	PR	3.18	3.10	45.9	43.0	14.6	13.3
29	PR	3.22	3.28	47.2	46.3	14.3	14.5
30	PR	-	-	-	-	-	-
31	PR	3.36	3.33	37.0	37.4	15.4	16.8
32	PR	3.36	3.84	32.5	33.3	10.6	7.4
33	TL	3.68	3.66	64.2	61.8	-	-
34	TL	3.98	4.04	61.3	59.6	-	-
35	TL	3.54	3.23	59.5	60.1	11.1	11.4
36	PR	3.40	3.30	45.3	41.5	11.7	11.4
37	PR	4.10	4.01	38.6	39.7	15.2	15.6
38	PR	3.04	3.04	60.2	57.7	27.3	27.2
39	PR	3.16	3.19	57.7	55.2	22.3	23.3
40	PR	3.55	3.51	53.1	44.5	21.7	22.4
41	PR	3.55	3.40	51.7	47.0	11.7	11.8
42	TL	3.89	4.10	65.6	63.8	-	-
43	TL	3.98	3.99	59.2	56.3	-	-
44	TL	4.03	3.86	62.6	59.2	-	-
45	-	-	-	-	-	-	-
46	TL	3.79	3.71	69.3	68.0	-	-
47	-	-	-	-	-	-	-
48	-	-	-	-	-	-	-

* Rating 1 - no damage 5 - severely damaged
** PR = Poza Rica, Mexico; TL = Tlaltizapan, Mexico.

In the Companion Nurseries, an additional replication of the progeny trials is planted on CIMMYT experiment stations in Mexico; and innoculated with stalk rot and ear rot pathogens.

TABLE 3.2.2 Summary of performance of full sib families developed from Advanced Unit populations. (Families grown in 5m plot without replication, with natural infestation only. No data from Tlaltizapan.)
INSECT NURSERY DATA: POZA RICA, MEXICO, 1974.

IPTT No.	BUDWORM Spodoptera frugiperda Foliar damage rating* Pop. $\bar{x}$	Sel. fam $\bar{x}$	STEMBORER Percent damaged Pop. $\bar{x}$	Internodes Sel. fam $\bar{x}$	EAR INSECTS Ear damage rating* Sel. fam $\bar{x}$
21	6.3	6.4	26.6	26.4	5.7
22	6.3	6.1	20.6	19.9	5.8
23	6.1	6.1	22.6	22.4	4.5
24	6.1	6.0	21.8	20.9	4.1
25	6.5	6.5	21.3	22.4	5.4
26	6.6	6.6	14.6	15.1	5.8
27	6.7	6.8	20.8	20.6	6.0
28	5.6	5.3	23.6	24.6	6.0
29	5.4	5.2	20.6	20.8	6.2
30	No data	-	-	-	-
31	5.8	5.7	21.6	21.3	6.0
32	6.2	6.1	24.6	23.9	6.0
33	No data	-	-	-	-
34	No data	-	-	-	-
35	6.2	5.9	30.8	29.8	6.0
36	7.4	7.1	25.2	24.8	6.6
37	No data	-	-	-	-
38	6.7	6.7	20.5	18.4	5.0
39	6.1	6.1	22.0	21.7	5.1
40	6.2	5.9	16.0	15.5	4.9
41	5.9	6.0	23.2	22.0	4.9
42-48	No data	-	-	-	-

* Damage rating on scale 1 to 9
1 No damage
9 Most severe damage

TABLE 3.2.3 Summary of performance of full sib families developed from Advanced Unit populations. (High Density Nursery sown 80,000 plants/ha; IPTT sown 53,000 plants/ha. Poza Rica nursery not harvested.)
HIGH DENSITY NURSERY: TLALTIZAPAN, MEXICO, 1974

IPTT No.	IPTT Tlaltizapan: Yield ton/ha Pop. $\bar{x}$	Sel. fam $\bar{x}$	High Density Nursery Yield ton/ha Pop. $\bar{x}$	Sel. fam $\bar{x}$	Plant lodging % Pop. $\bar{x}$	Sel. fam $\bar{x}$	Ears per plant Pop. $\bar{x}$	Sel. fam $\bar{x}$
33	5.89	6.87	6.21	6.85	14.3	11.2	0.88	0.89
34	6.56	7.18	5.05	5.52	10.3	9.7	0.88	0.92
43	8.01	9.15	7.29	7.93	7.5	6.3	0.79	0.81
44	7.20	7.98	6.71	6.83	18.8	17.1	0.85	0.85
46	4.49	5.52	5.48	6.14	8.3	7.6	0.92	0.97
47	4.06	4.96	5.14	5.98	12.8	10.5	0.97	0.98

TABLE 3.3.1 Changes in Advance Unit Populations: 1975 (Progeny Testing)

IPTT No.'s 1974	1975	Name
21	21	Tuxpeño 1
22	22	Mezcla Tropical Blanca
23	23	Blanco Cristalino 1
24	24	Ant. Gpo. 2 - Ver. 181
25	25	(Mix. 1 x Col. Gpo. 1) Eto
26	26	Mezcla Amarilla
27	27	Amarillo Cristalino 1
(28 & 30)	28	Amarillo Dentado 2
(29 & 32)	29	Tuxpeño Caribe 2
	30	Blanco Cristalino 2
31	31	Braquiticos
	32	Eto Blanco (Advanced from back-up)
		Tuxpeño Caribe 1
(33 & 46)	33	Amarillo Subtropical
(34 & 47)	34	Blanco Subtropical
	35	Ant. Rep. Dominicana (Advanced from back-up)
(35 & 36)	36	Cogollero
37	37	Tuxpeño (La Posta) O_2
	38	Open
(39 & 41)	39	Yellow Hard Endosperm O_2 (Ver. 181 - Ant. 2)
		Ven. O_2
40	40	White Hard Endosperm
	41	Open
42	42	Eto x Illinois
43	43	La Posta
44	44	AED x Tuxpeño
45	45	Discontinued in 1974 (Open)
	46	Open
	47	Open
48	48	Compuesto Hungary

1974 IPTT No.'s combined:	IPTT No. for 1975
Amarillo Dentado 2 (28) & Amarillo Dentado 1 (30)	28
Tuxpeño Caribe 2 (29) & Tuxpeño Caribe 1 (32)	29
Amarillo Subtropical (33) & Amarillo Pakistan (46)	33
Blanco Subtropical (34) & Blanco Pakistan (47)	34
IDRN (35) & Cogollero (36)	36
(Ver. 181 - Ant. 2) Ven. O_2 (38), Y.H.E. O_2 (39) & Comp. K (41)	39

Additions:	
Blanco Cristalino 2*	30
Eto Blanco from back-up	32
Ant. Rep. Dominicana from back-up	35

* From: (Tuxpeño x Nicarillo) Sint. 10 lineas - 69 white progenies (Mix. 1 x Col. Gpo. 1) Eto Sint. 10 lineas - 36 white progenies. Eto Blanco - Sint. 10 lineas - 33 white progenies.

maize research in national programs, (5) advances in services by chemical laboratories to handle opaque-2 work in selecting for hard endosperm phenotype; (6) additional trained personnel available to handle the specialized work; (7) greater international cooperation in exchange of germplasm and systematic evaluation of materials at population or family level; and (8) new screening techniques--to detect the presence of opaque-2 gene as in floury-1 conversion program, or to detect new mutants from normal materials. (The simple and rapid Ninhydrin test has helped substantially in breeding of opaque-2 materials).

However, for additional gains in adoption, opaque-2 must become more comparable in performance to normal maize types in yield, agronomic characteristics, pest resistance and kernel acceptability. The problems are complex and inter-related--and their solution will depend on sustained interdisciplinary and cooperative research efforts in different disciplines.

3.41 CONVERSION PROGRAM

For the last two years, major emphasis has been upon converting all maize materials in the Advanced and Back-up stages of maize improvement work.

3.411 Conversion of Advanced Unit Materials

The Advanced Unit originally consisted of 28 maize populations, of which 23 were normal populations, along with 5 populations having the opaque-2 gene. The materials, in general, were of tropical-subtropical and of temperate origin.

All 23 advanced stage normal materials are being converted to hard endosperm opaque-2 phenotype through the use of one or more appropriate opaque-2 donors in each population. The handling of opaque-2 donor is done through a breeding scheme that permits parallel improvement in normal and opaque-2 counterparts. Modifications of the scheme are used wherever needed.

It is highly desirable to use more than one type of opaque-2 donor to increase the probability of getting hard endosperm opaque-2 segregates in F_2. The quality of hard endosperm opaque-2 segregates recovered in F_2 determines whether the hard endosperm opaque-2 families will be crossed to the selected families of normal population every cycle or alternate cycle. If good modifiers are not found in the F_2 generation, the segregates may be handled separately to F_3 or F_4 to increase the frequency of modifiers, before crossing again to the selected families of corresponding Advanced stage populations.

In the year 1974A, over 1,500 F_1 crosses were developed among opaque-2 donors and different Advanced stage populations. F_1 crosses were advanced to F_2, resulting in over 1,200 F_2 families. F_2's have been advanced to F_3, and we now have over 2,000 very good F_3 families. While the parallel improvement continues if material looks good at any stage, it can be multiplied and tested in experimental variety trials. Also, if a material compares well with normal population, the normal population can be replaced by an opaque-2 population.

3.412 Conversion of Back-up Materials

In the Back-up Unit, there are now 29 gene pools. The pools represent three different ecological zones, i.e. highland, tropical and temperate. Within each ecological zone there are a number of pools that have different maturity, grain color and type. At present, there are 12 tropical, 4 temperate and 13 highland pools.

All of the above pools are being converted to opaque-2 through a scheme for making parallel improvement in normal and opaque-2 counterparts. The pools are managed so that the hard endosperm opaque-2 segregates can be crossed with the half-sib families of the pool every alternate cycle. (Modifications of the scheme may be made whenever necessary). The opaque-2 families from Back-up stages are worked separately; then incorporated into opaque-2 Back-up pools (white opaque-2 Back-up pool or yellow opaque-2 Back-up pool) or other Back-up opaque-2 populations, if any. The families can be derived from pools once in every 2 or 3 years, and then subjected to systematic progeny testing. The selected opaque-2 families can either be merged with appropriate Advanced stage population or, in some instances, the selected families may provide a new Advanced stage opaque-2 population.

Pools 16 to 26 were crossed to one or more sources of opaque-2 during 1974A. F_1 crosses were advanced to F_2. From 60 to 100 ears segregating for hard endosperm opaque-2 were selected and sorted out for hard endosperm opaque-2 segregates. The selected segregates will be planted on family basis during the year 1975A. Hard endosperm opaque-2 segregates were recovered from the following number of F_2 families

Pool No.	No. of F_2 families
19	73
20	95
21	71
22	111
23	68
24	52
25	86
26	126
27	11
32	45
33	85
34	23

All thirteen highland pools were crossed during the year 1974 and will be advanced to F_2 during the year 1975.

3.413 Conversion of Populations Being Selected for Plant Efficiency and Adaptation

The number of F_2 families from some of the populations are given below:

Amarillo Bajío	42
Amarillo Bajío x Varios Templados	27
Amarillo Bajío x Mezcla Tropical Amarilla	32
Maíz tropical selección Batán	31

3.42 POPULATION IMPROVEMENT PROGRAM

Five opaque-2 populations in the Advanced Unit are undergoing second cycle of full sib family selection. Four of the five materials possess hard endosperm opaque-2 phenotype, whereas the fifth has a soft kernel phenotype. The five materials are:

Tuxpeño x La Posta o_2	IPTT-37
Ver.181-Ant.Gpo.2 x Ven.1 o_2	IPTT-38
Yellow H.E. o_2	IPTT-39
White H.E. o_2	IPTT-40
Composite K (H.E.) o_2	IPTT-41

Major emphasis in these 5 populations was placed on the following:

(a) Systematic progeny testing trials

(b) Accumulating frequency of favorable modifiers controlling kernel vitreousness in opaque-2 materials. This is done by selecting the best vitreous seed from each family for planting. When new families are generated through reciprocal full sib, only those families with two vitreous ears are selected.

(c) Testing of full sib families over a range of environments helps to stabilize modifiers by selecting and recombining only those families that show stability for modified phenotype character over a number of locations.

(d) Reducing incidence of ear rot organisms. Each family from each Advanced Unit population is subjected to artificial inoculation, both for ear rots and stalk rots. In the selection of families to generate new families, the disease data is given critical consideration.

3.43 DEVELOPMENT OF BROAD-BASED GERMPLASM SOURCES

Several broad-based opaque-2 populations have been developed in the last two years, and are now at different stages of development, including:

PD(MS)6 - H.E.o_2: Has undergone 3 cycles of recombination in a half-sib system. This material has excellent kernel type. Over 700 families were saved from the last cycle of recombination.

CIMMYT H.E.o_2: Has undergone 3 cycles of recombination, plus selection for modifiers and protein quality. Over 600 families were saved from last cycle of selection.

Yellow opaque-2 Back-up pool and White opaque-2 Back-up pool: Were formed by advancing F_1 crosses of opaque-2 "side-cars" with different normal Advanced stage populations in the usual half-sib recombination blocks. Modified opaque-2 kernels were selected from segregating F_2 ears and again planted in a half-sib recombination block to obtain the second cycle of selection (675 families in white opaque-2 pool and 512 in yellow opaque-2 pool).

Temperate x tropical H.E. o_2: Has achieved one cycle of recombination. The second cycle of recombination involved over 600 families.

3.44 SELECTION FOR HARD ENDOSPERM

Emphasis has been placed on selection for kernel hardness at all stages of the conversion program, population improvement program, and development of germplasm source population. Best kernels from each ear or family are used in planting. Also, 10 seed from each ear are subjected to chemical analyses. Only families with satisfactory chemical values are selected and used in recombination. Excellent progress has been made in this process, and materials with very good modifiers are available in the program and can be considered as good source of modifiers in converting new normal populations.

3.45 STABILITY OF MODIFIERS CONTROLLING KERNEL HARDNESS

This stability can be achieved only through multi-location progeny testing. In the Advanced Unit, the families are tested in 6 sites; whereas in the Back-up Unit the progeny tests are limited to 3 locations within Mexico. Families exhibiting good modified phenotype across location are selected and used in recombination. Limited experience from trials in one year indicates that there is fairly high frequency of modified phenotype families performing well across locations.

3.46 REDUCING EAR ROT INCIDENCE

Families from both the Advanced and Back-up Units that are subjected to systematic progeny testing also are evaluated for ear rot organisms by artificial inoculation with ear rots. Artificial inoculation helps to identify resistant families during the selection process. Through continued selection and artificial inoculation, it should be possible to build up resistant to ear rot organisms.

3.47 TRANSFER OF OPAQUE-2 GENE IN FLOURY-1 GENETIC BACKGROUND

Considerable emphasis has been placed on transfer of the opaque-2 gene to floury-1 materials for Andean regions and some progress has been made. Some opaque-2 versions in floury-1 backgrounds are now

available. In addition, an opaque-2/floury-1 composite has been developed and is now undergoing a second cycle of selection.

The discovery of the Ninhydrin test by Dr. Mertz adds a new dimension as a screening tool to identify soft opaques from floury and is a very simple and rapid test.

3.48 SUGARY-2/OPAQUE-2 DOUBLE MUTANT

Development of this double mutant combination has generated considerable interest in the last two years. Some of the advantages of this combination are: good digestibility and superior biological value, good kernel density, vitreousness in endosperm, good acceptability, less ear rots and less damage from storage insects(and improved vitreousness is not accompanied by a decrease in protein quality.)

A disadvantage of this combination is its reduced seed size; thus lower yields.

CIMMYT has begun work on this combination and some materials are in F_3 generations. The segregates are, in general, not appealing--but some seemed reasonably acceptable. It is expected that this combination in different genetic backgrounds may exhibit kernels of varying appearance.

3.49 INTERNATIONAL TESTING

Progeny trial and experimental variety trials were sent to the locations shown in Table 3.16 .

Table 3.41 shows the performance of 5 opaques in relation to some of the best normal checks.

Seed samples of hard endosperm opaque-2 maize have been sent to over 22 locations. The seed samples ranged from 50 kernel samples to 50 kgs. lot.

3.5 PHYSIOLOGY - AGRONOMY - PRODUCTION

Maize agronomists provide assistance in trials by the germ plasm bank, and in the Back-up and Advanced Units. Agronomy trials in Mexico are conducted jointly with the training program, including variety trials and comparisons of responses of improved and unimproved varieties to high and low levels of management.

The physiologists study factors that limit yields, ways to manipulate grain storage in the plant, adaptation to climate, drought stress, and crop water requirements. These studies help define selection criteria in breeding improved plants for the future.

3.51 PHYSIOLOGY

Recent findings (1971 to 1973) have indicated that the capacity of the grain to store dry matter limits grain yield in both lowland and highland tropical varieties. The numbers of grains per ear and the incidence of barrenness at high plant population were both identified as important yield limiting components. Thus, high density nurseries were introduced in 1974 as part of the progeny testing program, to select progenies with a low incidence of barren plants. There was also a need for studies on the control and development of the female inflorescence (as the grain storage site). Measurements were taken during the year at Poza Rica, Tlaltizapán and Batán, to determine how environmental factors (temperature and radiation) before anthesis affect storage capacity (the number of ears per plant and grains per ear) and how factors after anthesis affect the duration and rate of grain filling.

3.511 Growth and Yield of Lowland Maize

The patterns of accumulation and distribution of dry matter in Tropical Maize grown at three locations in Mexico, have been reported in CIMMYT Tech. Reps. (Sec.10). At one of these locations (Poza Rica - elevation 100 m), an artificially severe infestation of the leaf pathogen Phyllachora maydis caused a reduction in leaf area after flowering. A subsequent trial showed that when the leaf diseases are controlled chemically

TABLE 3.41 RESULTS OF INTERNATIONAL EXPERIMENTAL VARIETY TRIALS - 1974.

Serial Number		Sids, Egypt	Legon, Ghana	Cuyuta, Guatemala	Santa Tecla, El Salvador	Alajuela, Costa Rica	Cañas Guanacaste, C.R.	Tocumen, Panama	Univ. de Panama	San Andrés, Panama	Obregón, Mexico	Tlaltizapan, Mexico	Quevedo, Ecuador	Santa Cruz, Bolivia	La Molina, Perú	Suwan, Thailand	Khumaltar, Nepal	Nepalguinj, Nepal	St. James, Barbados, W.I.	St. Philip, Barbados, W.I.	Across Sites Mean
1	Yellow H.E.o_2	3561	2424	2918	1256	1753	3534	3474	3727	3715	1746	4013	3621	4520	9475	5240	3247	2610	2388	2924	3481
2	White H.E. o_2	3975	3400	3706	1385	2424	3091	2619	3845	3517	1331	4566	3822	3600	8689	5231	3066	3338	1916	2738	3487
3	Comp. K H.E.o_2	3600	3932	3036	1363	2108	3054	2426	3874	4137	1525	4427	3834	3659	7751	4981	3415	2560	1951	2170	3358
4	Ver. 181-Ant. Gpo.2 x Ven. 1 o_2	3054	4439	2805	1118	1907	2771	2573	3160	2877	958	3701	3159	4310	7617	4616	2003	2535	2332	2304	3065
5	Tuxpeño o_2	2659	4125	4154	965	2613	3081	3030	4053	3992	990	4796	3688	4754	8790	4969	3839	2585	1387	2841	3542
6	Tuxpeño-1	5180	4070	5119	1219	4264	3730	4186	5348	5233	1994	6322	4462	4615	10804	5867	3722	2660	2426	3084	4437
7	Amarillo Dentado-2	5022	3100	3152	1879	2537	4755	3284	4577	4947	2651	6135	4785	4913	9332	5273	3201	2936	2670	3459	4137
8	Amarillo Cristalino	5266	3539	2636	1832	2926	4162	2495	4345	4550	2149	5387	4497	4749	9178	5371	4207	2785	3494	2697	4013
9	Mezcla Amarilla	5599	3583	3134	2355	2071	3729	3198	4036	3671	1889	5046	4639	4153	7689	5465	2902	2811	1469	3422	3729
10	Ant. x Ver. 181	4961	3893	4035	925	2980	3700	3284	4482	4708	1618	5027	4465	4480	8759	5010	3217	2309	2360	3046	3855
11	Blanco Cristalino	5857	3847	3827	1551	2212	4061	3213	5200	5720	2336	5854	4951	4561	8597	6003	4083	3438	1908	3121	4228
12	Mean of checks	6058	3970	4291	946	3279	3895	3360	5357	4205	1705	6005	5108	4373	11077	5853	2521	2886	1565	2704	4167*
	LSD .05	1308	1452	1697	452	662	843	670	709	901	546	1201	891	966	1061	694	1553	1219	2006	885	
	% C.V.	18.2	27.7	34.2	25.7	18.0	17.6	16.9	11.7	15.8	23.6	15.6	14.1	16.3	8.3	9.5	30.9	28.6	70.8	22.7	

* Checks varied with sites

(or by breeding), the capacity of the grain to store dry matter limits yield in this environment (as has been shown, also, in the higher yielding environment at Tlaltizapán) (Fig. 3.51, 3.52).

When Tropical materials were grown at Tlaltizapán (elevation 900 m) under high radiation and low incidence of leaf pathogens, 19% of the stem dry matter at flowering was in the form of soluble sugars, increasing to 22% at grain maturity. This finding of a reserve of transportable assimilates in the stem (approximately 1.2 tons/ha), in addition to previous evidence of increasing stem dry weight during grain filling, suggests that the grain yield of Tropical materials is limited by the capacity for storage of dry weight in the grain. Thus, there seems to be scope for improving yields in both kinds of environment; but to do so, storage capacity must be increased in some way.

3.512 Control and Development of Grain Storage of the Crop

The grain storage capacity of the crop is the product of the number of plants per unit area, the number of ears per plant, the number of grains per ear, and grain size. Our findings suggest that grain yield of short-plant selections increases with increase in plant density; however, the incidence of barren plants has been identified as an important component limiting yield. Selection procedures are being used to measure the performance of the 250 full-sib progenies from each of the Advanced stage populations of the CIMMYT maize program when grown at high plant density (80,000 plants/ha). Those progenies showing a resistance to lodging, and having the ability to produce one ear per plant consistently at high plant density, are being identified for subsequent use in the crossing nursery.

In a study of temperate maize in the U.S.A., Anderson et al showed that the tendency for barrenness in high populations was associated with an increase in the interval between tasseling and silking. A similar study was made in one of the tropical materials (Tuxpeño-1) grown at 53,000 and 80,000 plants/ha at Poza Rica. (The data for the high density was lost due to flooding of this site). At the lower density, there was no significant association between grain yield and flowering interval (the variance in grain yield and flowering interval was partitioned between progeny families). However at the low density, there were few barren plants. This study will be repeated in the summer cycle of 1975 in the high density nurseries.

Selected Tropical maize materials are being planted every two months at three locations in Mexico to explore environmental and genetic control of the number of grains per ear. The development of floret numbers on the primary and secondary ears is being measured. Measurements are also being taken of the growth of the tassel and stem and of the changes in dry weight in these plant parts. Figures 3.531, 3.532 and 3.533 show the development of floret numbers in the primary ear for five varieties in the first of this series of plantings at El Batán (2,250 m), Tlaltizapán (900 m) and Poza Rica (90 m). In the two tropical lowland sites, potential grain number was determined soon after initiation of the inflorescence made in all the materials. For the earlier tropical varieties (Eto x Illinois, Amarillo Pakistan and Mezcla Amarilla (Poza Rica only), there was a greater loss of florets during the period preceeding pollination than in the later Tuxpeño material. Thus, at Tlaltizapán (and to a lesser extent at Poza Rica), the number of grain per ear for Tuxpeño-1 was limited by the number of spikelets differentiated--not by their subsequent loss.

At Poza Rica and Tlaltizapán, the total number of florets were produced during a period of 15 to 20 days. At the Batán site, the rate of differentiation of florets was much slower in the lowland tropical materials (particularly Tuxpeño-1 and Tuxpeño Co) than in the tropical highland material (H28) which is better adapted to the lower temperatures. During this period of floret development, the stem and tassel were rapidly increasing in length and these organs may compete with and limit the differentiation and growth of the ear shoot. Rapid dry matter increase in the tassel and the ear occurred after differentiation of the florets (Fig. 3.54).

For Tuxpeño-1 there was a similar number of florets initiated by both the primary and secondary ear; but in the latter, they failed to pollinate (Fig. 3.55).

The duration of the grain filling period and the rate of growth per grain may be important components determining grain yield. The increase in grain size (dry weight) with time after pollination is being measured in 28 of the CIMMYT advanced materials planted monthly at three locations in Mexico. Fig. 3.56 is an example of the raw data (for two varieties and two locations only) to which suitable growth functions will be fitted. The analysis will be aimed at understanding the genetic and environmental control on the rate of duration of grain growth.

Figure 3.51

CHANGES IN DRY WEIGHT FOR TUXPEÑO-I WITH AND WITHOUT FUNGICIDE APPLICATION (POZA RICA 1974A)

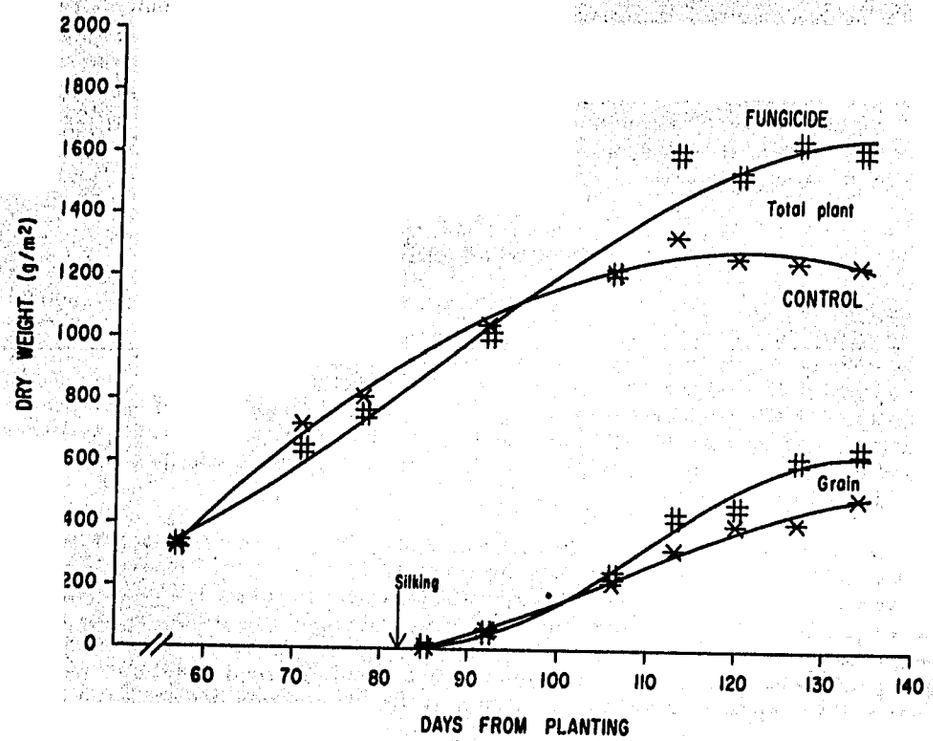


Figure 3.52

CHANGES IN LEAF AREA INDEX FOR TUXPEÑO-I WITH AND WITHOUT FUNGICIDE APPLICATION (POZA RICA 1974A)

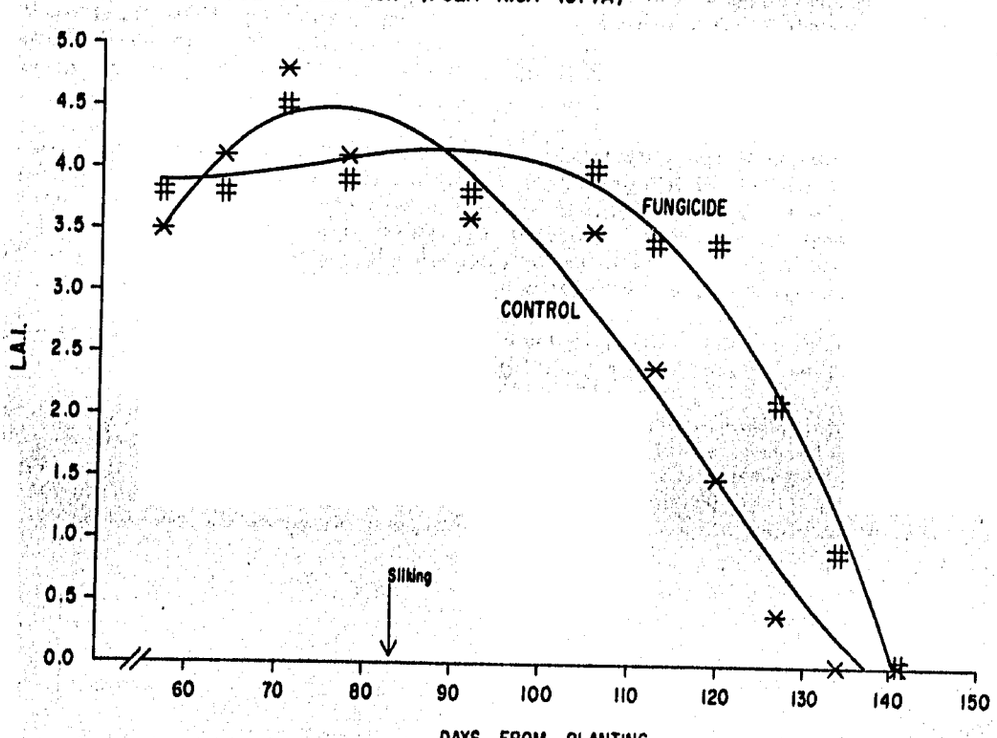


Figure 3.5.31

CHANGES IN THE NUMBER OF FLORETS IN TROPICAL MAIZE MATERIALS: TUXPEÑO-1 (▲), ORIGINAL TUXPEÑO (○), ETO x ILLINOIS (△), AMARILLO PAKISTAN (●) AND MEZCLA AMARILLA (□) GROWN AT POZA RICA, MEXICO (Planted 27th May)

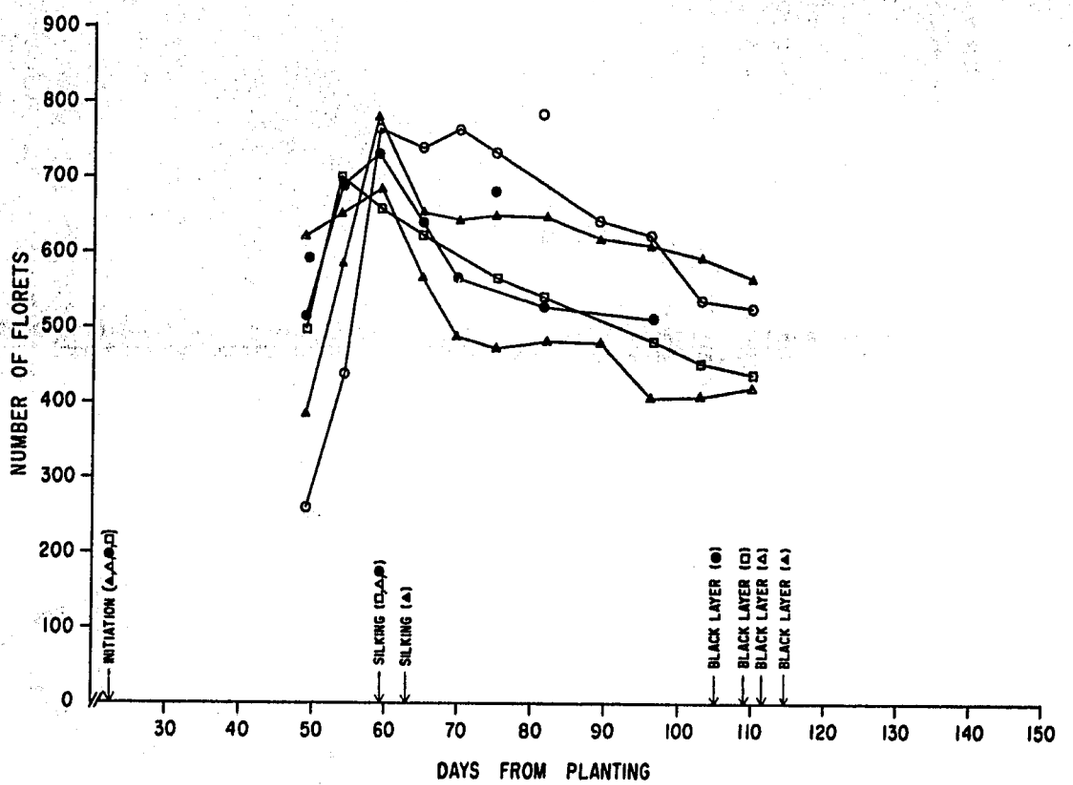


Figure 3.5.32

CHANGES IN THE NUMBER OF FLORETS IN TROPICAL MAIZE MATERIALS: TUXPEÑO-1 (▲), ORIGINAL TUXPEÑO (○), ETO x ILLINOIS (△) AND AMARILLO PAKISTAN (●) GROWN AT TLALTIZAPAN, MEXICO (Planted 1st May)

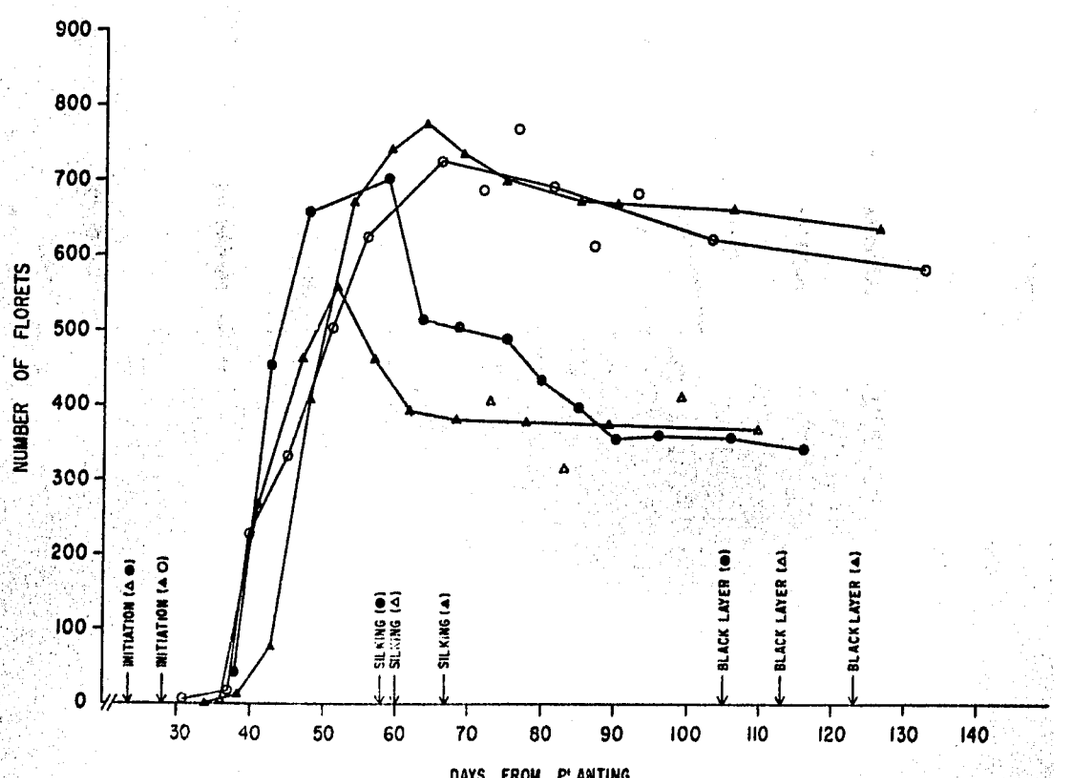


Figure 3.5.33

CHANGES IN THE NUMBER OF FLORETS IN TROPICAL MAIZE MATERIALS: TUXPEÑO-1 (▲), ORIGINAL TUXPEÑO (○), ETO x ILLINOIS (△), AMARILLO PAKISTAN (●) AND H-28 (□) GROWN AT EL BATAN, MEXICO (Planted 29th April)

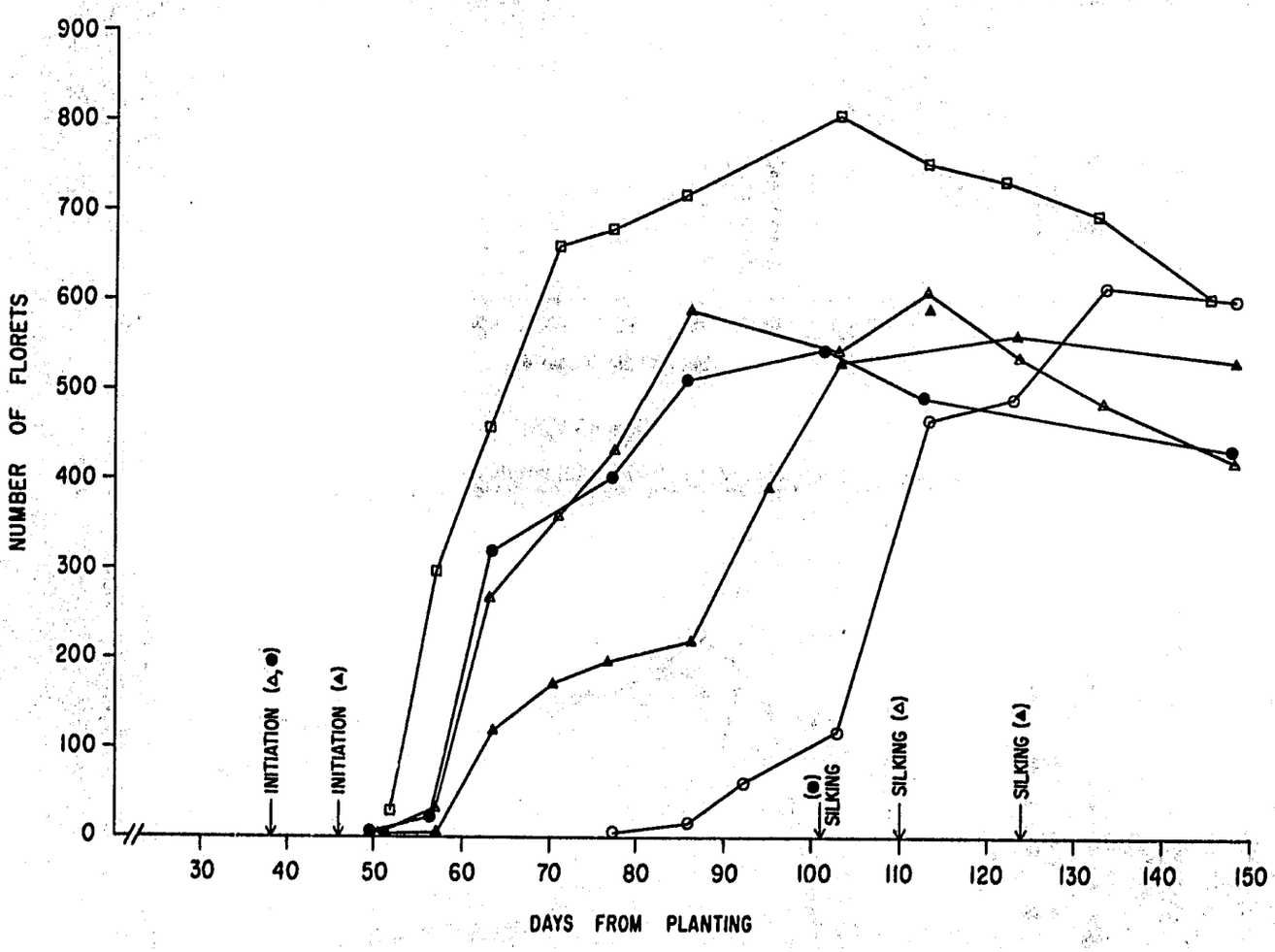


Figure 3.5.6

CHANGES IN THE DRY WEIGHT OF INDIVIDUAL GRAINS AFTER SILKING FOR TUXPEÑO-1 (●) AND MEZCLA AMARILLA (○) PLANTED AT TWO LOCATIONS AND VARIOUS DATES

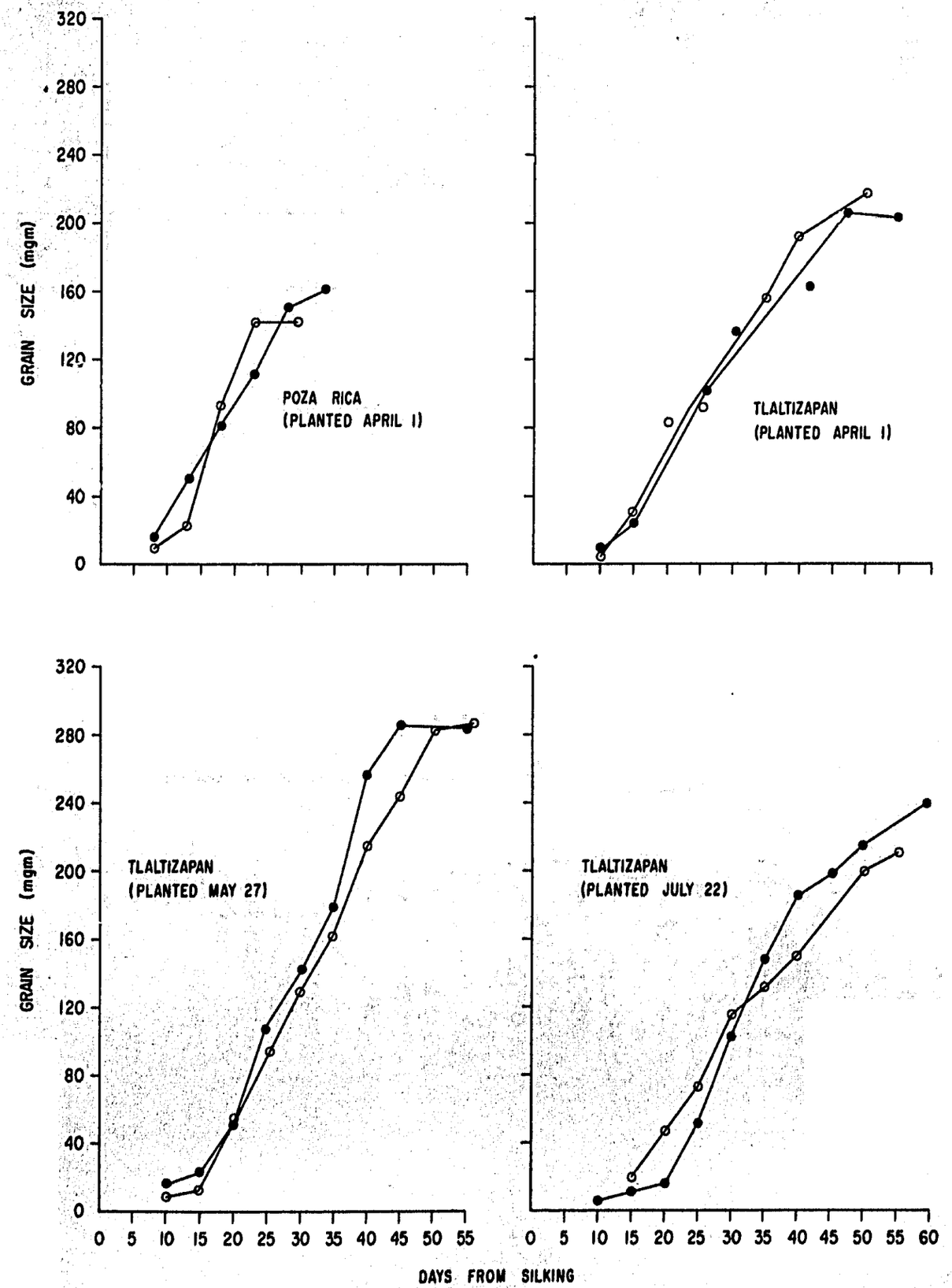


Figure 3.5.4

CHANGES IN THE LENGHT OF PLANT PARTS [STEM (O), TASSEL (□) AND PRIMARY EAR (Δ)] AND WEIGHT [TASSEL (■), PRIMARY EAR (▲)] IN TUXPEÑO-1 GROWN AT TLALTIZAPAN, MEXICO (Planted 1st May) (Data transformed to logarithm).

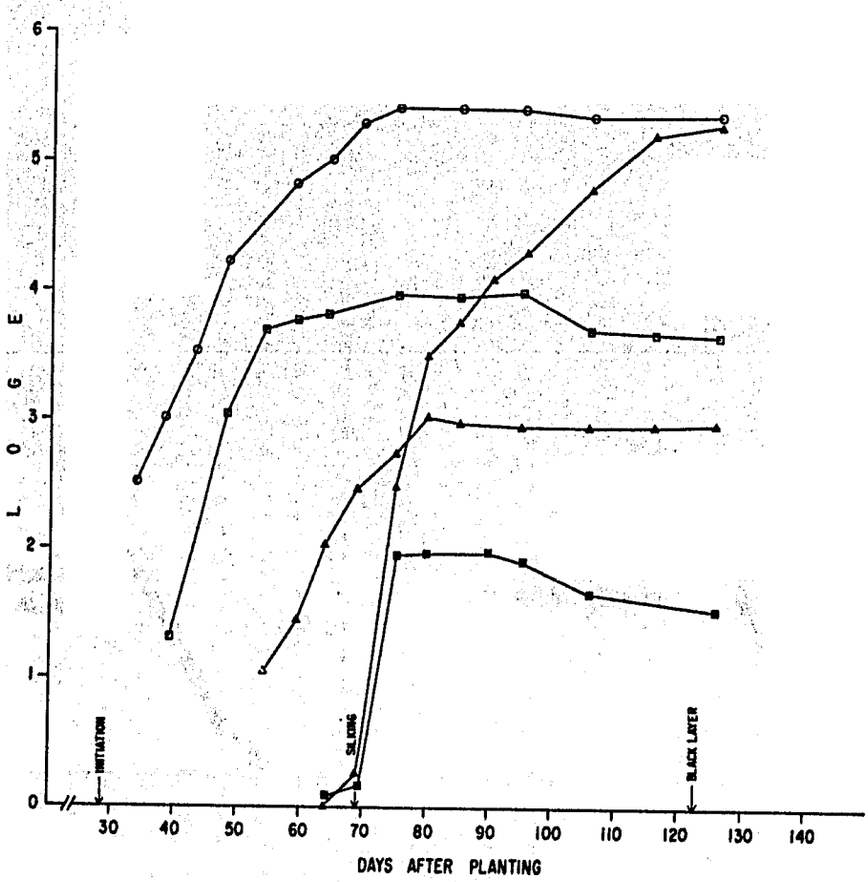
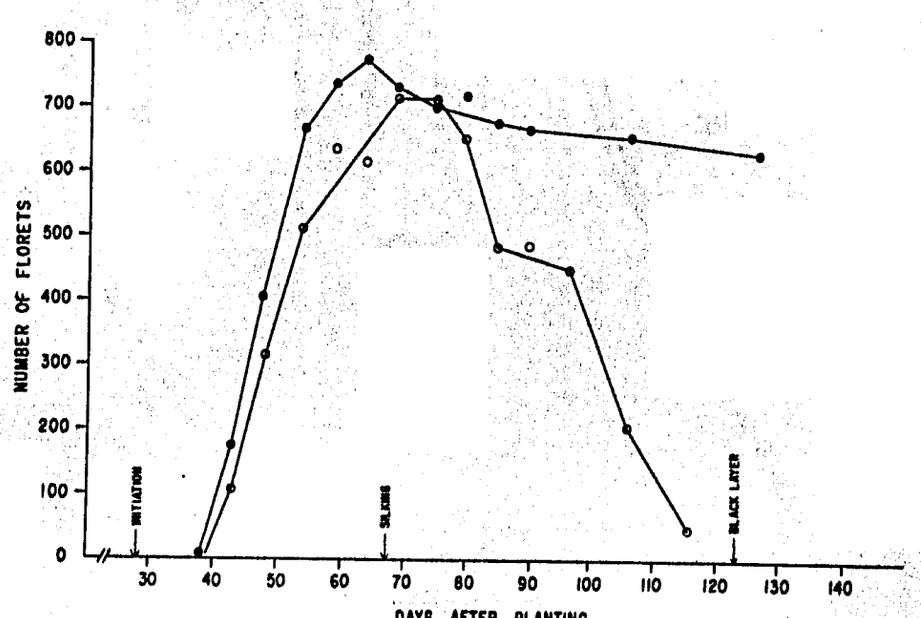


Figure 3.5.5

CHANGES IN FLORET NUMBERS IN THE PRIMARY (●) AND SECONDARY (O) EARS OF TUXPEÑO-1 GROWN AT TLALTIZAPAN, MEXICO (Planted 1st May)



3.513 Genotype Comparison under Simulated Drought

Seven maize genotypes were grown, under simulated drought conditions imposed at three stages of plant development and at two levels of intensity, during the winter (dry) season at Tlaltizapán. Stress treatments resulted in a 0 to 54% reduction in grain yield.

The data is presented in Fig. 3.57 and Table 3.51 in the form of a linear regression analysis of variety yield on treatment mean yield. With the exception of ETO x Illinois, there were only small changes in the relative performance of the higher yielding entries over the range of water stress treatments (Environmental Index). For ETO x Illinois, the linear coefficient was less than unity, but this was associated more with an inability to respond to a better water environment than an advantage under severe water stress.

A larger proportion of the dry weight is incorporated into the grain in the temperate hybrid than in the tropical varieties. A comparison of the yields of Y.H.E. o_2 and the temperate hybrid indicates that the present efforts to improve grain yield of tropical varieties by improving the proportion of dry weight that is incorporated into the grain can be expected to result in more efficient water use, even at low levels of water availability.

The Mexican hybrid H28, which contains Michoacan 21 germplasm (the source of "latente") was developed for the rainfed areas of the Tropical Highlands. Its response in this experiment demonstrates its overall poor adaptation to the higher temperatures at lower altitudes.

Measurements of plant moisture stress with a pressure chamber,and of stomatal resistance, were made on three of the entries of this trial. A preliminary analysis of this data suggests that measurements of leaf water potential mid-morning or mid-afternoon are more closely associated with yield effects than are mid-day values.

These studies are being continued with a similar number(but different set)of maize varieties in 1975.

3.52 AGRONOMY

The agronomy trials complement the physiology studies and are conducted on the experiment stations in cooperation with the training program. They serve both a research and teaching function. The main input into the trials consists of the experimental varieties coming from the Advanced Stage populations. These trials explore the range of maturities available in the experimental varieties; and examine interactions of late, intermediate and early varieties with management practice, particularly plant densities.

CIMMYT's maize agronomists have also been involved in the international series of experimental variety trials that began in 1974. This series of trials is being extended in 1975 and will be the principal source of information on the interactions between varieties and environments. Most of the maize physiology carried out at CIMMYT is designed to aid the interpretation of this kind of trial by providing some basic information on plant responses to environment. This approach helps ensure that the most promising varieties receive the widest possible use.

3.521 International Agronomy Trials 1973-1974

A series of variety x fertilizer trials was conducted in 1973-74 as a forerunner to the current program of experimental variety trials. There were two sets of trials: one set consisted of nine normal varieties with three levels of nitrogen (0, 100, 200 kg/ha); the other set consisted of 5 opaque-2 varieties, with three levels of nitrogen (as above). The set containing normal varieties was divided into a group of varieties for lowland test sites and a group for intermediate altitude or subtropical sites. Summary analyses of yield data from these trials are presented next.

3.5211 Normal Varieties

The differences in yield between varieties were significant at nine of the ten locations and there was a significant response to nitrogen at six of them (Table 3.52). The largest nitrogen effect was at one of the sites in Kisanga in Zaire (a response of 5675 kg grain/ha to 200 kg N/ha). This clearly demonstrates the capacity of the varieties to respond to fertilizer when, as on this site, the level of fertility is comparable

TABLE 3.5.1 Adaptation analysis for maize materials grown under a number of different watering treatments (Tlaltizapan, Mexico) 1974.

Variety	Mean grain yield (kg/ha)	Linear Coefficient	R^2
Tuxpeño - 1	4798	1.42	0.74
Eto x Illinois	4816	0.92	0.83
Amarillo del Bajio	5115	1.28	0.83
Pioneer Hybrid 3369A	6810	1.38	0.75
I.D.R.N.	4976	1.27	0.81
Y.H.E. O_2	3990	1.25	0.88
H - 28	1057	0.49	0.22

TABLE 3.5.3 Local varieties used in Internat[illegible] Agronomy Trials 1973/74.

	Local 1	Local 2
Mexico - Poza Rica	H 507	Criollo
Mexico - Tlaltizapan	H 503	H 412
Mexico - Obregon	H 503	H 412
Thailand - Pak Chong	Thai Composite No. 1 C3	Cuprico x Flint Comp. (F) C5
Zaire - Gandajika	GPS 4	Nigerian Comp. A_c1xB_c2
Pakistan - Pirsabak	Shaki	Khyber

TABLE 3.5.2 INTERNATIONAL AGRONOMY TRIALS 1973/1974

Grain Yields Kg/Ha.

9 Var. x 3 Levels N in 9 x 9 Quasi Latin Sq.

	LOWLAND							INTERMEDIATE						
	Mexico			Thailand	Zaire			Pakistan	Nepal	Zaire				Highland &
	P.Rica	Tlaltizapan	Obregon	Pak Chong	Gandajika	Lowland Mean		Pirsabak	Rampur	Kisanga	Gand.	Fungarume	Highland Mean	Lowland Mean
Variety	***	***	***	***	*	V		***	***	***	NS	***		
1. Eto	2118	7361	2780	3758	5543	4312	1. Eto	2615	42[illegible]	9143	4088	3171	3889	4100
2. Tuxpeño x Eto	2843	9430	3958	4026	5842	5219	2. Tuxpeño x Eto	4687	1250	9244	4232	3727	4628	4923
3. Mezcla Amarilla	3001	8021	3795	3945	4993	4751	3. Mezc.Amarilla	2775	878	6500	3493	2366	3202	3976
4. (Mix. 1xCol.Gp. 1)Eto	2732	8280	3402	3488	5257	4631	4. (Mix. 1xCol.Gp. 1) Eto	3861	563	8975	4671	3197	4253	4442
5. Ant. x Dom. Rep.	2619	6120	2898	3131	4248	3803	5. Ant.xDom.Rep.	2707	930	5551	3194	1908	2858	3330
6. Tuxpeño 1	3405	9126	3511	3276	5613	4986	6. Amarillo Bajio	3506	627	5488	3273	1834	2945	- -
7. Tuxpeño br_2	2680	7805	2805	3065	4789	4228	7. Eto x Illinois	3056	632	7971	3950	2473	3616	- -
8. Local 1	3032	8274	2939	4872	4394	4702	8. Local No. 1	4314	1612	8107	4374	2712	4223	- -
9. Local No. 2	1503	8707	3412	4345	4693	4532	9. Local No. 2	4122	1131	11700	5002	3989	5188	- -
SE.	±134	±178	±167	±153	±366		SE.	±165	±182	±439	±352	±135		
Site mean yield	2659	8125	3278	3767	5041		Site mean yield	3516	894	8076	4031	2820		
Levels of Nitrogen	NS	*	NS	**	***		Levels of Nitrogen	***	NS	NS	***	***		
0	2671	7986	3284	3486	3621	4209	0	2779	564	7802	882	2268	2859	3534
100	2608	8029	3232	3974	5251	4619	100	3745	1075	8004	4654	2988	4093	4356
200	2699	8359	3319	3842	6252	4894	200	4023	1044	8421	6557	3203	4649	4771
SE.	± 77	±103	± 96	± 89	±211		SE.	± 95	±105	±253	±203	± 78		
Var. x Nitrogen	NS	NS	NS	NS	NS		Var. x Nitrogen	NS	NS	NS	NS			

TABLE 3.5.6 GRAIN YIELDS KG/HA. OF OPAQUE-2 VARIETIES IN TRIALS AT POZA RICA AND TLALTIZAPAN 1973/74.

	OPAQUE VARIETY TRIALS			VARIETY x NITROGEN LEVEL x TIME				
		1974 A		1973A	1973B	1973B	1974A	1974A
	Poza Rica	Tlaltizapan	Buena Vista	Poza Rica	Poza Rica	Tlalt.	Poza Rica	Tlalt.
1. Tuxpeño x La Posta	4461	5550	3881	4941	3539	6691	3324	6110
2. Compuesto K (H.E.)	3469	5116	3621	4113	-	-	-	-
3. W.H.E. o_2	3597	5075	3517	-	3102	5840	2909	5752
4. Y.H.E. o_2	3270	5113	3532	-	-	-	-	-
5. (Ver.181xAnt.Gp.2)	3181	4703	3165	3851	3164	5413	2786	5360

As new varieties are developed, they are subjected to specific management treatments (agronomy trials) to determine the most suitable production techniques, in plots much larger than regular variety comparison trials.

TABLE 3.5.4 INTERNATIONAL AGRONOMY TRIALS
1973/74

Grain Yields Kg/Ha. 5 Opaque Var. x 3 Levels N in 5x5 Latin Square

	Mexico P.Rica	Mexico Tlaltizapan	Mexico Obregon	Thailand Pak Chong	Zaire Gandajika	Zaire Kisanga	Pakistan Pirsabak	Nepal Rampur	Colombia C.I.A.T.	MEAN
Variety	**	***	**	NS	***	***	**	NS	***	
1. Compuesto Blanco	2014	3585	-	2608*	-	4294	4195	1903	4051	3235
2. Compuesto Amarillo	2162	5837	2429	2991	3311	2852	3676	1908	6111	3475
3. Compuesto K	2166	5592	2170	3166	2925	3672	3868	2297	-	3561
4. Tuxp. x La Posta	2640	5875	2891	3031	4099	4085	5029	1893	1480	3692
5. Ver. 181 x Alt. Gpo. 2 x Ven. 1	2167	5535	2288	2739	3231	3498	3900	1991	6677	3558
SE.	± 79	±142	±106	±	±151	±168	±205	±145	±230	
Site mean yield	2230	5284	2445	2907	3391	3678	4133	1999	4905	
Levels of Nitrogen	NS	NS	NS	*	***	***	***	NS	NS	
0	2240	5147	2687	2343	2089	3042	3407	1990	4749	
100	2219	5420	2342	3104	2867	3830	4158	1986	5103	
200	2230	5169	2306	3274	3184	4162	4636	2021	4866	
SE.	± 90	± 91	± 84		± 89	±138	±146	±113	±205	
Var. x Nitrogen	NS	NS	NS		NS	NS	NS	NS	NS	

* Variety 1 was Thai opaque-2 Composite in the trial.

TABLE 3.5.5 CYCLES OF SELECTION YIELD TRIAL
1974 B

	TLALTIZAPAN Yield kg/ha	Days to flower o	Days to flower o	Plant Height cm	% Lodging	POZA RICA Yield kg/ha	Days to flower o	Days to flower o	Plant Height cm	% Lodging
Varieties	*	***	***	*	***		***	***	**	NS
(Mix. 1 x Col. Gp. 1) Eto	6970	68.5	70.3	219	25		63.0	65.1	244	29
Eto	6178	69.6	71.3	225	13		64	67	231	15
Tuxpeño	6961	71.8	73.4	236	27		65	67	253	20
Cycles of Selection	*	***	***	***	***		**	***	***	***
Original	6165	72.7	75.2	264	39		66.8	69.9	277	47
Intermediate	6875	69.4	70.7	209	15		63.0	65.5	226	4
Final	7068	67.9	69.0	205	11		62.4	63.8	225	13
Plant Density	*	*	*	NS	NS		*	NS	NS	**
Low	6320	71.0	72.5	224	19		64.2	66.4	245	6
Medium	6522	70.0	71.8	225	25		64.5	66.7	238	19
High	7266	68.9	70.7	231	21		63.5	66.1	245	39
SE ±	288	0.46	0.46	4.5	3		0.4	0.4	5.3	0
Interactions										
Variety x Cycle	NS	NS		*	*		**	NS	NS	NS
Variety x Density	*	NS		NS	NS		NS	NS	NS	NS
Cycle x Density	NS	NS		NS	NS		NS	NS	NS	NS

NO DATA - TRIAL FLOODED BEFORE HARVEST

to that found on most farmers' land. The responses were smaller at other sites in Zaire, Pakistan, Thailand and Mexico, mainly because the trials were sited on experiment stations where, as a result of regular use of nitrogen fertilizer, the soil nitrogen status is higher than on farmers' land.

The differences in yield between the five lowland sites were large compared with the differences in yield between varieties. The mean yields of varieties varied from 5219 kg/ha for Tuxpeño x ETO, to 3803 kg/ha for Antigua x Dominican Republic. Tuxpeño x ETO and Tuxpeño-1 gave the highest yields and showed a slightly greater capacity than other varieties to respond to high yielding environments. With the exception of Antigua x Dominican Republic, the response of the varieties to differences in environment was similar. Antigua x Dominican Republic gave the lowest mean yield and, although not significantly different from other varieties in low-yielding environments, it was significantly less responsive to the high-yielding environment at Tlaltizapán. Antigua x Dominican Republic is shorter and normally silks about 8 days earlier than most of the other varieties, but in these trials was grown at the same plant density. Thus, it seems probable that it should perform relatively better at a higher density; experiments are being conducted in 1975 to examine such performance. The mean yields of the remaining four varieties (entries 1, 3, 4 and 7) were not significantly different from the overall mean.

Varieties number 8 and 9 were local checks and therefore different at each site. If good local varieties are available and are well chosen for each site, a high mean yield and a consistently good yield would be expected when treated as a single variety across sites. However, in these experiments, the mean yields of Tuxpeño x ETO and of Tuxpeño across sites were significantly better than the mean yields of the local checks; the yields of Mezcla Amarilla and of (Mix. 1 x Col. Gpo.1) ETO were equal to those of the local checks. The name of the local checks used in these trials, where known, is shown in Table 3.53. In most instances these local checks were improved materials, though not necessarily the varieties that farmers were using.

The first five entries in the trials at intermediate (subtropical) locations were the same as in the lowland set (Table 3.52) but the remaining two entries, Amarillo del Bajio and ETO x Illinois, replaced Tuxpeño 1 and Tuxpeño brachytic, respectively. Tuxpeño x ETO and (Mix.1 x Col. Gpo.1) ETO had above average yields at these intermediate sites, with good yields at the best site (Kisanga, Zaire). The average yield of ETO was lower, mainly because it gave poor yields at the two low yielding sites (Pakistan and Nepal). Antigua x Dominican Republic, Amarillo Bajio, Mezcla Amarilla and ETO x Illinois all had below average yields at these locations. They are from six to ten days earlier to flowering than Tuxpeño x ETO or (Mix.1 x Col. Gpo.1) ETO. Of these five, Tuxpeño x ETO was the only one that gave consistently above average yields across both lowland and intermediate sites (Mean yield 4920 kg/ha). The mean yield of the next best variety, (Mix.1 x Col. Gpo.1)ETO was significantly lower and was below average at two sites (Thailand and Nepal). Of the other varieties ETO gave yields which differed little from the average at lowland and intermediate sites; Mezcla Amarilla gave better yields at lowland sites than at the intermediate sites, while the low mean yield of Antigua x Dominican Republic was the result mainly of its inability to respond to high yielding environment.

There were large differences in plant height between locations, from a mean of 240 cm at Tlaltizapán to 150 cm at one location in Kisanga, Zaire. Inspection reveals no simple relationship between plant height and yields: the mean plant height was similar (240 cm) at Poza Rica where yields were lowest (2608 kg/ha), and at Tlaltizapán where yields were highest (8359 kg/ha). In Thailand and at Kisanga, Zaire, where plants were shortest (140 cm) the yields were between these extremes (3767 and 4031 kg/ha respectively). Because of variety x environment interactions of this kind, CIMMYT is basing its progeny selections on the results of yield trials at several different locations. It is also one of the main reasons for having the extensive international series of experimental variety trials that were begun in 1974. With the information provided from these trials and from complementary studies in Mexico on the response of varieties to different environments, CIMMYT will be better able to direct variety improvement towards the needs of particular types of environment.

3.5212 Opaque-2 varieties

The results for 5 opaque-2 varieties at 9 test sites are shown in Table 3.54. As in the other trials, differences between locations were large compared to differences between varieties. Nevertheless variety differences were significant at 7 of the 9 test sites. There was a significant response to nitrogen fertilizer at four locations; in Thailand, Zaire (Kisanga), Pakistan and Nepal. As in the trials with normal varieties, there was no evidence of significant interactions between varieties and response to nitrogen fertilizer.

The difference in yield between varieties across sites was comparatively small (mean yields of grain from 3134 to 3717 kg/ha). Compuesto Amarillo, Compuesto K and (Ver.181 x Ant. Gpo.2) Ven. showed a capacity to respond to favorable environments and gave the most consistent performance over sites. Compuesto Blanco showed the least promise; its yields were equal to or below average at all sites, with the exception of the yields at Kisanga in Zaire. The comparatively low mean yield of Tuxpeño x La Posta is largely accounted for by the exceptionally low yield of this variety in the trial at CIAT, Colombia. This was because of very low plant counts, presumabley as a result of poor germination. Poor germination also accounted for the failure of Compuesto Blanco at Gandajika in Zaire and of (Ver. 181 x Ant. Gpo.2) Ven. in Obregón.

3.5213 Cycles of Selection Yield Trial

Experiments were begun in 1973-74 winter season to examine the effects of several cycles of selection on the height, yield, and yield components of Tuxpeño. An additional objective was to determine how the changes which have occurred as a result of selection have influenced the response of the varieties to plant population and nitrogen fertilizer. Subsequently, in the 1974 summer and winter season, original, intermediate and recent cycles of selection of the following three varieties were compared:

(Mix. 1 x Col. Gpo.1)ETO	Cycles C_0, C_5, C_{10}
ETO	Cycles C_0, C_5, C_{10}
Tuxpeño	Cycles C_0, C_7, C_{13}

A separate technical report (Maize Agronomy Trials Results, 1975A) of these trials is being prepared; however a summary of some of the data is shown in Table 3.55 and Figs. 3.58; 3.59; 3.510.

Fig. 3.58 shows that the recent cycles of selection have a higher mean yield than the original varieties, at populations from 30,000 to 80,000 plants/ha. It shows also the difference in response of the successive cycles of selection to increase in plant density. As plant population increased up to 70,000 or 80,000 plants/ha, the yield of the varieties derived from recent cycles of selection increased almost linearly. In contrast, the yield of the original varieties of (Mix.1 x Col. Gpo.1)ETO and Tuxpeño 1 decreased sharply at densities greater than 40,000 plants/ha, mainly as a result of lodging.

The yields of ETO were smaller than those of the other two varieties at low plant populations, but they increased more rapidly as plant density increased and were similar at populations of 70,000 to 80,000 plants per hectare.

Plant height has been reduced by about 62 cm (from 268 cm to 206 cm) from the original to the recent selections of (Mix.1 x Col. Gpo.1)ETO and Tuxpeño 1. Plants of the original cycle of ETO were shorter (256 cm) than the originals of the other two varieties and consequently showed less tendency to lodge; which accounted for the better response of the original ETO to increase in plant population. In the other two varieties, the reduction in height was also associated with a significant decrease in the tendency of plants to lodge. The relationship between the decrease in plant height and susceptibility to lodging in the successive cycles of selection is clearly illustrated in Fig. 3.59. Less lodging,probably as much as any other factor, accounts for the improved response of the recent cycles of selection to increase in plant population.

The varieties derived from recent selections flowered five to six days earlier than the originals. The results at Poza Rica suggested that this change has been greater in ETO and Tuxpeño 1 (from 69 days to 63 days) than in (Mix. 1 x Col. Gpo.1)ETO (from 64 days to 62 days only).

It is also interesting to note that in both these trials anthesis and silking were earlier at the high plant population than at low population.

Earlier growth analyses (CIMMYT Tech Report Sec.10) identified the number of ears as an important yield limiting component at high density. Fig. 3.510 shows the relationship between the number of plants and the number of ears at different plant populations for the three varieties. A 1:1 slope, which would be observed if each plant had one ear, is indicated in Fig. 5.510. It can be seen that for (Mix.1 x Col. Gpo.1)ETO C_0, there was a large proportion of barren plants at densities greater than 40,000 plants/ha. which partly explains the decrease in yield observed as plant density increased. In the more recent cycles of selection there were fewer barren plants as density increased. Fig. 3.510 shows similar differences

Figure 3.5.7

THE EFFECT OF SIMULATED DROUGHT ON THE GRAIN YIELD OF MAIZE (TLALTIZAPAN, MEXICO)

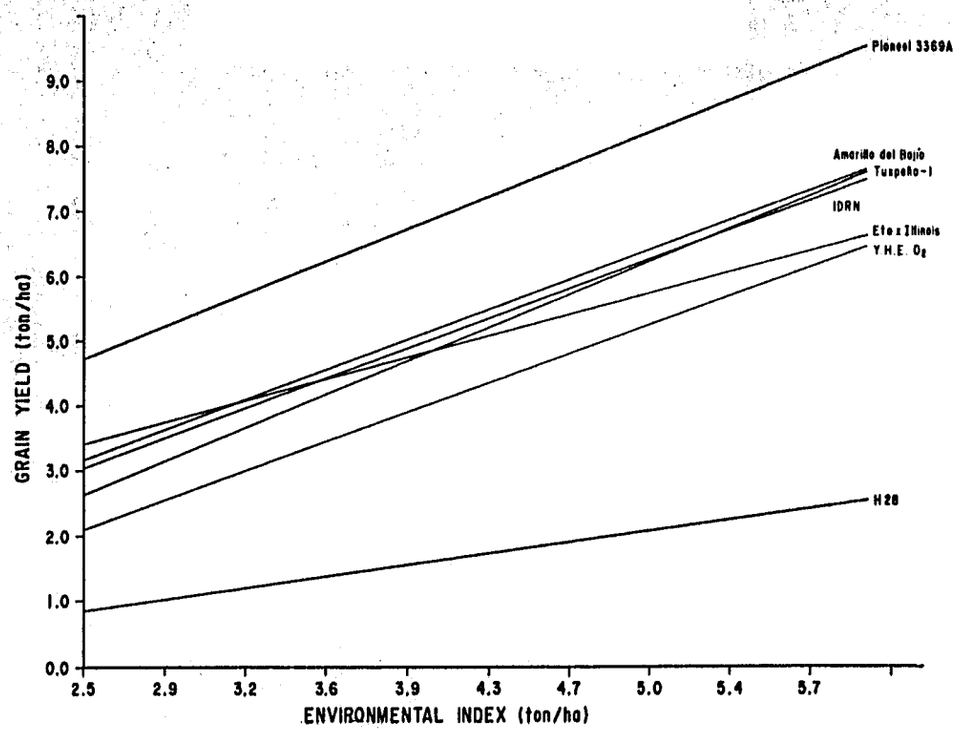


Figure 3.5.8

CYCLES OF SELECTION YIELD TRIAL TLALTIZAPAN 1974B

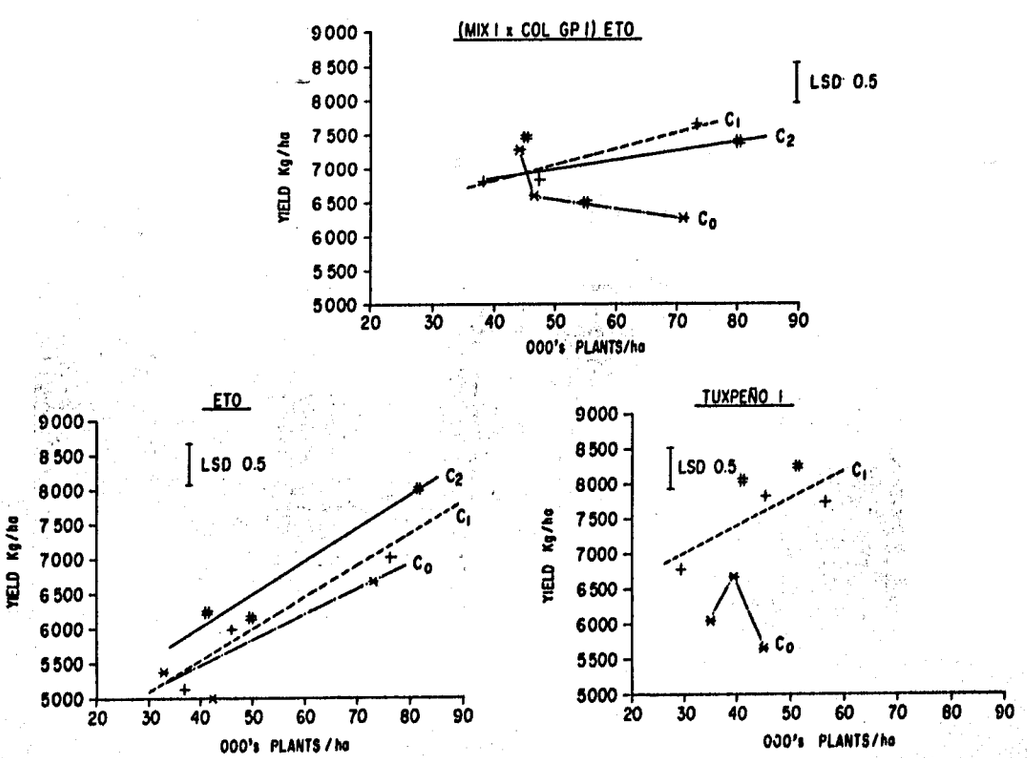


Figure 3.5.9

CYCLE OF SELECTION YIELD TRIALS 1974 A

RELATIONSHIP OF PLANT HEIGHT TO INCIDENCE OF LODGING

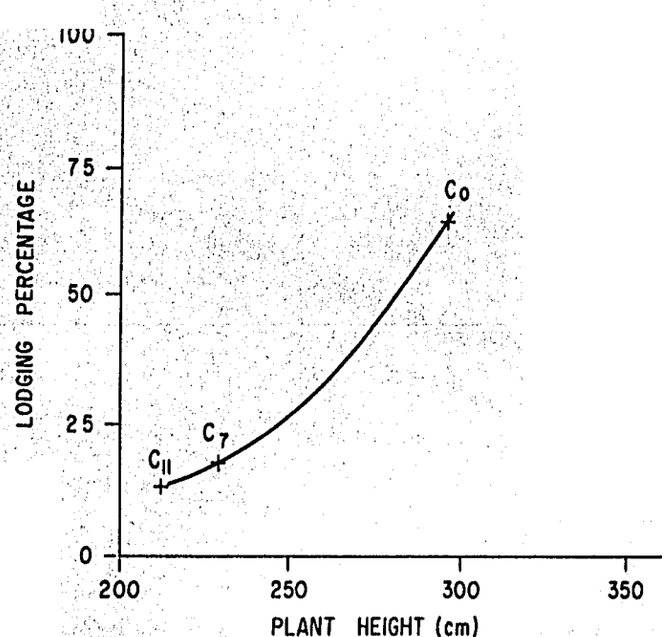
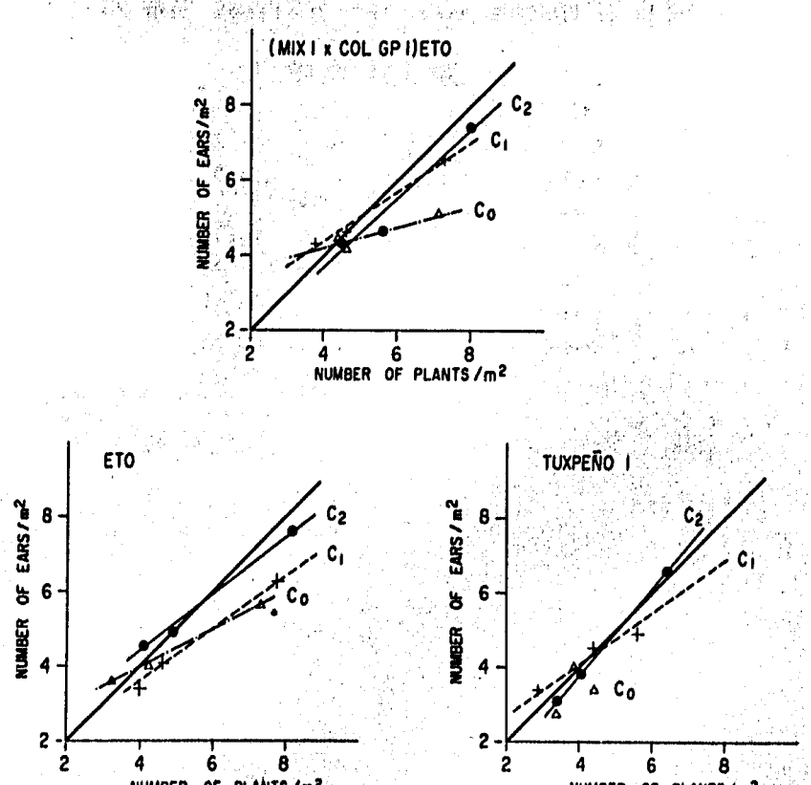


Figure 3.5.10

CYCLES OF SELECTION YIELD TRIAL TLALTIZAPAN 1974 B



between cycles of selection in the other two varieties.

Because the trial in Poza Rica was lost in the flood, and the densities attained with Tuxpeño 1 were lower than those intended, the trials have been repeated in the 1975 A cycle at both sites.

3.5214 Response of Opaque-2 Varieties to Nitrogen

Experiments were repeated at Poza Rica and Tlaltizapán to determine the effect of levels of nitrogen and times of application, on the grain yield of opaque-2 varieties.

The three varieties tested were White Hard Endosperm Composite, Tuxpeño x La Posta and (Ver.181 x Ant. Gpo.2) Ven. o_2. Nitrogen at 100 and 200 kg/ha was applied either as two equal doses (at planting and about six weeks later) or in three equal parts (the last dressing at anthesis).

The yields of Tuxpeño x La Posta o_2 were larger than those of the other two varieties at both locations, but as in the previous trials, the nitrogen treatments had no significant effect on yield. This latter fact is probably explained by the high residual fertility on the experiment stations.

The yields from these two trials, and from three earlier trials of the same kind are shown in Table 3.56 together with the yields from three simple opaque-2 variety trials conducted in Mexico. In these and the International Agronomy Trials (Table 3.54), Tuxpeño x La Posta has given consistently good yields compared with other opaque-2 varieties.

The Ninhydrin test is a very simple and rapid screening device to identify opaque-2 genotypes in soft floury endosperms. A section of the endosperm is sliced off to make this test, and the remainder of the seed can be planted.

4.0 Back-up Unit Operations: 1974

4.1 MAIZE GERM PLASM BANK: 1974 ACTIVITIES

The Maize Germ plasm bank continued to maintain and rejuvenate seedstocks to add new accessions to the bank inventory, to fill seed requests from breeders and research workers, and to evaluate bank accessions in replicated field tests to select the more promising materials for incorporation in the Back-up stages.

4.11 REJUVENATION OF SEEDSTOCKS

Two nurseries were planted at Tlaltizapán in 1974 and one at El Batán, to rejuvenate or multiply accessions of the Bank. A total of 1,371 populations were grown on 15 hectares; with new accessions accounting for 388 of these populations.

During the year, seed from 284 accessions from Bolivia, Ecuador, and Peru (propagated for CIMMYT by the Programa Cooperativo de Investigaciones en Maíz of Peru) was received in Mexico and incorporated into the Bank's inventory.

.111 Seed Shipments

Table 4.11 shows that 45 seed shipments involving 4,771 items were sent to 22 countries.

Since May 1st., 1967, the Bank has made 517 seed shipments involving 19,504 items.

TABLE 4.11 Destination of seed shipments sent by CIMMYT's maize germplasm bank during 1974.

DESTINATION	NUMBER OF SHIPMENTS	ITEMS
Argentina	1	15
Brasil	2	809
Bulgaria	1	2
Canada	1	4
Costa Rica	2	11
England	1	10
Federal Republic of Germany	2	11
Haute Volta	1	20
Ivory Coast	1	201
India	1	278
Ireland	1	1
Japan	2	56
Kenya	2	60
Lebanon	1	31
Mexico	7	2323
Pakistan	1	.42
Philippines	1	500
Romania	1	39
Taiwan	2	90
USA	12	181
USSR	1	35
Yugoslavia	1	52
Sum:	45	4771

4.12 EVALUATION OF BANK ACCESSIONS

A total of 1,891 accessions of tropical origin and from elevations lower than 1,000 m. above sea level were tested in replicated field trials grown at the Poza Rica Station during the Winter Crop of 1974 along with eighteen checks, among which were some of the populations in the Advanced stages. Eight adjacent 16 x 16 simple lattices were grown with a single set of two replicates. The single row plots were five meters long, with two plants per hill, set .50 m. apart. Spacing between rows was .75 m., providing a density of 58,674 plants per hectare.

The yield array in Table 4.12 is a partial summary of 36 Bank entries and the eighteen checks. Bank entry yields have been adjusted to eliminate fertility differences between experiments (as indicated by the performance of the checks).

All Bank entries in this summary yielded as well, or better than, the highest yielding check. These entries also were slightly later in silking, taller, and lodged more than the checks; but were similar in ears harvested per plant, rotten ear index, and percent moisture at harvest. When interpreting the performance of these Bank entries, it is necessary to take into account that they have not undergone any selection, whereas the checks have.

A single replicate of the above eight tests was planted at Farm Suwan in Thailand. Personnel of the Inter-Asian Corn Program took readings for percent infection by Sclerospora spp. (Downy Mildew) under conditions of heavy field infections. Among the 94 entries, including 4 of the checks, infections varied between 17 and 50%, as shown in Table 4.13.

A total of 972 Bank accessions from the highlands of Mexico were compared with 13 checks, in four 16 x 16 triple lattices, with a single set of three replicates grown at El Batán and Atizapán.

Unfortunately, an early killing frost (September 7th.) prevented the collection of yield data at Atizapán, but the tests were completed at El Batán. Table 4.14 summarizes the Atizapán data, including the 36 highest yielding Bank entries and the thirteen common checks. Yields of the Bank entries were adjusted on the basis of the thirteen checks for fertility differences between experiments.

Of the checks used in these tests, only Composite I and H 129 can be considered as improved populations of economic importance. None of the Bank entries outyielded the highest yielding check, but their mean (8.3 tons/ha.) closely approached that of Composite I. At least twelve of the Bank entries required 100 or less days to reach silking, which is considered to be the maximum for materials grown under natural rainfall conditions in the Mesa Central of Mexico. With the single exception of ear height, no differences were found between the means of the selected Bank entries and Composite I for days to silking, % root and stalk lodging, ears harvested per plant, and percent moisture at harvest. Composite I showed a higher incidence of ear rots than the Bank entries.

4.13 MAIZE GERM PLASM BANK CATALOG

Keypunching is nearly complete for all information available for the catalog. The bringing together of the many data sets representing the various kinds of information about the Bank is the responsibility of the Genetic Resources Communication, Information and Documentation Systems Project (GR/CIDS) at the University of Colorado. CRCIDS is part of the International Board for Plant Genetic Resources, and has contact with the Food and Agriculture Organization. (It is expected that a preliminary printout of the main listing in the catalog will be available by mid-1975, with the printed version to be published near the end of 1975). All Bank Increase Nursery field books, the 1974 Bank Evaluation, and the World Composite Formation Nursery field book have now been keypunched, as have the original collection notes and most of the NAS-NRC catalog of Latin American collections (1954). A number of books from pre-CIMMYT programs have useful information about the collections, some of which are being incorporated.

All groups (geographical-morphological composites or collection mixtures with limited variation) that were formed in Mexico and Brazil now have computer-ready pedigrees, and many other breeding populations in the bank are well documented.

Table 4.12 Yield, Adjusted for Experiment Effect, and Agronomic Data of Selected Germplasm Bank Entries and Checks Tested in Field Trials Grown at Poza Rica in the Winter Crop of 1974.

Population	Yield Kilograms/Ha.	Days to silking.	Ear height meters.	% root lodging.	% stalk lodging.	Ears harvested /plant.	Rotten ears index.	Moisture Percentage.
				BANK ENTRIES				
Puebla 178	6,334.39	93.5	2.05	59.1	15.9	1.2	0.0	23.4
San Luis Potosí 100	5,767.45	78.0	1.40	20.5	23.4	1.0	1.0	16.5
Veracruz 118	5,487.26	87.5	1.74	32.7	46.4	1.0	1.0	18.3
Mix. 1	5,333.57	94.0	1.68	34.6	14.1	1.0	1.0	27.0
San Luis Potosí 127	5,115.22	88.5	1.67	2.3	47.7	1.0	1.0	16.9
Veracruz 150	4,999.53	109.5	2.24	36.4	18.2	0.9	1.0	30.1
Hidalgo 51	4,980.06	81.0	1.57	13.6	50.0	1.2	1.0	21.5
Nayarit 154	4,816.14	88.5	1.63	27.3	27.9	1.0	0.5	22.6
Veracruz 179	4,764.56	102.0	1.77	40.8	16.6	1.0	1.5	26.3
Veracruz 39	4,726.24	91.5	1.73	25.0	18.2	1.0	1.0	18.1
Nayarit 155	4,723.46	87.0	1.66	15.9	27.3	1.0	0.0	19.5
Veracruz 195	4,690.73	94.0	1.74	36.4	38.6	1.0	0.5	22.1
Veracruz 213	4,688.23	89.5	1.54	16.0	27.7	0.9	0.5	17.8
Colima 4	4,680.18	92.5	1.77	50.0	38.6	1.0	1.5	27.5
Tabasco Grupo 1	4,678.93	91.0	1.66	52.0	28.7	0.8	0.5	23.7
Nayarit 177	4,660.87	84.0	1.65	46.5	34.7	0.9	1.0	22.4
Veracruz Grupo 20	4,599.45	101.0	1.90	49.0	21.5	1.0	0.5	24.4
Sinaloa 21	4,594.38	86.0	1.60	23.3	44.4	1.0	0.5	16.3
Cuba 83	4,577.68	86.0	1.40	17.0	49.5	0.9	0.5	21.8
Guatemala 786	4,558.49	87.0	1.47	0.0	29.5	1.0	1.0	20.2
Nayarit 178	4,557.39	79.0	1.58	25.4	23.2	0.9	1.0	19.3
Saint Croix 6	4,535.64	72.0	0.96	9.1	4.5	1.1	1.0	25.9
San Luis Potosí 121	4,533.12	88.0	1.62	9.2	37.7	0.9	0.0	17.7
Oaxaca 244	4,525.94	77.0	1.53	22.7	43.2	1.1	1.5	15.4
Guatemala 794	4,524.29	88.0	1.64	35.1	21.0	1.1	0.5	23.9
Veracruz 176	4,520.65	89.0	1.50	2.4	41.8	1.0	0.5	17.5
Veracruz 117	4,472.34	93.5	1.97	50.0	24.1	1.0	0.5	18.4
Tabasco 2	4,462.26	87.5	1.59	19.0	28.6	0.8	0.5	20.3
Veracruz 215	4,416.16	91.0	1.92	54.5	40.9	0.9	1.0	22.6
Nayarit 174	4,442.28	87.0	1.59	25.0	27.3	1.1	1.0	20.8
Jalisco 286	4,439.63	81.5	1.49	31.0	31.0	0.9	1.0	21.0
Veracruz 141	4,415.82	91.0	1.68	18.2	27.3	0.9	1.0	17.0
Guadeloupe 16	4,402.93	85.5	1.31	2.6	77.8	0.6	1.0	20.7
Jalisco 279	4,398.06	77.5	1.48	0.0	40.9	1.0	1.0	17.8
Guatemala Grupo 21-11A	4,374.03	89.5	1.63	26.9	37.7	0.8	0.5	22.2
Guatemala Grupo 13-5A	4,370.58	88.5	1.54	43.2	31.8	1.1	1.0	24.0
				CHECKS				
Tuxpeño P.B. x 19 materiales	4,372.53	85.8	1.30	7.9	30.3	1.0	0.9	21.1
(Tuxp.x Nic.)Sint.10 B.C. etc.	4,300.21	83.1	1.24	12.3	37.0	1.0	0.4	20.6
(Mix.1 x Col.)ETO x Sintético 10 líneas	4,040.31	83.1	1.17	7.8	28.6	1.0	0.6	20.1
ETO P.B. x Tuxpeño P.B.(C11)	3,981.04	82.0	1.10	5.3	34.2	1.0	0.9	20.4
Tuxpeño P.B. x Sintético 10 líneas	3,893.30	83.8	1.20	14.8	34.1	1.0	0.6	21.2
Tuxpeño P.B. (C-11)	3,876.18	85.4	0.89	3.3	21.5	0.9	0.9	21.0
Familias Seleccionadas Ensayo 512	3,627.76	86.4	1.24	6.8	33.0	1.0	0.9	21.6
Cuba x Rep.Dom.x Mezcla Amar. P.B. F_3	3,522.76	84.9	1.23	14.0	32.5	1.0	0.7	20.2
Líneas E.S. x Varios	3,487.80	87.8	1.28	17.5	27.8	0.9	0.7	20.6
Antigua x Rep.Dom.Amar. S.C.	3,487.32	76.6	0.99	6.5	9.8	1.0	0.5	22.1
Mezcla Amarilla P.B.	3,331.78	79.4	1.02	6.3	22.2	1.0	0.7	21.3
Blanco Cristalino Int.	3,247.16	79.8	1.09	5.5	23.5	0.9	0.8	19.6
Amarillo del Bajío x Sint.10 Lin.	3,053.53	78.6	1.17	9.9	26.8	0.9	0.9	19.9
(Mix.1 x Colima Gpo.1)ETO P.B.	2,957.66	85.3	0.95	2.6	29.9	0.9	0.9	19.3
Antigua x Veracruz 181	2,826.18	87.6	1.17	9.5	39.1	0.9	0.5	21.2
ETO x Líneas Seleccionadas	2,735.09	76.4	1.17	2.0	10.9	0.9	1.5	23.0
Tuxpeño br_2 br_2	2,522.85	91.0	0.91	4.9	17.2	0.9	1.4	24.6
ETO Blanco P.B.	2,264.55	84.7	0.92	8.8	37.4	0.9	0.7	20.7

TABLE 4.13 Reaction to Sclerospora spp. of Maize Populations from CIMMYT's Germplasm Bank and Checks at Farm Suwan in Thailand, 1974.

Population	Number of Plants	Number of Infected plants	Infection %	Population	Number of Plants	Number of Infected plants	Infection %
	Bank entries				Bank entries		
Tamaulipas 4	30	5	17	Chiapas 57	31	14	45
Surinam 796	34	6	18	Guatemala 242	33	15	45
Oaxaca 70	26	6	23	Guatemala 253	31	14	45
Saint Vincent 8	33	9	27	Veracruz 117	33	15	45
Nicaragua 3385	32	9	28	Sonora 112	33	15	45
				Nuevo Leon 23	28	13	46
Sinaloa 71	29	8	28				
Chiapas 56	21	6	29	Honduras 37	30	14	47
Chiapas 160	28	8	29	Honduras 32	32	15	47
Guadeloupe 12	18	6	33	Guatemala Grupo 5-6A	30	14	47
El Salvador 68	34	12	35	Nayarit 9	19	9	47
Chiapas 62	31	11	35	Veracruz 92	30	14	47
				British Virgin Islands 138	33	16	48
Colima 5	31	11	35				
Sinaloa 21	28	10	36	Guyana 813	31	15	48
Colima 7	30	11	37	Tolima 378	31	15	48
Guatemala 588	30	11	37	Honduras 105	29	14	48
Chiapas 96	30	11	37	Panama 132	27	13	48
				Honduras 133	31	15	48
Guatemala 231	32	12	38	Guatemala 748	21	10	48
Chiapas 99	32	12	38				
Cauca 343	33	13	39	Guatemala 123	29	14	48
Nicaragua 81	31	12	39	College Yellow Flint	33	16	48
El Salvador 63	28	11	39	Nayarit 38	33	16	48
Nayarit 62	33	13	39	Veracruz 23	29	14	48
				Mejores Variedades Amarillas	27	13	48
Chiapas Grupo 7	23	9	39				
Cuba 120	30	12	40	British Virgin Islands 140	31	15	48
El Salvador 98	30	12	40	Tamaulipas 32	21	10	48
Guatemala 128	35	14	40	Cuba 88	32	16	50
Surinam 795	29	12	41	Brasil 61	28	14	50
Nicaragua 3380	32	13	41	Honduras 52	30	15	50
Costa Rica Grupo 25	32	13	41	El Salvador 51	34	17	50
Guatemala Grupo 7-1A	29	12	41	Guatemala 721	28	14	50
Veracruz 55	34	14	41	Chiapas 30	26	13	50
Jalisco 42	17	7	41	Guatemala 151	20	10	50
Guatemala Grupo 21-1A	31	13	42	Guatemala 120	34	17	50
Oaxaca 48	31	13	42	Guatemala 109	32	16	50
El Salvador 92	30	13	43	Chiapas 172	26	13	50
Honduras 86	30	13	43	Oaxaca 226	34	17	50
San Luis Potosi 54	21	9	43	San Luis Potosi	32	16	50
Honduras 47	28	12	43	Tamaulipas 37	30	15	50
Cuba 51	28	12	43	San Luis Potosi 97	38	19	50
Cuba 167	32	14	44				
					Checks		
Diacol V 206	32	14	44				
El Salvador 111	18	8	44	Blanco Cristalino Int.	30	11	37
Nayarit 170	18	8	44	Amarillo del Bajio x			
Nuevo Leon 13	32	14	44	Sintetico 10 lineas	28	12	43
Cuba 99	9	4	44	Eto PB x Tuxp. PB (C11)	32	15	47
Diacol V 101	31	14	45	Tuxp. x Nic. Sint. 10 B. C. etc.	31	15	48

Table 4.14 Yield, Adjusted for Experiment Effect, and Agronomic Data of Selected Germplasm Bank Entries and Checks Tested in Field Trials Grown at El Batán, México in 1974.

Population	Yield Kilograms/Ha.	Days to silking	Ear height meters	% root lodging	% stalk lodging	Ears harvested/ plant	% rotten ears	Moisture Percentage
			BANK ENTRIES					
Chalqueño Tardío	10,146.6	110.3	1.82	10.5	8.8	1.9	22.6	29.3
Puebla 364	9,793.2	97.0	1.63	21.0	6.3	1.5	28.0	26.1
Puebla 359	9,430.3	94.3	1.32	9.8	11.2	1.4	19.3	25.6
México Grupo 12	9,400.7	107.0	1.66	16.3	2.0	1.8	10.5	32.2
México 153	9,259.0	110.0	1.63	20.8	3.5	1.4	28.1	30.6
Chihuahua 245	9,115.7	83.7	1.03	9.9	13.4	2.4	12.8	15.2
México Grupo 10	9,077.9	111.0	1.59	3.0	3.2	1.5	17.4	27.7
Hidalgo 7	8,990.2	108.3	1.79	6.2	6.2	1.5	32.5	25.9
Michoacán 317	8,790.3	124.0	2.14	11.7	3.4	1.5	23.6	36.8
Puebla 388	8,715.1	98.3	1.52	15.7	10.1	1.7	20.0	21.4
Zacatecas 192	8,687.2	113.7	1.65	4.6	5.3	2.8	25.5	32.6
Puebla 355	8,586.0	113.0	1.81	22.1	5.1	1.8	16.8	33.8
Zacatecas 7	8,438.8	113.0	1.75	5.7	3.9	3.1	17.8	27.4
Puebla 356	8,430.7	111.0	1.85	25.6	1.5	1.6	14.5	30.7
Durango 17	8,404.7	102.3	1.49	1.8	4.8	2.4	19.7	28.5
México 180	8,344.8	109.3	1.61	23.2	8.3	1.6	18.0	28.3
Puebla 398	8,235.3	106.7	1.82	13.4	5.0	1.7	15.7	34.0
Puebla 360	8,167.1	96.0	1.51	14.9	7.5	1.4	37.1	27.2
Puebla Grupo 32	8,015.0	106.3	1.78	6.8	1.8	1.8	12.4	27.7
México 172	7,973.7	102.3	1.53	16.5	0.0	1.3	31.5	29.0
Puebla 374	7,968.3	107.0	1.75	15.3	3.5	1.2	26.8	34.4
Puebla 339	7,967.3	91.3	1.27	22.5	10.1	1.4	28.0	20.2
Chihuahua 244	7,893.6	84.0	1.01	2.0	16.1	2.4	20.3	18.0
Puebla 354	7,863.2	106.0	1.75	14.1	4.8	1.5	10.4	29.8
Michoacán 329	7,846.2	102.3	1.63	11.2	1.6	1.4	56.6	20.3
México 158	7,820.0	108.0	1.58	9.5	3.1	1.2	43.5	30.6
Puebla 504	7,729.7	101.7	1.44	0.0	1.5	1.5	6.3	25.2
Michoacán 322	7,697.9	97.7	1.50	8.0	1.5	1.4	32.5	24.5
Michoacán 353	7,669.1	108.7	1.64	9.3	6.0	1.7	50.4	21.8
Puebla 455	7,615.0	100.0	1.72	3.3	3.0	1.5	19.4	29.8
Michoacán 331	7,609.1	100.0	1.33	11.2	6.3	1.2	29.1	20.7
Puebla Grupo 61	7,605.8	115.0	1.98	10.4	3.7	2.5	53.0	31.1
Nuevo León 16	7,595.9	103.7	1.77	2.1	6.8	2.7	19.2	23.8
Puebla Grupo 49	7,540.7	107.7	1.71	11.1	1.5	1.3	17.4	33.8
Puebla 462	7,514.6	97.7	1.35	1.9	1.9	1.4	17.2	26.9
Puebla 465	7,506.3	96.0	1.39	11.6	9.9	1.3	30.9	23.0
			CHECKS					
Chalqueño A	10,289.3	110.7	1.79	9.7	4.9	2.1	13.6	29.1
Composite I (o202)	8,635.8	107.1	1.52	10.4	6.5	2.1	32.8	28.3
H - 129	7,183.9	108.1	1.51	12.2	4.5	2.2	18.1	28.8
Compuesto Intermedio de Altura	6,489.6	93.3	1.20	7.7	6.6	1.6	37.9	20.8
World Composite	6,185.8	114.2	1.62	10.2	3.0	2.1	29.1	32.1
Andean Zone Grupo II	6,069.7	104.9	1.47	4.7	3.3	1.7	50.2	29.5
Andean Zone Grupo I	5,789.9	113.7	1.71	10.1	5.0	1.7	50.3	32.1
Compuesto Harinoso	5,693.5	97.3	1.30	8.6	8.7	1.9	44.0	24.9
Andean x Temperate	5,480.8	106.7	1.40	5.4	2.6	1.8	55.0	28.3
Compuesto muy Precoz de Altura	5,227.3	83.4	0.94	2.8	3.0	1.6	61.0	20.2
Andean Zone G (Granos Grandes)	4,226.7	90.2	1.05	6.1	2.8	1.3	75.5	21.6
Criollo Baraza	3,552.1	82.5	0.98	14.4	3.7	1.1	60.8	17.6
Híbridos Tropicales Selección Batán	3,279.2	115.7	1.19	5.7	5.3	1.7	54.9	28.1

4.14 MAIZE-TRIPSACUM CROSSES

New crosses between maize and Tripsacum were attempted during the summer of 1974, using both genera as the pistillate parent. Two diploid maizes and one tetraploid maize were used, as well as all blooming Tripsacum accessions. F_1's and BC_1's have been recovered and are growing in the greenhouse.

Table 4.15 is a summary of data on the crossability of maize and 5 Tripsacum species and two putative Tripsacum hybrids when the latter were used as pistillate parents obtained in 1973.

Percent crossability was expressed as the ratio of putative F_1 caryopses recovered and the fruit cases examined times 100. Crossability varied from 0-3.0% and was very low, under the best of circumstances. These results suggest the need for larger scale work to obtain a satisfactory number of hybrid offspring, as well as the necessity of developing improved techniques for greater crossability.

4.2 BACK-UP UNIT YIELD TRIAL 1974

Using data obtained in yield trials of materials under development, the population Antigua Gpo. 2 Rep. Dominicana was moved into the Advanced stages, for the 1975 as an early maturity, short plant variety, with good yield and resistance to most common diseases. Grain type is yellow, semi-dent. Also moved to the Advanced stages were: ETO Blanco, with white flint grain; and a slightly later maturing new combination, also having white flint grain, made up from selected progenies from crosses of Sintetico 10 lineas PD(MS)6 with ETO Blanco, (Mix. 1 - Col. Gpo. 1) ETO and Tuxpeño x Nicarillo and to be called Blanco Cristalino 2 (IPTT-30).

Summaries of the yield trials are shown in Table 4.21 and 4.22. Yields were higher at the Tlaltizapán station, probably due to the longer period for achieving maturity. The planting at Obregón, however, was made in early June, so that the entire period of development was during the intense summer heat. Maturity was reached much more rapidly, and yields were lower under these severe conditions.

The major movements of progenies from the Back-up Stage to Advanced Stage populations and into the Back-up Pools are shown in the summary Table 4.23. These are phases of the continuing recombination process in which the Back-up stage develops new materials.

Table 4.15 Summary of pollinations of different Tripsacum species by maize at Tlaltizapan, Morelos, 1973.

Species or Hybrids	Clones	Propagules	Number of Pollinations	Number of Fruit Cases	Caryopses	Range in % Crossability
Tripsacum dactyloides	26	88	3,660	30,017	298	0-3.0
Tripsacum dactyloides ssp. hispidum	5	16	238	1,791	3	0-1.2
Tripsacum latifolium	1	4	50	1,323	1	.08
Tripsacum maizar	3	6	104	4,849	0	0
Tripsacum pilosum	8	23	833	25,396	41	0- .3
Tripsacum zopilotense	4	13	148	782	0	0
Tripsacum maizar-dactuloides	2	2	4	168	0	0
Tripsacum pilosum-maizar	1	3	131	4,143	1	.02
Sum	50	155	5,168	68,469	344	

TABLE 4.2.1 Comparative Performance of Back-Up materials tested at Two Locations in Mexico. 1974 Winter Season

BU No.	PEDIGREE	Grain Type	TLALTIZAPAN Yield* x̄ Pop.	Highest Check	Range	x̄ Sel. Fam.	Days to Flower x̄ Pop.	Plant Height cm x̄ Pop	POZA RICA Yield* x̄ Pop.	Highest Check	Range	x̄ Sel. Fam.	Days to Flower x̄ Pop.	Plant Height cm x̄ Pop.	No.Sel. Fam.
1	Ant. Gpo. 2 x Rep. Dominicana	YD	5718	7513	1185 8924	6670	87	183	3063	4378	914 5384	3368	77	1.70	105
2	Comp. Blanco Pfister USA x Var. Trop.	WF	6257	8490	364 9800	7224	90.6	205	3191	4553	1709 4687	3594	80	1.99	42
3	Ant. Gpo. 2 Blanco x Eto Blanco C_6	WF	6072	8305	3154 8293	6649	95	178	2520	3506	1122 3847	2711	81	1.74	42
4	Sint. 10 Lin. PD(MS)6 Cuba, Rep. Dom., Nicarillo x Mez. Am. P.B.	YF	6435	8568	3461 9062	6966	94	193	2931	3576	1802 4743	3360	79	1.99	48
5	Sint. 10 Lin. PD(MS)6, Rep. Dom., Nicarillo, Ant. Gpo. 2 x Ver. 181	YF &D	6304	7739	4196 9112	6960	99	210	2880	3266	1634 5112	3258	82	2.10	34
6	Am. Bajío x Tuxp. P.B.	Y&W D	6646	7706	3459 9467	7180	98	210	2662	4200	855 4225	3083	82	2.01	34
7	Am. Bajío x Eto. P.B.	Y&W D&F	7715	8655	3014 10814	8559	88	241	2109	3712	530 4372	2428	75	1.82	47
8	Comp. Ecuador, México, Arg., India	Y&W D&F	7179	8699	4450 10562	7848	92	222	2774	2886	1794 4392	3234	78	2.15	43
9	Comp. Blanco Tipo Caribe	WD&F	6472	7735	3111 9655	7236	96	227	2526	3588	1308 3816	2825	82	2.43	31
10	Comp. Ecuador, Mexico, Arg.,	Y&W F&D	7015	7673	4763 10114	7871	94	217	3164	4276	1608 4411	3381	79	2.10	19
11	Comp. Caribe Sel. Blanca	WF	6997	8132	3878 10648	7580	94	251	2434	3159	1074 4341	2958	79	2.04	30

* Kg/ha, 15% moist.

TABLE 4.2.2 Comparative Performance of Back-Up materials tested at two Locations in Mexico. 1974 Summer Season.

			TLALTIZAPAN							OBREGON						
			Yield*				Days to Flower	Plant Height cm		Yield*			Days to Flower	Plant Height cm		
BU No.	PEDIGREE	Grain Type	x̄ Pop.	Highest Check	Range	x̄ Sel. Fam.	x̄ Pop.	x̄ Pop.	x̄ Pop.	Highest Check	Range	x̄ Sel. Fam.	x̄ Pop.	x̄ Pop.	No. Sel. Fam.
100	Eto Blanco P.B.	WF	7422	10301	1934 12462	8747	67.1	216	2574	3773	195 4688	3037	64.5	198.6	117
101	Mix. 1 x Col. Gpo. 1	WD	7924	10116	2047 14582	9846	69	229	1855	3251	99 3702	2597	67	209	51
102	Am. Dentado Sel. Misc. P.B.	YD	7941	10212	3412 11633	9187	66	232	2401	4432	574 4942	3054	64	206	51
103	Am. Dentado Sel. Misc. P.B.	YD	7729	9157	3168 10875	9405	66	237	2851	4429	408 4908	?	65	219	50
104	(Tuxp. x Nicarillo)Sint. 10 Lineas	Y&W D&F	7856	8617	3457 11235	8496	66	257	2280	2952	493 3532	2640	65	219	78
105	(Mix. 1 x Col. Gpo. 1)(Eto x Sint. 10 Lin.)	Y&W D&F	9127	10060	3670 10512	9632	65	261	3235	4047	1361 5275	3645	64	229	50
106	Eto Blanco x Sint. 10 Lineas	Y&W D&F	6299	6096	1751 10456	7220	72	211			No data from Obregon				34

* Kg/ha, 15% moist.

TABLE 4.23. - Summary of Major Progeny Transfers in Back-Up Unit, 1974.

Trial No.	Material	Test season	No. of Progenies Tested	Selected	Remarks:
		1974A			
1	Ant. Gpo. 2-Rep. Dominicana	TL&PR	250	105	To Advanced Unit(Y)*
2	Composite U.S.A.-Tropical (Pfister)	TL&PR	250		Pending (W)*
3	Ant. Sel. Bl. -ETO Bl. C-6	TL&PR	250		" (W)
4	Mezcla Am. -Sint. 10 lineas, Cuba-R. D. Etc.	TL&PR	250		" (Y)
5	Ant. -Ver. 181-Sint. 10 lineas, Cuba-R. D. etc.	TL&PR	250		" (Y)
6	Amarillo Bajío-Tuxpeño P.B.	TL&PR	250		" (Y&W)
7	Amarillo Bajío-ETO P.B.	TL&PR	250		" (Y&W)
8	Comp. Ecuad. r, Mex., Arg., India	TL&PR	250		" (W)
9	Comp. Blanco Tipo Caribe	TL&PR	190		" (W)
10	Comp. Ec., Mex., Arg., India	TL&PR	100		" (Y)
11	Comp. Caribe Sel. Blanca	TL&PR	144		" (W)
		1974B			
100	Eto Blanco P.B.	TL&OB	250	117	To Advanced Unit(W)
101	Mix. 1 - Col. Gpo. 1	TL&OB	250	51	To IPTT-43 & Pool 24 (W)
102	Amar. Misc. 1 Dentado	TL&OB	250	51	To IPTT-36 & Pool 26 (Y)
103	Amar. Misc. 2 Dentado	TL&OB	250	51	To IPTT-36 & Pool 26 (Y)
104	(Tuxpeño-Nicarillo) Sint. 10 Lineas	TL&OB	250	69(W)	To IPTT-30 & Pool 23(W)
				78(Y)	To IPTT-27 & Pools 25 & 21 (Y)
105	(Mix. 1-Col. Gpo. 1) Sint. 10 Lineas	TL&OB	250	36(W)	To IPTT-25 & 30 & Pool 23 (W)
				49(Y)	To IPTT-27 & Pool 25 (Y)
106	Eto Blanco - Sint. 10 lineas	TL&OB	250	33(W)	To IPTT-30 & 32 & Pool 19 (W)
				34(Y)	To IPTT-27 & Pool 21 (Y)

* (Y) = Yellow & (W) = White grain.

Table 4.24 1974 BACK-UP STAGE : POOLS*

No.	Name	Abbre-viation	No. of families	Approx. cycle of mixing	Days to 50% silk	Location
	Highland					
1	Early White Flint	(HEWF)	287	3	84	Batan & Toluca
2	Early White Dent	(HEWD)	1178	3	84	Batan & Toluca
3	Early White Floury	(HEWFl.)	448	3	90	Batan & Toluca
4A	Early Yellow Flint	(HEYF)	333	3	86	Batan & Toluca
4B	Early Yellow Flint	(HEYF)	465	3	86	Batan & Toluca
5A	Early Yellow Dent	(HEYD)	553	3	82	Batan & Toluca
5B	Early Yellow Dent	(HEYD)	390	3	83	Batan & Toluca
6	Intermediate White Flint	(HIWF)	Not formed yet			
7	Intermediate White Dent	(HIWD)	1469	3	95	Batan & Toluca
8A	Intermediate White Floury	(HIWFl.)	369	3	92	Batan & Toluca
8B	Intermediate White Floury	(HIWFl.)	786	3	96	Batan & Toluca
9	Intermediate Yellow Flint	(HIYF)	553	3	98	Batan & Toluca
10A	Intermediate Yellow Dent	(HIYD)	4003	3	96	Batan & Toluca
10B	Intermediate Yellow Dent	(HIYD)	1562	3	91	Batan & Toluca
11	Late White Flint	(HLWF)	Frosted	2		Batan
12	Late White Dent	(HLWD)	Frosted	2		Batan
13	Late Yellow Flint	(HLYF)	Frosted	2		Batan
14	Late Yellow Dent	(HLYD)	Frosted	2		Batan
	Tropical					
15	Early White Flint	(TEWF)	768	6	54	Poza Rica
16	Early White Dent	(TEWD)	192	6	54	Poza Rica
17	Early Yellow Flint	(TEYF)	348	6	57	Poza Rica
18	Early Yellow Dent	(TEYD)	140	6	56	Poza Rica
19	Intermediate White Flint	(TIWF)	Flooded	3		Poza Rica
20	Intermediate White Dent	(TIWD)	Flooded	3		Poza Rica
21	Intermediate Yellow Flint	(TIYF)	Flooded	3		Poza Rica
22	Intermediate Yellow Flint	(TIYD)	342	4	60	Poza Rica
23	Late White Flint	(TIWF)	Flooded	3		Poza Rica
24	Late White Dent	(TLWD)	Flooded	3		Poza Rica
25	Late Yellow Flint	(TLYF)	Flooded	3		Poza Rica
26	Late Yellow Dent	(TLYD)	Flooded	3		Poza Rica
	Temperate					
27	Early White Flint	(TmEWF)	403	3	61	Tlaltizapan
32	Intermediate White Dent	(TmIWD)	508	3	68	Tlaltizapan
33	Intermediate Yellow Flint	(TmIYF)	992	3	66	Tlaltizapan
34	Intermediate Yellow Dent	(TmIYD)	787	3	67	Tlaltizapan

* See 1973 Annual Report Appendix for original germplasm used.

5.0 Training

Maize research and its associated training attempt to produce varieties and technology that are practical for the widest range of farm conditions. Training activities link with research to combine those aspects best done under experiment station conditions with a continuing confirmation procedure under farm conditions. Thus: varieties and cultural practices developed on stations are verified by on-the-farm use, and (2) the process of continuous farm checking helps reduce the time required from development of a practice to its widespread farm use. (See 1973 Annual Report for Training objectives, philosophy, and practices).

CIMMYT's capacity for in-service training in maize is limited to about 50 trainees per year, thus can provide only a relatively few trained people. However, the worldwide needs for trained personnel are enormous, and the need to transmit and multiply the training is obvious. It is hoped that CIMMYT trainees will function upon return to their countries, as trainers in the preparation of others, and the training program is increasingly oriented to that task. In the long run, the critical training job must be done within the countries' own national programs. Four of the 1974 trainees are expected to be operating their own country training program in 1975.

In 1974, a total of 47 trainees initiated their in-service training at CIMMYT, 24 beginning in May, and 23 in November. The trainees come from 20 countries: Belize (2), Bolivia (2), Brazil (1), Colombia (2), Dominican Republic (1), Egypt (3), Ethiopia (1), Ecuador (3), Ghana (3), Honduras (2), India (1), Ivory Coast (1), Mexico (2), Nepal (2), Nigeria (4), Peru (1), Philippines (1), Pakistan (4), Tanzania (4), El Salvador (1), Venezuela (1), and Zaire (5).

Their fields of specialization were Maize Production (33), Breeding (6), Protection (3), and Protein Evaluation (5). This training was sponsored by Banco Interamericano de Desarrollo, Belize Government, Ford Foundation, DSE (Deutsche Stiftung für International Entwicklung), FORENAIZ (Venezuela), IITA (International Institute of Tropical Agriculture, UNDP (United Nations Development Programme), USAID (United States Agency for International Development, ZAMNP (Zaire Maize National Program) and CIMMYT.

Since 1966, CIMMYT has trained a total of 198 agronomists: 100 from Latin America, 35 from Asia and 63 from Africa.

A portion of the training program is conducted in cooperation with the Mexican Agricultural Extension Service in the State of Veracruz. The trainee production agronomists are responsible for conducting trials in farmers' fields, and for the organization of field days and discussions related to such trials. This activity provides practical training, under the conditions that exist in the area, as a part of the Mexican national program. Technological advances indicated by experiment station work are carried to the farmers for verification in their fields. Results of the trials are analyzed, and the information obtained becomes the base of the technological package that is to be recommended for the area.

The farmer's own resources are utilized in the program so that the farmers can make their own evaluations on their own land. They participate in the sowing, management and harvest of simple experiments involving specified fertilizers, varieties and pesticides. Large plot demonstrations compare four treatments (1) the farmers' variety with local technology, (2) an improved variety with local technology, (3) the farmers' variety with recommended technology and (4) an improved variety with recommended technology. (On the average, the improved varieties under local technology have provided a yield increase of 23%, while recommended technology with the improved variety increased yields by 75%.) Although many countries do not attempt production improvement programs unless an improved variety is available, it has been shown that important increases can be achieved through use of better cultural practices with the varieties already available.

6.0 Collaborative Research

Certain kinds of problems involving special environmental conditions or perhaps equipment or staff not available in CIMMYT are being considered for action at locations other than CIMMYT. Two such situations in which preliminary agreements have been made are (1) Downy Mildew selection in collaboration with the University of the Philippines at Los Baños, Philippines, and (2) Stunt disease with the Ministry of Agriculture of El Salvador at Santa Cruz Porrillo, El Salvador.

These two cases represent two very serious diseases of the corn plant and are considered for the most appropriate areas in which they occur and where a collaborating institution exists with the [illegible] to undertake such work. Intensification of selection for genetic resistance to these diseases is considered urgent in view of the threat to major areas of production posed by the pathogens involved.

The first field plantings will be made in 1975.

Seed for the Advanced Unit progeny trials is shelled, cleaned, treated with insecticides and fungicides, and counted into progeny trials that will be shipped to cooperating countries.

7.0 Regional Programs: Central America and Caribbean

Two CIMMYT scientists, a breeder and an agronomist-trainer, have been assigned for full time work in maize improvement in Central America and the Caribbean area. Financed by BID (Banco Interamericano de Desarrollo). This prototype program was begun in late 1974, with an initial work base in nine countries: Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama, Haiti, Jamaica and the Dominican Republic.

As an expansion of CIMMYT's outreach activities, the basic aim is to post CIMMYT scientists for work with local maize scientists and national programs in specific geographic regions, supplementing the services now provided from Mexico. Negotiations are underway for similar programs in the Andean Region of South America and in Asia, with financing to be provided by the UNDP.

CIMMYT's regional program cooperation consists of action in three major areas: maize research, maize production, and training of technical personnel.

7.1 MAIZE RESEARCH

Working alongside local national program technical personnel, the CIMMYT staff helps study, identify and evaluate maize production barriers. Emphasis is upon:

Improvement of Maize Materials: working with the national breeding programs and providing guidelines for improving breeding methods to improve yields, adaptability, plant and grain characteristics, and nutritional quality.

Exchange of Genetic Maize Materials: developing improved varieties by exchange of materials within the region.

Agronomic Practices: refining the technological packages used in each country, including experiments on date of planning, soil preparation, fertilizers, insects and disease control, plant density and weed control. These factors will be testing using the varieties be adapted for the area.

Technical visits and workshops: organizing visits by technical personnel of national programs to countries within the region and to CIMMYT operations in Mexico. Yearly workshops are planned to discuss the development of each participating country.

7.2 MAIZE PRODUCTION

"Regionalization", the process of sub-dividing the total agricultural surface of a country into production areas, is underway in many of these countries. A major aim of outreach work is to implement programs in such regions. In the initial stages, such programs will focus on the selection of some more favorable production areas, afterwards to be extended throughout a country. Participation by a number of technicians appointed by each country is a key element of the production activities. Numerous (over 100) small and demonstration trials in farmers' fields can demonstrate the benefits of applying better production practices and superior varieties.

Technicians appointed by the agricultural authorities are directly responsible for these trials,

including the evaluation of data, field day organization, promotion of attendance, and reporting of results. A few large demonstration plots--planted in fields owned by selected cooperating farmers--can demonstrate the increased production possibilities of more extensive holdings.

7.3 TRAINING OF IN-SERVICE TECHNICAL PERSONNEL

Development of National Training Programs is being encouraged in each participating country. A team of three or four selected "Ingenieros Agronomos" (agricultural school graduates) will be trained in the CIMMYT Maize Training Program in Mexico. It is intended that this team form the nucleus of their home country National Training Program.

In a farmer's field in the Chiriqui Province, Panama, Robert Soza assists in setting up a production trial – one of his roles as production agronomist in CIMMYT's Regional Program in Central America.

8.0 Inter - Center Collaboration

8.1 SORGHUM

Sorghum occupies over 42 million hectares world-wide and is used as a source of food, feed, and industrial raw material. It is grown in the warm, subhumid, and rainfed semiarid regions of all continents. The crop requires 120 or more frost free days and temperature above 20°C during the season. The major areas of production are Africa, Asia, Argentina, and United States of America.

Sorghum possesses a high degree of tolerance to drought conditions because of its extensive fibrous root system and xerophytic nature of leaf. The incorporation of an acceptable degree of cool temperature tolerance might permit the extension of its cultivation into high altitude areas of the world that are characterized by scarce and erratic rainfall. Thousands of hectares of such areas exist in the American continent, Europe, Asia, and Africa, where cool temperature tolerant sorghum can play an important role in both human and animal diets.

8.11 SORGHUM BREEDING

The initial success in developing a cool temperature tolerant sorghum germ plasm pool that grows well in the valley of Mexico (2,250 meters elevation), and its potential usefulness in similar areas of the world which are characterized by scarce and erratic rainfall, has led to an expansion of the effort. This expansion has included the introduction of new sources of genetic variability for different agronomic types, disease and insect resistance, higher nutritional quality, large seed sizes, and white and yellow seed color. This addition of genetic variability for desirable characters simultaneously reintroduces the lack of tolerance to cool temperatures; therefore selection must be continued under appropriate conditions to recover the desired recombination types.

The major breeding objectives in developing cool temperature tolerant cultivars and populations are: (1) higher yields; (2) wide adaptation, giving stability of production; (3) different agronomic and grain color types; (4) field resistance to important diseases and insect pests; (5) early maturity; (6) higher protein quantity and quality; (7) tolerance to bird damage; and (8) a continued search for and use of new sources of cool temperature tolerance.

To achieve the desired crosses, it will be necessary to work under higher temperature conditions, such as those available at Poza Rica and Tlaltizapán, where both cool temperature tolerant and non-tolerant materials can be grown together. Over 2,300 controlled single, double, and three-way crosses were made during 1974. Unfortunately, two-thirds of these were lost in the flood at Poza Rica.

8.111 Breeding Procedures

Several breeding procedures are being utilized, as briefly described below.

Modified pedigree system with selective matings within and among families in early segregating generations: This procedure handles single, double, and multiple crosses that appear to be agronomically desirable and free from certain diseases and/or insect pests. Grain yields and its components are the main criteria of selection, along with the required degree of cool temperature tolerance.

Population development using genetic male sterility: Nebraska population "NP10BR" and Purdue population "PP23" are being used as sources of genetic male sterility (ms_3). Two additional populations

KP6BR (from Kansas) and PR1BR (from Puerto Rico) have recently been obtained for the same purpose. The major objective of this approach is to incorporate a wide range of germ plasm--with different sources of resistance to diseases and insect pests, wide adaptation, and cool temperature tolerance--into a large intermating gene pool. After several cycles of recombination, half-sib, full-sib, and S_1-testing procedures will be used to improve the base population and to generate elite lines. Work is also under way to develop a "Cool Temperature Tolerant High Protein" pool with use of genetic male sterility.

Backcross methods: This method is used for conversion of tall, late maturing, and photoperiod-sensitive lines into their dwarf-early counterparts and also to improve protein quantity and quality. As agronomically desirable cool temperature tolerant recombinants are developed, simple backcross sub-populations will be carried to simultaneously improve their nutritional quality.

Six locations in Mexico (Table 8.1) provide environments for selection under widely different conditions of soil types, temperature, moisture, solar radiation, diseases and insect pests. Proportion at each of these stations permits identification of genotypes that do well at two or more of these locations, and is a means of gradually building genotypes with increasingly wide adaptation. Observations at latitudes (U.S.A., Canada, Europe, etc.) also is contemplated to identify relatively day-neutral lines.

8.112 Cool temperature tolerance

At the end of 1973, 1510 families were selected from the main cool temperature tolerant germ plasm pool that consists of over 3,500 families. Duplicate sets of each family were prepared. One complete set of 1,510 families was planted at El Batán and the others at Atizapán (Valley of Toluca) on April 9, 1974. The entire Atizapán nursery was lost due to killing frost in September. Similar frost damage in El Batán was about 20-25%. However, at El Batán, 664 individual plants were selected from "early" families and 312 individual plants from late families. These will be screened thoroughly for common diseases and insect pests for 1975.

To identify new sources of cool temperature tolerance, 44 sorghum lines were introduced from highlands of Ethiopia. One complete set of this material was planted at four of the CIMMYT experiment stations. The entire set was lost in the flood at Poza Rica and at El Batán and Atizapán due to early frost. From the Tlaltizapán crop, it appeared that all but one entry is very tall, late maturing and photoperiod-sensitive. Thus, to screen these entries for cool temperature tolerance, each must first be converted to their early-dwarf counterparts so as to fit in the short growing season of El Batán and Atizapán. The conversion program will begin in 1975.

A set of 37 cool tolerant selections with 3 controls was sent out to 13 different locations around the world as an observation nursery. So far, information received from these is not complete.

8.113 Disease and insect resistance

Common diseases which have been identified in CIMMYT nurseries are: Helminthosporium leaf blight (H. turcicum), leaf rust (puccinia purpurea), zonate leaf spot (Gloeocercospora sorghi), sorghum downy mildew (Sclerospora sorghi), maize dwarf mosaic virus, and head molds. Thus far, the latter have been of minor significance, but their incidence has been increasing from season to season. Arrangements for artificial inoculations were made for Helminthosporium leaf blights and zonate leaf spot in 19[illegible]. Incidence of leaf rust in the nursery at Poza Rica and Tlaltizapán was so severe that artificial inoculation was felt unnecessary. Sources of resistance for these diseases have been identified and additional sources are regularly added from the "International Sorghum All-Disease Nursery" conducted through Texas A&M University.

Sorghum midge (Cantarinia sorghicola), fall armyworm (Spodoptera frugiperda), corn leaf aphid (Rhopalosiphum maydis), green bug (Schizaphis graminum), and webworm (Celama sorghiella, a tentative identification) are common pests (with the midge and fall armyworm causing greatest concern). Relatively low levels of tolerance to fall armyworm appeared to exist in the materials. Resistant materials for sorghum midge and green bug have recently been obtained from U.S.A. Attempts will be made to incorporate these and other available sources of resistance into cool temperature tolerant germ plasm.

8.114 Nutritional Quality

This program was started in January, 1974. Seed of six high lysine sorghum lines was obtained from the Purdue University collections from Ethiopia. These original lines have shriveled grains, are late maturing, photoperiod-sensitive and tall growing. Sixteen crosses were made between these and dwarf-early lines. The F_2 seeds harvested from each F_1 cross were classified into three groups: Normal, Modified, and Shriveled. Protein and lysine analyses were done for 8 families. Modified recombinants were detected which appear to be of great potential significance inasmuch as they are of normal grain appearance with a large proportion of hard endosperm and a protein percentage ranging from 15 to 18%. However, the lysine content in these appeared to be normal (1.8 to 2.1%), and it is quite possible that the modified recombinants do not contain the genes for high lysine levels. There is still a great deal to be learned about these "modified" types and their further improvement. The significant point appears to be that of high protein level combined with a normal, non-shriveled seed.

8.12 TRAINING

The first trainee spent six months in the sorghum program. While learning various aspects of sorghum breeding and production and assisting with the program, he evaluated his materials from El Salvador and made over 200 crosses between these and promising CIMMYT sorghum lines. Unfortunately his crosses were lost in the flood. He returned to his country in the middle of November and resumed his duties with the national program.

Table 8.1 Experiment stations where CIMMYT sorghum research is conducted in Mexico.

Name of station	Altitude (meters)	Nature of work	Crops/ year
1. El Batan, State of Mexico	2,250	Screening for cool tolerance and yield trial.	1
2. Atizapán, State of Mexico	2,650	"	1
3. Obregón, State of Sonora	60	"	1
4. Huamantla, State of Tlaxcala	2,450	Screening for drought and cool tolerance	1
5. Tlaltizapan, State of Morelos	1,000	Yield trial and seed increase.	2
6. Poza Rica, Veracruz	50	Breeding nursery, yield trial, and selection for resistance to diseases and insect pests.	2-3

9.0 Special Projects

As described in the preceding pages, the central Maize Improvement program focuses on the development of commercially usable varieties, within a relatively structured routine. Special Projects, however, have been designed into the longer range improvement work as a series of corollary investigations. These Projects pursue research leads uncovered in the continuing program, with reinforcement or exploration of findings that seem particularly promising.

9.1 TUXPEÑO "PLANTA BAJA"

The recurrent selection program in Tuxpeño Crema 1--using the concept of a multigenic, quantitative additive genetic system for controlling plant height--has been so successful in reducing plant height that essentially the same idea has been extended to include all materials in the CIMMYT varietal improvement program. The shortened version of this material has been re-named "Tuxpeño-1", and is now being commercially increased in several countries.

The accumulated "genes for short height", also have been incorporated into a number of other materials by intercrossing. This includes the developing pools in the Back-Up Unit.

The ultimate effect of conducting this type of selection for an extended period is not yet clear. Apparently, a great deal of genetic variability for further height reduction remains in this population. Further investigations are being made to determine such additional effects.

With extreme selection for height, we need to know what happens to yield, leaf area, root development, maturity, etc. The question arises: At what point do undesirable side effects (if indeed these become of importance) begin to make further selection counter-productive. We think this sould be investigated as a guide to the handling of materials generally. It is already obvious that enormous changes can be made in the architecture of the maize plant, with the consequent implications for agronomic practices. Our intent is to push as far as possible with this one material to determine the consequences of continued, extreme selection for increasingly shorter plants.

9.2 TROPICAL VERSUS TEMPERATE TYPE GERMPLASM

In general, tropical maize plants grow taller, have more leaves, and produce relatively smaller ears than do maize types evolved in temperate climates. These characteristics produce a comparatively poor grain-to-stover ratio for tropical maize. Since efficiency of grain production is an important basic concept, there are several complex and related considerations:

Heavy foliage canopy results in inter-plant competition and the tendency to produce barren plants when higher plant densities are grown.

In other species, such as wheat, rice, sorghum, there appears to be relatively more grain to total dry matter in the smaller, earlier types, as compared to longer-season large plants.

It is not known to what extent luxury foliage development is essential to the ability to sustain ravages of foliage diseases and pests and still produce an acceptable yield.

Observations of maize grown under stress conditions that cause less than normal foliage development suggest that the maize plant produces far more foliage than is necessary for the grain that is normally produced.

The high sugar content found in mature plants (after maturation of the ears under protected conditions) indicates that some mechanism is limiting grain accumulation in tropical maize to a greater degree than in temperate materials.

Various germ plasm combinations are being made to combine the disease and insect tolerance of tropical corns with the better grain-to-stover characteristics of temperate types. Among these involves a visual selection process that systematically recombines segregates with an obviously good grain-to-stover ratio -- either very large ears or multiple ears. This combination is being called planta pequeña - mazorca grande (small plant - large ear), and is being conducted with highly heterogeneous germ plasm mixtures.

9.3 ADAPTATION

There are at least two kinds of environmental factors that combine to determine how a plant performs: (1) the physical factors of light, temperature, daylength, etc. through which the complex chemistry of the growing plant generates the products that constitute the plant itself and its "yield", and (2) the biological factor, including the diseases and pests that impede or damage the developing plant. Both factors are important in determining "Adaptation".

Development of resistance to pests and diseases at a practical field level is a daily concern of most breeding work in most crops.

However, "adaptation" as related to the physical factors described above, is somewhat more difficult to comprehend--and to do something about. There are a number of over-simplified examples that may help to illustrate at least part of the problem. "Tender" plants such as beans, maize, etc. are damaged or killed when subjected to freezing temperatures. Under less extreme conditions, we find wide differences in the ability of different maize varieties to grow under different temperature regimes. For example, tropical lowland types grow very slowly, are pale and chlorotic, etc., when grown under very cool conditions at Toluca, Mexico. Their chemistry is adjusted to a different range of temperatures than the so-called native corns at Toluca that grow normally --although fairly slowly--with good color and good yields. Obviously, different genes are carried! an extremely complex set of enzymes and chemical processes is involved, which has its basis in the genetic complement of these types. The question arises as to whether these two types of temperature responses can be combined in a single genotype. If the genes are non-allelic, it may be possible to put together combinations that will do well over much wider ranges of temperature conditions than do our present maize varieties that generally appear to have evolved at specific sites.

An illustrative example is provided by the potato, which does well in cool climates. When it is grown under high temperature regimes, there is little or no tuber formation. Apparently, the products of photosynthesis are burned up in the metabolism of the plant at high temperatures, with no resulting accumulation or yield. Something akin to this appears to happen to cool climate maize varieties when they are grown under lowland tropical condition.

CIMMYT is developing two kinds of procedures to explore "adaptation":

(1) We use the term day length studies to describe the stepwise mixture of germ plasm that has been built up using representatives (in about equal proportions) from all latitudes and altitudes in the Western hemisphere from Alaska to Argentina. It includes the New England Flints, Corn Belt Dent, Mexican highlands and lowlands, Caribbean, etc. These materials have been intercrossed in stepwise fashion and then mixed through several generations.

Identical "sets" of 132 families are grown in recombination blocks at as many sites as possible. Each site selects those plants that seem best suited at that site. Periodically, all these selections are brought back to a central location and recombined. We are growing this mixture at El Batán, Toluca, Obregón, Poza Rica and Tlaltizapán in Mexico. Other locations include Canada, the U.S., Colombia, Thailand, South Africa, Hungary and Iran.

This is a long-range attempt and no immediate commercial result is anticipated, although cooperators are welcome to use whatever they wish. It is hoped that longer range a broadly adapted complex should result.

(2) A small-scale attempt is being made to identify existing types of maize that do well over a range of conditions and to identify types that perform in totally different ways so that combinations can be made among these to study the inheritances of these differences. For example, lines from Illinois, when crossed to Mezcla Amarilla (a tropical type), produce a material that does well at El Batán and Toluca. The parents do not produce well by themselves, so apparently they contain complementary genes for adaptation to cool climates.

The Indonesian corns are very small and early maturity types. Yet at Obregón they grow very tall and do not mature at an early date. Thus, they appear to be very sensitive to day length. Perhaps we can set up a selection procedure to control these types of reactions.

9.4 EARLY MATURITY

This work is in early stages yet, but the idea has been put forth that recurrent selection aimed at producing very early genotypes from later maturity, higher yielding types, should eventually result in higher yielding, earlier materials than any of those now available. An array of early and later types have been intercrossed preliminary to initiate such an effort.

10.0 Related Maize Improvement Information

Bulletins

Chemical screening methods for maize quality protein at CIMMYT
Evangelina Villegas, Edwin T. Mertz. 1971 (RB 20)

Maize diseases. 1974 (HB 11)

CIMMYT Annual Report 1966-67; 1967-68; 1972

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Research and training in the development of high lysine maize. 1973 (Published by UNDP).

Statistical genetic theory and procedures useful in studying varieties and inter-varietal crosses in maize. C.C. Gardner and J.H. Lonquist. 1966 (RB 2)

The Puebla Project, seven years of experience 1967-73.

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Nurseries

International opaque-2 maize trials 3rd. 1972-75 (HB 13)

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Preliminary report. International experimental variety trials. 1974.

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2. Case Study: The Rockefeller Foundation program in corn and wheat in Mexico. 1969.
D.T. Myren.

12. Some ways international research programs can assist advanced nations.
E.W. Sprague. 1975.

13. National production programs for introducing high-quality protein maize in developing countries. C.R. Pomeroy. 1975.

14. A comparison of maize diseases in temperate and in tropical environments.
B.L. Renfro. A.J. Ullstrup. 1975.

15. The field support functions of the agricultural experiment station in the developing countries.
C.R. Pomeroy. 1975.

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Growth and yield of lowland tropical maize in Mexico
P.R. Goldsworthy. A.F.E. Palmer. D.W. Sperling. 1974.

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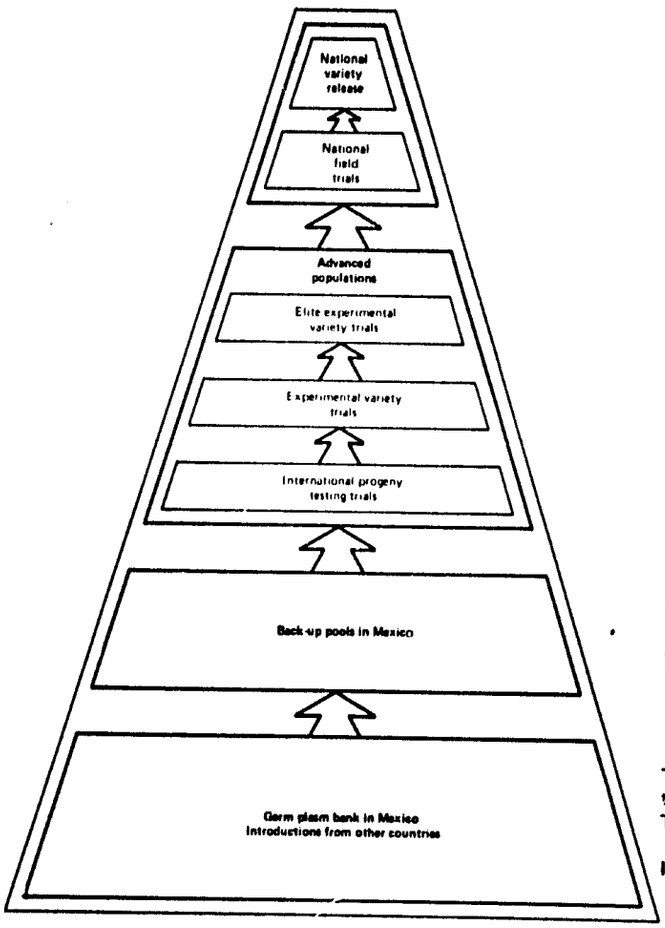
E.D. Carter. 1975.

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.

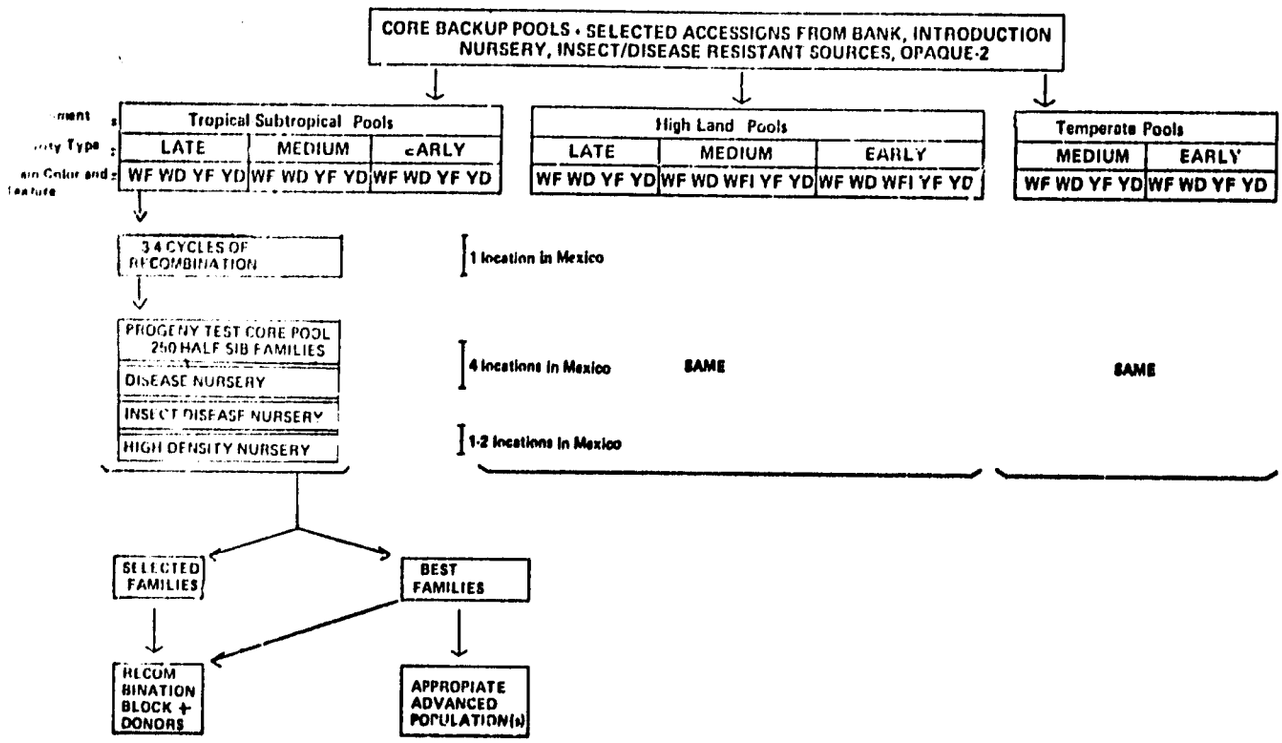
Introductions from other countries move directly to the back-up pools.

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 +

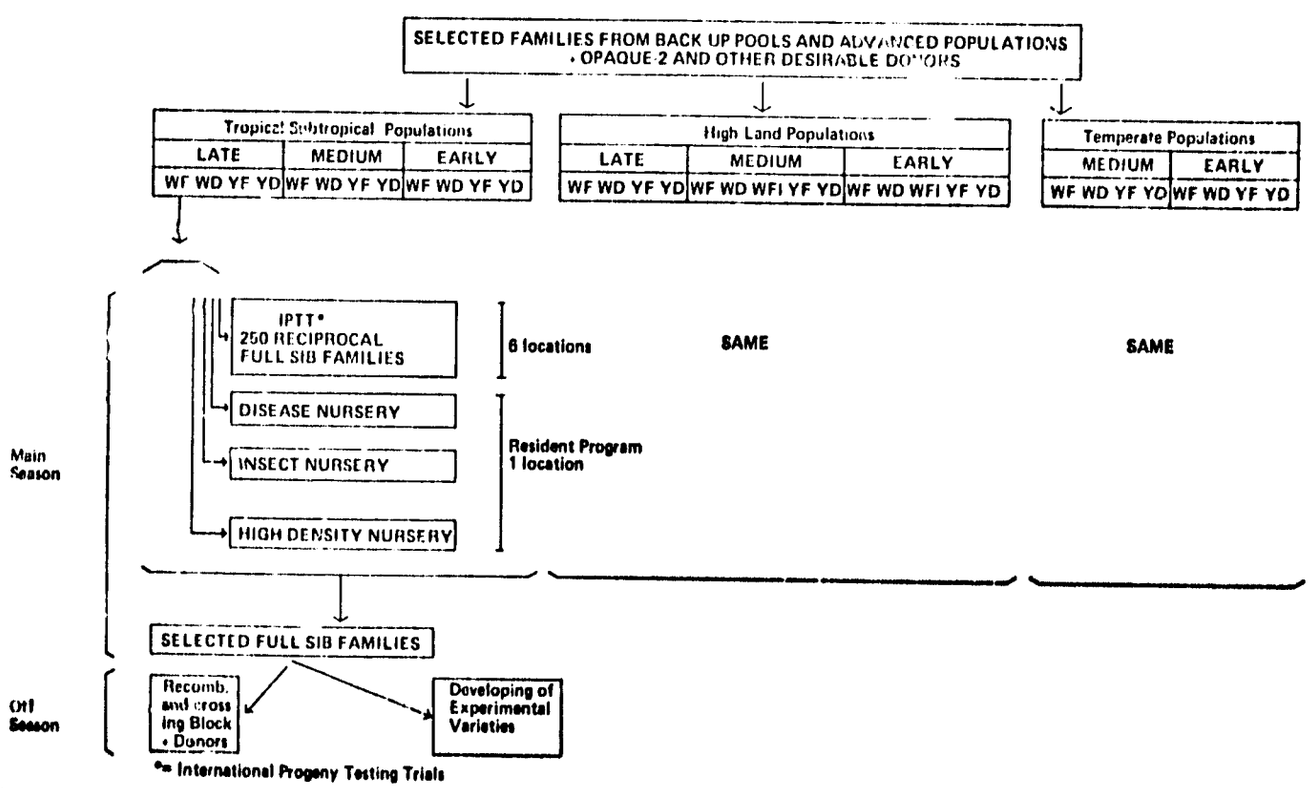
a/ Mean of main growing season.

CIMMYT'S BACKUP GERMPLASM UNIT



WF= White Flint
WD= White Dent
YF= Yellow Flint
YD= Yellow Dent
WFI= White Floury

CIMMYT'S ADVANCED GERMPLASM UNIT



*= International Progeny Testing Trials

Se dio término a la impresión de este libro el 19 de diciembre de 1975 en los talleres de Ediciones Las Américas. Tiro: 2,000 ejemplares. Impreso en México.