BIBLIOGRAPHIC DATA SHEET

1. CONTROL NUMBER
PN-AAJ-067

2. SUBJECT CLASSIFICATION (695)
AF00-0120-0000

3. TITLE AND SUBTITLE (240)
CIMMYT report on maize improvement, 1976-77

4. PERSONAL AUTHORS (100)

5. CORPORATE AUTHORS (101)
CIMMYT

6. DOCUMENT DATE (110)
1977

7. NUMBER OF PAGES (120)
104p.

8. ARC NUMBER (170)
633.15.C397 - 76/77

9. REFERENCE ORGANIZATION (180)
CIMMYT

10. SUPPLEMENTARY NOTES (500)
(Research summary)

11. ABSTRACT (950)

12. DESCRIPTORS (920)
Maize
Yield
Plant breeding
Germplasm
Training methods
Plant diseases
Research

13. PROJECT NUMBER (150)

14. CONTRACT NO.(140)
AID/ta-G-1083

15. CONTRACT TYPE (140)

16. TYPE OF DOCUMENT (160)
52

AID 590-7 (10-79)

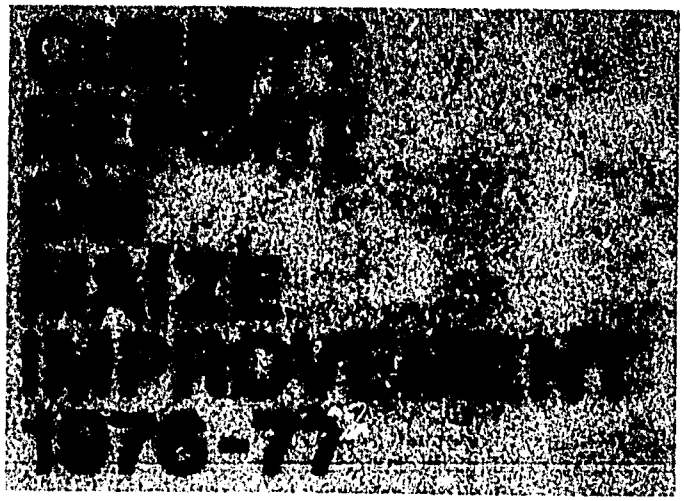
CIMMYT REPORT ON MAIZE IMPROVEMENT 1976-77

CIMMYT

ISSN 0304-548X

Correct citation: CIMMYT Report On Maize Improvement 1976–77. Centro Internacional de Mejoramiento de Maíz y Trigo, 1980, El Batan, Mexico.

CIMMYT. The International Maize and Wheat Improvement Center (CIMMYT) receives support from government agencies of Australia, Canada, Denmark, Federal Republic of Germany, France, Japan, Netherlands, Switzerland, United Kingdom, and USA; and from the Ford Foundation. Inter-American Development Bank, International Development Research Centre, Rockefeller Foundation, United Nations Development Programme, and the World Bank. Responsibility for this publication rests solely with CIMMYT.



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

CIMMYT

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1.0 INTRODUCTION

In 1976 and 1977, our maize scientists worked alongside national program scientists in 45 countries. We had firsthand looks at international trials and at production problems in farmers' fields. We also contacted former trainees and some national program leaders to discuss policy issues that influence maize production.

The crucial questions continue to be these: Have we systematically identified the factors that limit production? Do we have effective research plans to investigate and overcome these constraints? How can we best overcome such restraints—by changes in technology, changes in policy, or both?

In approaching these problems, we find that maize research workers often isolate themselves—within disciplines, within programs, within countries. They have not been sufficiently aware of factors other than technological research that might be effective in developing their agricultural production systems.

However, there seems to be a consensus that planning production programs is not a desk task; rather it requires that the scientists move into the field to seek out the limiting factors and determine which constraints can be remedied by research and/or policy changes. Once these aspects have been identified, it is relatively simple to design appropriate trials for on-farm testing and to establish farm demonstrations on the basis of data from on-farm testing. The on-farm testing results will quickly indicate the strengths and weaknesses of the technology available, which in turn should dictate the specific kind of research that should be undertaken immediately.

In the same way, the involvement with the farmers and extension service will quickly identify the strengths and weaknesses of extension service or other delivery mechanisms, allowing prompt correction. The constraints that are slowing production, and which might require policy changes, will be highlighted, and thus more easily corrected.

This kind of problem solving depends on a team approach—several different disciplines working together in a totally integrated effort. Integration is the key concept here; yet we find few cases where assessments of agricultural research needs are made in this pragmatic way. Such assessment must be done at several different levels.

Research Priorities, Organization, and Management

In discussing integration of disciplines to plan a production program, we can begin with research. There is continual debate as to how much "basic" or fundamental research should be done, and how much effort should be devoted to "applied" research. Perhaps this is where we first need to consider integrations. Why not forget these old labels and think in terms of the farmer—the basic production unit—and his problems? If we dedicate ourselves to the urgent task of solving his production problems, and apply our mental and physical resources at this level, we can build cooperation across disciplines and institutes. We shall then be conducting essential research, instead of setting up artificial barriers by pursuing purely academic problems.

Given the farmer's problems as a basis for examination, essential research priorities can be determined at the national level, using specific *farmer-field* problems to pinpoint the specialities and skills that might be needed. True, this would be a great departure from what we see in many countries today. It is frustrating to see the tremendous amount of duplication and isolation of research (or, in many places, so-called research) that is not relevant to real needs, but which reflects the whim of the individual researcher, or director of a research unit. Associated with this waste and indifference to the needs of the total society, we invariably hear complaints of inadequate budgets, inadequate freedom to spend budgets available, inadequate foreign exchange components for purchasing (often unnecessary) instrumentation, and inadequate opportunity for foreign and local travel.

Today, virtually every country is very much concerned with the issues of food production and general rural development. Thus, various national institutes (plant protection institutes, plant breeding institutes, etc.) are being established. Often these steps have been taken to move sections of agricultural research out of traditional bureaucratic systems so that more freedom and autonomy can be given

One of the key links in CIMMYT's work is on-farm testing. Farmers, trainees, research staff, and extension workers can meet on this common ground and work together to integrate their respective capabilities.

to the researcher. There is an obvious need to relieve some researchers of a badgering civil service system. This does not guarantee, however, that well-defined research objectives will be established, or that integration and cooperation will be automatic.

Integrating Research and Extension

In systematic planning, we cannot overlook the integration of the research and extension services and provision for their more thorough mixing with the farm community. Also to be integrated are: credit, marketing, pricing policies; in fact the total system and the infrastructure that supports the system.

One of the key links missing in system development has been on-farm testing—where we identify superior technology. This is where we can validate actual fertilizer and plant density responses, economic rates of insecticide, etc. All of these production functions should be examined in cooperation with extension workers and farmers, with the full understanding that they are an essential part of the research system.

Farmers, extension staff, and research staff can meet on this common ground and work together to integrate their respective capacilities. This process brings the farmer physically and emotionally into the center of the system; to decide which products of research are useful to him and to determine (with research and extension staff) what research should be done. In other words, this type of integration reverses the traditional direction of research, as well as the role of the farmer: *recommendations of farmers direct the researchers.* Extension and research become full partners.

There are only a few examples of this farmer-based system working in the world today, and in most cases it has developed into a fruitful and harmonious relationship. We often are asked: Where in this dynamic system does research stop and extension begin? Our response: If we develop a true flow system, then one does not stop and the other start, rather one flows into the other without a halt or break. It is tragic, but rarely does one find this process operating. As a consequence, research is isolated from the real needs of agriculture; the researcher's product has little value, and practically no influence on production. The extension worker, on the other hand, is isolated from research, and has no influence on research objectives of the system. As a consequence, nothing flows to him, or through him to the farmer.

Again we come back to an administrative and budgetary structure which discourages (rather than encourages) communication, cooperation or integration. There often is a lack of respect among the groups and there are often power struggles between the heads of two different agencies. The losers are the farmer, the consumer, and their societies which finance these agencies.

Crop Improvement

When we look at crop improvement, it becomes obvious that genes are the hub of the issue. Genes for yield potential, disease resistance, adaptation or stability, etc., must be manipulated to produce varieties with higher yield and reduced risk for the producer. Where then do the entomologist and pathologist fit into the system? The problem—solving approach suggests that they fit directly into the variety development process: they provide the inoculations, artificial infestations, etc., to apply the appropriate pressures for disease and insect resistance. Thus, their special skills are part and parcel of the gene manipulation and selection process.

In other words, the dynamic programs needed today should not follow the traditional concepts of "breeders", "pathologists", "entomologists", etc. Our biosystem does not (nor has it ever) recognize these disciplines as isolated territories. Instead, crop species have evolved through the biosystem (with the help of man), surviving all of the interactions of the forces of the biosystem that has sorted out the genes available to us today.

Why then should we not break away from the comfort and convenience of studying isolated sectors of the biosystem and accept the fact that we must deal with the whole system—as a team. When this is done, the disciplines will have been integrated. Thus we would have a homogeneous mixture of breeders, pathologists, entomologists, etc., who have moved from their compartmentalized disciplines to serve as equals in the crop improvement process. This would result in much more effective manipulation of the genes within a crop series, and superior cultivars could be developed much more rapidly, with far broader adaptation and greater stability.

An often overlooked step of integration in the system is the simple but more important definition of what the varieties must be like if they are to be acceptable to the producer. In other words, it is totally immaterial how good the variety developed by the combined efforts of the research team might be, if *it does not fit the needs of the producer and the consumer.*

We must integrate and organize the research system so that it flows continuously to and from the production fields of the farmers. Only then will the researchers be certain that they have, in fact, put together a combination of genes that is useful and provides the farmer with a tool to increase production.

Other Major Concerns in a Totally Integrated System

Seed has proven to be a limiting factor in many situations. It is fair to say that there are few examples in which government seed agencies and government seed farms have been very successful in meeting the farmer's seed requirements. By the same token, there are very few examples of good seed organizations operating in the food importing countries.

It is of little value to have a successful variety with a successful technology, if there is no mechanism to move the seed to the farmer. Since a good seed industry evolves slowly, interim ways must be found.

Traditionally, farmers have saved their own seed and seed has moved from farmer to farmer. In trying to replace this traditional system with a more sophisticated one, we have often gone overboard in recommending overly complicated release policies and seed policies that we cannot implement. Could we not change this philosophy and encourage farmers to save their own seed of superior varieties and sell seed to their neighbors? If this were done, we then could provide another function for the extension worker and the agronomist in their on-farm testing efforts. They could encourage farmers throughout the country to grow, promote and sell seed of new varieties, rather than depending on inadequate quantities produced on government farms, with extension to distribute them.

Where does credit fit into the total integrated system? Credit agencies are usually not agriculturally oriented, and operate under a different bureaucratic system. As a result, credit is often not available at the appropriate time. In other situations, it is so difficult to handle the paperwork that farmers find it simpler not to use credit, or find it easier to use the expensive traditional sources of credit. As a result, credit programs on paper meet the concept of credit to agriculture—but do not actually help the rural community.

Inputs, such as fertilizer, often are not available when needed. In other cases, agencies with little knowledge of agricultural needs are managing the purchasing and distribution of fertilizer; as a result, inappropriate fertilizers may be supplied to the farmer. These agencies should be closely allied with the research and extension services to avoid costly mistakes that use precious foreign exchange and do not serve production.

Marketing and financing policies also must be allied with research and extension with a much better understanding of what is going on in the rural community.

The economists and planners are, more often than not, working in isolation from agricultural research and extension. As a result they are not aware of rapid changes that are taking place and often grossly underestimate the input requirements or the quantity of production that will be harvested. These are costly mistakes that could usually be avoided if there were greater integration and communication within the total system.

Let us think a bit about factors of the total agricultural system that do not involve food crops, per se. With the rapidly expanding population, how much time do we have to meet our food production needs? At the present rate of population increase, per capita food production is going down, not up. If there were guaranteed surplus centers that could keep pace with the population growth, how would it be distributed? The world transport system is so overloaded now that there are continuous delays in deliveries. Building more ships is not the answer, alone. Virtually every major port in the world has a continuous line of ships waiting for a berth. After food and other commodities reach a country, the internal transport facility is so overloaded that there is a constant loss of imported food before it reaches the consumer.

In countries where there are surplus and deficit areas, the transport system can hardly cope with the task of distribution. All of these problems must be of concern when we talk about integration, organization and management.

Our world has little additional land that can be brought into production. In fact, in many areas the clearing of large expanses of mountainous land has resulted in great erosion losses and damage. Lumber and fuel are [illegible] short supply. Forestry is part of the total agricultural [illegible] Where is the integration in the balance among agri[illegible] animal husbandry, and forestry? What will be the con[illegible]quences in just one generation of this lack of balance in planning and executing a total agricultural system? How many years will be deducted from the predicted life of our major irrigation reservoirs in the world? In fact, what will be the consequences for the world's major watersheds? Uncorrected problems have a tendency to become progressively worse. Let us begin to do whatever is necessary while we still have time.

National Program Considerations

A well planned, dynamic production program will set in motion a chain reaction of problems and constraints; as one problem is overcome, the next limiting factor will present itself and can be corrected. A production program, once it is set in motion in the right direction through an integration of the thinking and the efforts of the people involved, will become progressively more productive each year..... snowballing rather than deteriorating. Genuine integration in planning and execution is certain to result in success if the governments and scientists can respond with the necessary policy changes and keep a balance across the total agricultural system.

2.0 CIMMYT'S 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 in testing superior germ plasm and 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 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 most developing 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. Nonetheless, national programs having requisite expertise and infrastructure can use superior germ plasm for development of hybrids.

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

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

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

The remainder of this report provides a documentation of this process in action during 1976 and 1977.

Thousands of hand pollinations are required in the population improvement program.

3.0 ADVANCED UNIT OPERATIONS

3.1 INTERNATIONAL TESTING AND DISTRIBUTION

International testing and distribution of maize materials in CIMMYT's program involves the following closely-linked steps:

1) Tests to identify germ plasm that may be broadly suited to a given location.

2) Trials of full-sib progenies of germ plasm identified as suitable for a specific location (International Progeny Test Trials, IPTT).

3) Formation of experimental varieties with about 10 progenies that prove to be superior performers at that location. The decision as to which progenies should be recombined to form the experimental variety is made in collaboration with the national program that grows the progeny trial.

4) The superior 30-40 per cent of progenies (based on the across-sites performance of progenies), are planted in Mexico from remnant seed and are recombined to reconstitute the progenies under test as in step 2.

5) Trials of experimental varieties (EVT's) are conducted at many locations. At the same time, seed of all tested varieties is increased to meet the requirements of national programs.

6) Superior experimental varieties (selected on basis of step 5) are retested in widely-distributed Elite Experimental Variety Trials (ELVT's). Sufficient seed is available for supply to national programs for further multiplication for commercial varietal release, for on-farm testing to assess production potential and/or utilization in their improvement programs.

To effectively utilize international trial data from northern and southern hemispheres, CIMMYT has divided the Advanced-unit populations into two groups, each of which is progeny tested once every two years (see Appendix).

In 1976, 85 IPTT's in Group 1 were sent for testing in 21 countries. In 1977, Group 2, 71 IPTT's, was sent for testing to 23 countries.

Tables 3.1.A and 3.1.B indicate that data were returned from 68 per cent (1976) and 82 per cent (1977) of the testing sites for statistical analysis, with the development of 88 experimental varieties in 1976 and 77 experimental varieties in 1977. These progeny test data also were used for selection of the 35-40 per cent best-performing families across sites, which form the base for the next cycle of population improvement.

In 1976, requests from 60 countries were received, and delivery made, of 219 EVT's and 205 FLVT's. In 1977, 205 EVT's and 186 ELVT's were sent to 68 countries (Tables 3.2 and 3.2.A). Data were returned from 55 per cent of EVT's in 1976, and from 54 per cent in 1977. The ELVT data returns were 46 per cent in 1976, and 41 per cent in 1977.

Advanced materials have been assigned population numbers 21 through 60, inclusive. Numbers 1-20 are reserved for Experimental Variety Trials. Each normal grain advanced population is simultaneously converted to its opaque-2 equivalent. Several rows of an opaque-2 counterpart are planted adjacent to each advanced population to be backcrossed to the parent population during progeny regeneration. These crosses are sib-mated during the progeny trial period and the opaque-2 segregate kernels of the recurrent parent are again planted for the next backcross. Populations 38 to 41 are hard endosperm opaque-2 populations, the remainder are normal grain populations.

3.1.1 International Progeny Testing Trials

Data for individual International Progeny Testing Trials (IPTT's) has been reported in detail in the 1976 and 1977 Maize Program Preliminary and Supplementary Reports of IPTT's, and yield data is summarized in Tables 3.1.C and 3.1.D.

Three primary criteria (grain yield per hectare, days to flower, and plant height) are considered when making across-sites selections of superior progenies for recombination. The average selection pressure (selected families/total families) was 35 to 40 per cent. Late return of data from some locations prevented their inclusion in across-sites means.

In 1976, the selection differential was 9.3 per cent for yield: ranging from a high of 19.5 per cent for Braquiticos to a low of 5.8 per cent for AED x Tuxpeño. In 1977 this differential was 7.8 per cent on average, with a maximum of 16.2 per cent for Compuesto de Hungary and a minimum of 5.0 per cent for Blanco Subtropical. The average yield performance of the 10 best progenies (which formed experimental varieties) was 21 per cent better than the mean of **all** checks in 1976, but 3.9 per cent less than the mean of the **best** checks. For 1977, these figures

were 19.4 per cent better than all checks; but 5.7 per cent less than the best checks. On average, the best progenies were 2.2 days (3.5 per cent) earlier to 50 per cent silking than were the best yielding checks. In 1977, they were 4.1 days (6.6 per cent) earlier.

On average, the overall group of 250 families in 1976 was earlier than the best yielding checks by 2.0 days (3.2 per cent); in 1977, they were earlier by 3.8 days (6.1 per cent). The 250 families were shorter than the best checks by 20 cm (9 per cent) in 1976; and in 1977 were 21 cm (10 per cent shorter). Means of the 10 best selected progeny for recombination indicated modest reductions in plant height and days-to-50 per cent silking in comparison to the 250 family means. This trend is shown across all advanced populations.

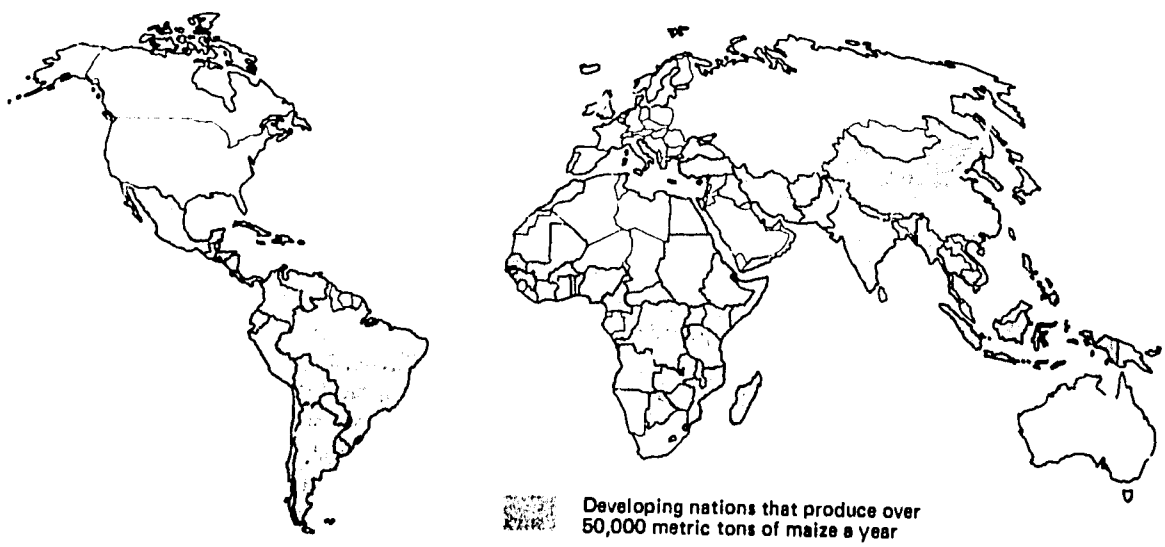
3.1.2 Experimental Variety Trials and Elite Experimental Variety Trials

Following evaluation of 23 Advanced unit populations in 1974 through 1976, a total of 188 experimental varieties was tested during 1976 and 1977. These included: Experimental Variety Trial EVT-12 (tropical/subtropical late white dent), EVT-13 (tropical/subtropical late yellow flint/dent), EVT-14A (tropical/subtropical, late/intermediate yellow flint/dent), EVT-14B (tropical/subtropical late white flint), EVT-15 (tropical/subtropical late white/yellow opaque-2) and EVT-16 (subtropical/temperate, early/intermediate, yellow/white, flint/dent). Data from individual trials has been reported in detail in the 1976 and 1977 Maize Program Preliminary and Supplementary Reports of EVT's. The across-site performance of varieties entering each of these trials is given in Tables 3.3 to 3.9. Table 3.9 shows data for EVT-17 means across 9 locations for normal and opaque-2 tropical highland materials tested in 1976.

Best performing varieties across all the test sites in 1976 originated from populations 22 (Mezcla Tropical Blanca), 23 (Blanco Cristalino 1), 25 [(Mix. 1 x Col. Gpo. 1) x Eto], 28 (Amarillo Dentado), 29 (Tuxpeño Caribe), 33 (Amarillo Subtropical), 34 (Blanco Subtropical), and 42 (ETO x Illinois). In 1977, the best performance was from populations 22, 28, 29, 36 (Cogollero), 37 (Tuxpeño O_2) and 42. The yield levels of these open-pollinated varieties exceeded that of the best checks; were in most cases 2 to 3 days earlier; and were from 10 to 15 cm shorter than these best-yielding checks (which frequently were hybrids).

A total of 30 Elite Experimental Varieties were tested in 1976 in CIMMYT's first Elite Experimental Variety Trials (ELVT's). In 1977, an equal number of ELV's were tested. Results from 1976 and 1977 are shown in Tables 3.10 to 3.12 for ELVT-18 (tropical/subtropical, intermediate/late, white/yellow, flint/dent), ELVT-19 (tropical/subtropical, late white/yellow flint/dent opaque-2) and ELVT-20 (subtropical/temperate, intermediate, white/yellow, flint/dent).

In 1976, the best performers across all test sites were La Maquina 7422 (from population 22, Mezcla Tropical Blanca) and Obregon 7442 (from population 42, ETO x Illinois). In 1977, the top varieties were Across 7422 (Mezcla Tropical Blanca), Cotaxtla 7429, Pichilingue 7429, and Across 7429 (all derived from population 29, Tuxpeño Caribe 2).



Analysis of individual site performance for each EVT and ELVT (Tables 3.13 to 3.22) indicates that high yield is associated with locations characterized by high insolation levels, low night temperatures, low humidity, and with adequate water for crop growth. Across all sites in 1976 the coefficient of variation (CV) for all EVT's averaged 16.3 per cent (range 7 - 33 per cent). For 1977, this average was 17.5 per cent (range 7 - 60 per cent). The CV's for the ELVT's in 1976 averaged 17.2 per cent (range 6 - 43 per cent); in 1977, 16.4 per cent (range 7 - 40 per cent). Across all 395 EVT's and ELVT's of 1976 and 1977, only 10 per cent had CV's of more than 25 per cent.

3.1.3 Experimental Variety Formation

During 1976 and 1977, a total of 165 experimental varieties were formed in Mexico. In general, these are created by growing (from remnant seed) and intercrossing the 10 progenies that were identified as superior by cooperating programs in the IPTT's or by CIMMYT in the previous testing cycle.

3.1.4 Seed Increases

A total of 266 increases of experimental variety seed was made during 1976 and 1977 while these same varieties were under trial in EVT's. This anticipates the requirements of national programs, and provides seed for Elite Experimental Variety Trials in 1977 and 1978.

3.2 COMPANION NURSERIES

All families evaluated for yield performance in IPTT's were planted (one replicate each) in disease, insect and high planting density companion nurseries in Mexico. In the insect nursery, one-half of a row was treated with insecticide. This half of the row was compared with the unprotected half to show reduction in yield induced by artificial infestation with fall army worm (*Spodoptera frugiperda*) or sugar cane borer (*Diatraea saccharalis*) in populations 22, 23 and 38.

In the disease nursery, half-rows were inoculated with stalk rot (*Fusarium, Gibberella* spps) laden toothpicks, and the whole row has inoculated with an ear rot (*Fusarium, Diplodia* spps) spore suspension. Plants were grown at 80,000 plants/ha in the high density nursery (normal density is 53,000 plants/ha) in two replications. Each replication consists of well-bordered half-rows. Data for yield, barrenness, and lodging were collected on all families.

During 1976, two composites were created, each consisting of the "ten best" and "ten worst" families selected from each population under high density. When these composites were retested under high plant density, the mean of all populations indicated that the "good family" composite yielded 18 per cent more, and had 16 per cent less lodging, than did the "bad family" composite. These differences were statistically significant. Seventy-seven per cent of the difference in grain yield between the two composites was accounted for by variation in ears-per-plant.

Data from the companion nurseries supplements data from IPTT's in selecting superior families for progeny regeneration in the next cycle.

CIMMYT staff worked alongside national program scientists in 45 countries in 1976 and 1977. Working with Ricardo Sevilla, of the Peru National Program, were Elmer Johnson, CIMMYT's headquarter staff, and Gonzalo Granados, Andean Region staff.

TABLE 3.1.A 1976 INTERNATIONAL PROGENY AND AVG. YIELDS (T/HA) OF EXPERIMENTAL

IFTT Population Name	POP. NUMBER	SOUTH AMERICA										CENTRAL AMERICA							N. AMER.		MEXICO						CARIBBEAN									
		1 Argentina	2 Bolivia	3 Brazil	4 Chile	5 Colombia	6 Ecuador	7 Guyana	8 Peru	9 Surinam	10 Venezuela	11 Belize	12 Costa Rica	13 El Salvador	14 Guatemala	15 Honduras	16 Nicaragua	17 Panama	18 Canada	19 U.S.A.	20 Batan	21 Obregon	22 Poza Rica	23 Tlaltizapan	24 Toluca	25 INIA	26 Antigua	27 Bahamas	28 Barbados	29 Dominica	30 Dominican R.	31 Grenada	32 Haiti	33 Jamaica	34 St. Kitts	35 Trinidad
MEZCLA TROPICAL BLANCO	22												X	5.4									4.7													
BLANCO CRISTALINO 1	23					6.1							X			X							4.3			5.9										
ANTIGUA GPO. 2 x VERACRUZ 181	24					X							X				7.4						4.5			5.5										
AMARILLO CRISTALINO 1	27					6.0			6.7					4.6		X						5.2	3.7													
BRAQUITICOS	31					6.6										4.1							5.4	7.2												
ETO BLANCO	32					X								5.0	4.5								4.9													
AMARILLO SUBTROPICAL	33								6.5													6.0		8.3												
ANTIGUA x REP.DOMINICANA	35														6.4			6.1					4.9													
YELLOW H.E. O_2	39								X								4.3	4.3					3.1													
ETO x ILLINOIS	42					6.6																		6.9												
LA POSTA	43															3.0						5.7	5.7													
AED x TUXPEÑO	44																							7.2												
BLANCO DENTADO PRECOZ DE ALTURA	52																				8.7					X										
BLANCO HARINOSO PRECOZ DE ALTURA	53																								8.4											
AMARILLO CRISTALINO PRECOZ DE ALTURA	54														5.1						8.2				6.6	X										
BLANCO HARINOSO INTERMEDIO DE ALTURA	58																								8.8											
AMARILLO DENTADO INTERMEDIO DE ALTURA	60																				9.7															
AMARILLO DENTADO PRECOZ DE ALTURA	55																				8.2					X										

X = TRIALS SENT BUT NO DATA RECOVERED

TESTING TRIALS: DISTRIBUTION BY COUNTRY 10 SELECTED FAMILIES THAT FORM AN VARIETY

36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
A F R I C A																											A S I A															
Algeria	Cameron	Benin	Botswana	Egypt	Ethiopia	Ghana	Guinea-Bissau	Ivory Coast	Kenya	Malawi	Mozambique	Nigeria	Rep.C.Africa	Rep.S.Africa	Senegal	St. Helena	Sudan	Swaziland	Tanzania	Tehad	Togo	Tunisia	Uganda	Upper Volta	Zaire	Zambia	Afghanistan	Bangladesh	India	Indonesia	Iran	Iraq	Malaysia	Nepal	Pakistan	Philippines	Saudi Arabia	Sri Lanka	Syria	Thailand	Turkey	Yemen A.R.
								8.4																					X							3.7						
						3.7																																				
																																			X							
												4.0																								X						
																													6.5							3.5						
																													7.5					X							X	
								7.2																					X						X							
								X				X																														
																													X					X	6.7						X	
						2.6		X																												2.9						
				8.4																									9.0						X							
									X																																	
					X																																					
					X																																					

TABLE 3.1.B 1977 INTERNATIONAL PROGENY AND AVG. YIELDS (T/HA) OF EXPERIMENTAL

IPTT Population Name	POP. NUMBER	SOUTH AMERICA 1 Argentina	2 Bolivia	3 Brazil	4 Chile	5 Colombia	6 Ecuador	7 Guyana	8 Peru	9 Surinam	10 Venezuela	CENTRAL AMERICA 11 Belize	12 Costa Rica	13 El Salvador	14 Guatemala	15 Honduras	16 Nicaragua	17 Panama	N. AMER. 18 Canada	19 U.S.A.	MEXICO 20 Batan	21 Obregon	22 Poza Rica	23 Tlaltizapan	24 Toluca	25 INIA	CARIBBEAN 26 Antigua	27 Bahamas	28 Barbados	29 Dominica	30 Dominican R.	31 Grenada	32 Haiti	33 Jamaica	34 St. Kitts	35 Trinidad
TUXPEÑO 1	21													4.5	5.4	7.4							6.0													
(mix. 1 x Col.Gpo.1) ETO	25												8.4		3.3								5.5													
MEZCLA AMARILLA	26		7.2	4.9			5.2																5.9													
AMARILLO DENTADO	28		6.7	5.2		X											6.2	5.0					6.3													
TUXPEÑO CARIBE	29												5.6	X									7.0													
BLANCO SUBTROPICAL	34																					3.7		8.1												
COGOLLERO	36		5.5	6.3													X						5.7	8.4												
PD(ms)6 H.E. O_2	38														5.1			2.4				3.4	4.4													
WHITE H.E. O_2	40																				4.0		5.3	7.6												
TEMPLADO AMARILLO O_2 - 2	41		4.2			X																		7.8												
COMP. DE HUNGRIA	48			X	X																3.0															

X = TRIALS SENT BUT NO DATA RECOVERED

TESTING TRIALS: DISTRIBUTION BY COUNTRY 10 SELECTED FAMILIES THAT FORM AN VARIETY

AFRICA																											ASIA															
36 Algeria	37 Cameroon	38 Benin	39 Botswana	40 Egypt	41 Ethiopia	42 Ghana	43 Guinea-Bissau	44 Ivory Coast	45 Kenya	46 Malawi	47 Mozambique	48 Nigeria	49 Rep.C.Africa	50 Rep.S.Africa	51 Senegal	52 St. Helena	53 Sudan	54 Swaziland	55 Tanzania	56 Tchad	57 Togo	58 Tunisia	59 Uganda	60 Upper Volta	61 Zaire	62 Zambia	63 Afghanistan	64 Bangladesh	65 India	66 Indonesia	67 Iran	68 Iraq	69 Malaysia	70 Nepal	71 Pakistan	72 Philippines	73 Saudi Arabia	74 Sri Lanka	75 Syria	76 Thailand	77 Turkey	78 Yemen A.R.
																			7.6						9.9																	
																			4.0						7.8				X													
																																								5.8		
						X													4.9						6.4																	
				7.6															6.6										4.8						6.4							
																																								6.3		
																													X											5.3		
								X											3.2																	5.3						
				5.4																									6.6					6.6								
																						X							2.4						X							

TABLE 3.1.C RESULTS OF 11 INTERNATIONAL MEAN PERFORMANCE OF THE FAMILIES, AND CHECKS; FOR

POPULATION	EXPERIMENTAL VARIETY AND COUNTRY	TON / HA Pop. X 250 Fams.	Pop. Range	Exp. Var. X 10 Fams.	Sel. Fams. X 100 Fams.	Checks X	Best Check X
Mezcla Tropical Blanco IPTT-22 Tropical Late White Dent (TLWD)	San Andres(1) 7622(El Salvador)	4.1	1.9-6.1	5.0	-	4.4	5.4
	San Andres(2) 7622(El Salvador)	4.1	1.9-6.1	5.4	-	4.4	5.4
	Ferke(1) 7622(Ivory Coast)	7.0	4.2-8.8	8.4	-	6.1	7.1
	Ferke(2) 7622(Ivory Coast)	7.0	4.2-8.8	8.0	-	6.1	7.1
	Poza Rica 7622 (Mexico)	3.6	4.0-5.7	4.7	-	3.5	4.8
	Los Baños(1) 7622 (Philippines)	2.4	1.0-5.0	2.7	-	1.8	2.4
	Los Baños(2) 7622 (Philippines)	2.4	1.0-5.0	3.0	-	1.8	2.4
	Los Baños(3) 7622 (Philippines)	2.4	1.0-5.0	3.7	-	1.8	2.4
	Across 7622 (3 sites)	4.1	-	5.0	4.6	3.9	4.9
Blanco Cristalino 1 IPTT-23 Tropical Late White Flint (TLWF)	Cali 7623 (Colombia)	4.1	0.5-7.3	6.1	-	2.6	4.5
	Nyankpala 7623 (Ghana)	2.7	1.1-4.9	3.7	-	2.8	3.5
	Cotaxtla 7623 (Mexico)	4.5	2.0-6.3	5.9	-	5.0	6.2
	Poza Rica 7623 (Mexico)	3.2	1.4-4.7	4.3	-	3.1	3.8
	Across 7623 (4 sites)	3.6	-	4.1	4.0	3.4	4.5
Antigua x Veracruz 181 IPTT-24 Tropical Late Yellow Dent (TLYD)	Nayarit 7624 (Mexico)	4.0	1.7-6.6	5.5	-	4.6	8.7
	Poza Rica 7624 (Mexico)	3.3	1.8-5.0	4.5	-	3.5	4.8
	Santa Rosa(1) 7624(Nicaragua)	5.7	2.8-8.3	7.4	-	5.4	7.0
	Santa Rosa(2) 7624(Nicaragua)	5.7	2.8-8.3	7.2	-	5.4	7.0
	Santa Rosa(3) 7624(Nicaragua)	5.7	2.8-8.3	7.3	-	5.4	7.0
	Across 7624 (3 sites)	4.3	-	5.3	4.7	4.5	6.8
Amarillo Cristalino 1 IPTT-27 Tropical Late Yellow Flint (TLYF)	Palmira(1) 7627 (Colombia)	4.0	1.7-9.5	5.5	-	2.0	3.4
	Palmira(2) 7627 (Colombia)	4.0	1.7-9.5	6.0	-	2.0	3.4
	San Andres(1) 7627 (El Salvador)	3.7	2.0-5.0	4.4	-	4.2	5.9
	San Andres(2) 7627 (El Salvador)	3.7	2.0-5.0	4.6	-	4.2	5.9
	Obregon 7627 (Mexico)	4.0	2.5-5.9	5.2	-	3.1	4.9
	Poza Rica 7627 (Mexico)	2.4	0.7-4.7	3.7	-	2.3	3.3
	Satipo (1) 7627 (Peru)	5.2	2.4-8.5	6.6	-	3.3	4.1
	Satipo (2) 7627 (Peru)	5.2	2.4-8.5	6.7	-	3.3	4.1
	Across 7627 (4 sites)	3.5	-	4.5	3.8	2.9	4.4
Braquiticos IPTT-31 Tropical Late White Dent (TLWD)	Palmira(1) 7631 (Colombia)	4.6	1.9-7.7	6.3	-	3.7	5.4
	Palmira(2) 7631 (Colombia)	4.8	1.9-7.7	6.6	-	3.7	5.4
	Omonita 7631 (Honduras)	3.1	1.4-5.2	4.1	-	3.5	3.9
	Poza Rica 7631 (Mexico)	4.0	1.9-6.4	5.4	-	4.4	6.7
	Tlaltizapan 7631 (Mexico)	5.5	2.4-8.3	7.2	-	4.9	6.3
	Ibadan (1) 763 (Nigeria)	2.9	1.0-6.1	4.0	-	2.7	3.6
	Ibadan (2) 7631 (Nigeria)	2.9	1.0-6.1	3.7	-	2.7	3.6
	Across 7631 (5 sites)	4.1	-	5.1	4.9	3.8	5.2
ETO Blanco IPTT-32 Tropical Late White Flint (TLWF)	San Andres (1) 7632 (El Salvador)	3.8	1.2-6.1	5.0	-	5.2	6.3
	San Andres (2) 7632 (El Salvador)	3.6	1.2-6.1	4.9	-	5.2	6.3
	Cuyuta 7632 (Guatemala)	3.5	1.1-5.2	4.5	-	3.8	4.9
	Pantnagar (1) 7632 (India)	4.2	0.8-7.6	6.1	-	5.5	6.8
	Pantnagar (2) 7632 (India)	4.2	0.8-7.6	6.5	-	5.5	6.8
	Poza Rica 7632 (Mexico)	3.5	0.5-5.1	4.9	-	3.5	4.9
	Los Baños (1) 7632 (Philippines)	2.6	1.2-4.2	3.1	-	1.9	2.6
	Los Baños (2) 7632 (Philippines)	2.6	1.2-4.2	3.6	-	1.9	2.6
	Los Baños (3) 7632 (Philippines)	2.6	1.2-4.2	3.5	-	1.9	2.6
	Across 7632 (4 sites)	3.7	-	4.6	4.1	4.5	5.7
Antigua x Rep. Dom. IPTT-35 Tropical Intermediate Yellow Dent (TIYD)	La Maquina 7635 (Guatemala)	5.0	2.6-7.1	6.4	-	6.9	8.7
	Ferke (1) 7635 (Ivory Coast)	5.8	4.0-7.9	7.2	-	6.4	7.2
	Ferke (2) 7635 (Ivory Coast)	5.8	4.0-7.9	6.7	-	6.4	7.2
	Poza Rica 7635 (Mexico)	4.0	2.5-5.2	4.9	-	5.1	7.9
	Tocumen 7635 (Panama)	4.8	2.9-6.8	6.1	-	5.8	6.8
	Across 7635 (4 sites)	4.9	-	5.7	5.2	6.1	7.7
La Posta IPTT-43 Tropical Late White Dent (TLWD)	Nyankpala 7643 (Ghana)	1.8	0.1-3.4	2.6	-	1.8	2.4
	Omonita 7643 (Honduras)	2.1	0.8-3.7	3.0	-	1.5	1.7
	Poza Rica 7643 (Mexico)	4.4	2.2-7.1	5.7	-	3.5	4.8
	Obregon 7643 (Mexico)	4.7	1.7-6.3	5.7	-	3.5	4.4
	Los Baños 7643 (Philippines)	2.1	1.0-3.7	2.9	-	1.5	2.1
	Across 7643 (4 sites)	3.2	-	3.7	3.4	2.5	3.3
Amarillo Subtropical IPTT-33 Sub-Tropical Late Yellow Flint (SLYF)	Dholi (1) 7633 (India)	5.4	3.1-9.3	6.0		6.8	8.4
	Dholi (2) 7633 (India)	5.4	3.1-9.3	7.5		6.8	8.4
	Obregon 7633 (Mexico)	4.1	1.3-6.8	6.0		4.5	4.7
	Tlaltizapan 7633 (Mexico)	6.4	3.1-9.2	8.3		6.2	7.9
	Satipo (1) 7633 (Peru)	4.4	1.8-8.3	6.1		4.3	6.0
	Satipo (2) 7633 (Peru)	4.4	1.8-8.3	6.5		4.3	6.0
	Across 7633 (4 sites)	5.1	-	6.4		5.4	6.7
ETO x Illinois IPTT-42 Temperate Sub-Tropical Intermediate Yellow White Dent (TmSIYWD)	Cali (1) 7642 (Colombia)	4.5	1.9-7.8	5.4	-	2.5	4.8
	Cali (2) 7642 (Colombia)	4.5	1.9-7.8	6.6	-	2.5	4.8
	Tlaltizapan 7642 (Mexico)	5.1	2.8-8.0	6.9	-	5.0	6.7
	Pirsabak (1) 7642 (Pakistan)	5.3	2.5-7.7	5.8	-	3.3	5.0
	Pirsabak (2) 7642 (Pakistan)	5.3	2.5-7.7	5.9	-	3.3	5.0
	Pirsabak (3) 7642 (Pakistan)	5.3	2.5-7.7	5.0	-	3.3	5.0
	Pirsabak (4) 7642 (Pakistan)	5.3	2.5-7.7	6.7	-	3.3	5.0
	Across 7642 (3 sites)	5.0	-	6.2	5.4	3.6	5.5
AED x Tuxpeño IPTT-44 Temperate Sub-Tropical Intermediate White Dent (TmSIWD)	Gemiza (1) 7644 (Egypt)	7.2	3.6-11.7	6.8	-	6.4	7.3
	Gemiza (2) 7644 (Egypt)	7.2	3.6-11.7	6.1	-	6.4	7.3
	Sids (1) 7644 (Egypt)	7.6	4.9-11.0	7.6	-	7.6	9.4
	Sids (2) 7644 (Egypt)	7.6	4.9-11.0	9.5	-	7.6	9.4
	Egypt (1) 7644 (Egypt)	7.4	-	8.4	-	7.0	8.3
	Dholi (1) 7644 (India)	7.8	3.8-10.5	8.7	-	5.0	8.0
	Dholi (2) 7644 (India)	7.8	3.8-10.5	9.0	-	5.0	8.0
	Tlaltizapan 7644 (Mexico)	5.8	3.2-9.4	7.2	-	4.6	5.6
	Across 7644 (3 sites)	6.9	-	8.2	7.3	6.2	7.4

PROGENY TESTING TRIALS IN 1976, WITH POPULATIONS, 10 BEST FAMILIES, SELECTED YIELD, DAYS TO FLOWER, AND PLANT HEIGHT

Pop. L.S.	C.V. %	Best Check	DAYS TO SILK Pop. X 250 Fams.	Pop. Range	Exp. Var. X 10 Fams.	Sel. Fams. X 100 Fams.	Checks X	Best Check X	PLANT HEIGHT IN CM Pop. X 250 Fams.	Pop. Range	Exp. Var. X 10 Fams.	Sel. Fams. X 100 Fams.	Checks X	Best Check X
1.6	20	H-1	58	55-65	58	-	57	55	235	195-275	213	-	245	227
1.6	20	H-1	58	55-65	57	-	57	55	235	195-275	213	-	245	227
1.8	13		63	57-69	62	-	64	64	203	147-247	219	-	198	217
1.8	13	-	63	57-69	63	-	64	64	203	147-247	205	-	198	217
1.3	18	H-507	60	56-66	59	-	60	64	222	165-270	223	-	226	275
1.4	30	DMR Comp.1	60	53-68	60	-	60	60	189	147-230	190	-	165	160
1.4	30	DMR Comp.1	60	53-68	59	-	60	60	189	147-230	188	-	165	160
1.4	30	DMR Comp.1	60	53-68	59	-	60	60	189	147-230	103	-	165	160
1.7	20		60	-	59	60	60	61	212	-	205	210	209	220
1.9	24	Tuxpeño Caribe-2	62	60-67	62	-	66	64	244	207-270	258	-	233	235
1.6	28	Comp.4	58	51-65	56	-	61	60	221	175-262	223	-	274	285
1.8	23	Lote La Curva	54	48-60	54	-	60	62	193	154-245	193	-	242	252
1.1	17	H-507	58	52-64	58	-	60	64	211	165-242	218	-	230	285
1.6	22		58	-	59	58	62	63	217	-	224	216	242	264
1.9	24	NK-Poey T-27	51	49-55	51	-	54	56	227	166-267	222	-	236	303
1.0	16	Tuxpeño Caribe-2	59	55-63	59	-	60	64	209	167-245	222	-	228	277
1.9	17	X-306B	50	48-56	50	-	50	52	173	135-203	173	-	174	191
1.9	17	X-306B	50	48-56	49	-	50	52	173	135-203	177	-	174	191
1.9	17	X-306B	50	48-56	50	-	50	52	173	135-203	170	-	174	191
1.6	19	-	53	-	53	54	55	57	203	-	208	203	213	257
2.4	30	Tuxpeño Caribe-2	64	61-69	64	-	67	67	260	210-297	258	-	218	225
2.4	30	Tuxpeño Caribe-2	64	61-69	64	-	67	67	260	210-297	265	-	218	225
1.4	19	C.S. 4106 x 4104	58	54-62	58	-	57	58	240	185-275	241	-	239	247
1.5	19	C.S. 4106 x 4104	58	54-62	58	-	57	58	240	185-275	235	-	239	247
1.5	18	Tuxpeño Caribe-2	63	58-75	62	-	63	62	229	190-252	228	-	227	227
1.3	27	Tuxpeño Caribe-2	62	55-69	60	-	61	61	229	177-267	226	-	232	232
2.4	24	PMC-747	59	55-63	58	-	62	61	257	211-303	257	-	279	243
2.4	24	PMC-747	59	55-63	58	-	62	61	257	211-303	250	-	279	243
1.6	24	-	62	-	62	62	62	62	240	-	240	237	229	235
2.6	27	Tuxpeño Caribe-2	68	64-72	67	-	68	66	209	142-262	212	-	203	215
2.6	27	Tuxpeño Caribe-2	68	64-72	69	-	68	66	209	142-262	212	-	203	215
1.7	27	HBP	57	54-63	55	-	56	56	185	140-242	177	-	211	207
1.3	16	H-507	62	56-67	60	-	61	63	207	165-245	204	-	220	270
2.0	18	H-507	75	68-83	72	-	75	80	175	137-235	180	-	191	240
1.8	31	-	68	64-75	65	-	66	65	148	111-188	153	-	183	205
1.8	31	Local Var.	68	64-75	65	-	66	65	148	111-188	150	-	183	205
1.9	24	-	66	-	65	65	65	66	185	-	197	188	202	227
1.4	19	H-5	58	53-62	58	-	58	58	221	190-260	220	-	241	250
1.4	19	H-5	58	53-62	57	-	58	58	221	190-260	224	-	241	250
1.6	23	ICTA BI-C4	57	53-62	57	-	55	55	213	175-260	220	-	209	210
2.7	31	HI-Starch	62	57-67	59	-	60	58	246	195-290	237	-	258	240
2.7	31	HI-Starch	62	57-67	61	-	60	58	246	195-290	240	-	258	240
1.1	17	H-507	59	56-64	59	-	60	65	212	182-242	221	-	255	272
1.2	23	UPCA Var.1	57	51-64	57	-	56	61	170	87-215	161	-	173	200
1.2	23	UPCA Var.1	57	51-64	57	-	56	61	170	87-215	172	-	173	200
1.2	23	UPCA Var.1	57	51-64	56	-	56	61	170	87-215	176	-	173	200
1.7	22		59	-	59	59	58	59	223	-	226	222	233	234
1.6	16	X-304A	50	48-56	51	-	53	54	197	175-230	195	-	228	215
1.6	14	La Maquina 7422	56	51-61	54	-	64	65	168	137-225	177	-	196	187
1.6	14	La Maquina 7422	56	51-61	54	-	64	65	168	137-225	171	-	196	187
1.2	15	H-507	53	48-58	53	-	58	62	188	155-215	190	-	227	290
1.4	15	Poza Rica 7328	49	47-52	49	-	52	53	187	162-205	195	-	199	290
1.5	15	-	52	-	52	-	57	59	185	-	186	183	213	231
1.5	41	La Posta	61	53-67	60	-	61	58	206	137-250	107	-	229	240
1.2	27	HB-105	56	54-60	55	-	56	55	247	210-280	242	-	220	197
1.7	20	H-507	62	58-67	61	-	62	64	271	237-300	271	-	260	292
1.7	19	La Posta	69	60-85	63	-	69	72	226	190-257	222	-	218	217
1.4	33		64	61-70	63	-	63	62	203	160-247	195	-	195	202
1.5	29	-	62	-	61	61	62	62	238	-	241	237	232	230
1.7	16	-	63	60-66	61	-	62	66	178	146-215	170	-	180	199
1.7	16	-	63	60-66	63	-	62	66	178	146-215	186	-	180	199
1.7	20	Pool 32	60	56-65	59	-	59	60	220	192-245	213	-	222	227
1.7	13	Pool 32	64	59-70	64	-	64	66	250	217-282	254	-	255	260
1.8	21	PMC 2	55	53-60	55	-	60	60	253	224-294	253	-	288	290
1.8	21	PMC 2	55	53-60	55	-	60	60	253	224-294	247	-	288	290
1.7	18		61	-	60	61	61	63	225	-	226	-	236	244
2.1	23	Tuxpeño Caribe-2	63	60-67	63	-	68	65	248	217-280	247	-	215	255
2.1	23	Tuxpeño Caribe-2	63	60-67	63	-	68	65	248	217-280	259	-	215	255
1.7	16	Pool 32	61	58-70	63	-	65	65	226	200-260	229	-	235	230
2.0	19	Khyber	55	50-62	53	-	52	52	188	146-252	175	-	183	200
2.0	19	Khyber	55	50-62	54	-	52	52	188	146-252	176	-	183	200
2.0	19	Khyber	55	50-62	54	-	52	52	188	146-252	173	-	183	200
2.0	19	Khyber	55	50-62	54	-	52	52	188	146-252	185	-	183	200
1.9	20	-	60	-	61	60	52	61	221	-	222	213	211	228
2.4	16	Gemiza-2	70	65-78	68	-	67	69	271	224-237	242	-	298	291
2.4	16	Gemiza-2	70	65-78	69	-	67	69	271	224-237	273	-	298	291
2.6	17	Sids-1	68	62-74	67	-	66	67	302	250-333	298	-	312	328
2.6	17	Sids-1	68	62-74	66	-	66	67	302	250-333	300	-	312	328
2.5	17	-	69	-	68	-	67	68	257	-	276	-	305	308
2.2	14	-	65	60-68	65	-	63	66	197	159-244	184	-	171	190
2.2	14	-	65	60-68	64	-	63	66	197	159-244	194	-	171	190
1.6	14	H-507	68	61-75	68	-	73	80	229	180-267	326	-	220	242
2.2	16	-	69	-	69	69	69	71	267	-	272	266	277	263

TABLE 3.1.D RESULTS OF 8 INTERNATIONAL MEAN PERFORMANCE OF THE FAMILIES, AND CHECKS; FOR

POPULATION	EXPERIMENTAL VARIETY AND COUNTRY	TON / HA						
		Pop. X̄ 250 Fams.	Pop. Range	Exp. Var. X 10 Fams.	Sel. Fams. X 100 Fams.	Checks X̄	Best Check X̄	Pop. LSD 5 %
Tuxpeño 1 IPTT-21 Tropical Late White Dent (TLWD)	San Andres 7721(1) (El Salvador)	3.4	1.6-5.1	4.5	-	3.6	5.2	1.4
	San Andres 7721 (El Salvador)	3.4	1.6-5.1	4.5	-	3.6	5.2	1.3
	La Maquina 7721 (Guatemala)	4.5	2.4-6.2	5.4	-	4.2	5.8	1.3
	Guaymas (1)7721 (Honduras)	5.9	4.0-8.5	7.7	-	5.6	6.5	1.9
	Guaymas 7721 (Honduras)	5.9	4.0-8.5	7.4	-	5.6	6.5	1.9
	Poza Rica 7721 (Mexico)	4.8	2.6-6.6	6.0	-	3.8	6.2	1.6
	Ilonga (1) 7721 (Tanzania)	5.7	2.3-8.9	7.5	-	5.5	6.8	2.6
	Ilonga 7721 (Tanzania)	5.7	2.3-8.9	7.6	-	5.5	6.8	2.6
	Gandajika 7721 (Zaire)	7.9	3.7-11.6	9.9	-	7.0	8.6	2.5
	Across 7721 (6 Loc.)	5.4		6.2	5.8	5.0	6.5	
(Mix.1 x Col.Gpo.1)ETO IPTT-25 Tropical Late White Semi Dent (TLWSD)	Alajuela(1) 7725 (Costa Rica)	6.6	4.0-10.4	7.8	-	6.3	7.8	1.8
	Alajuela 7725 (Costa Rica)	6.6	4.0-10.4	8.4	-	6.3	7.8	1.8
	Concepcion 7725 (Guatemala)	2.5	1.0-3.9	3.3	-	2.6	3.3	1.0
	Poza Rica 7725 (Mexico)	4.4	2.3-6.2	5.5	-	4.7	7.1	1.5
	Ilonga 7725 (Tanzania)	2.7	1.1-4.6	4.0	-	2.2	2.8	1.8
	Kaniama 7725 (Zaire)	7.0	4.6-9.5	7.8	-	7.8	10.0	1.8
	Across 7725 (5 Loc.)	4.0	- -	4.9	4.9	4.0	5.3	-
Mezcla Amarilla IPTT-26 Tropical Intermediate Yellow Flint (TIYF)	Chuquisaca 7726 (Bolivia)	6.0	3.8-8.6	7.2	-	7.1	8.5	2.1
	Sete Lagoas 7726 (Brazil)	3.8	1.8-5.9	4.9	-	3.5	4.8	1.2
	Petrolina 7726 (Brazil)	3.9	2.6-6.3	4.8	-	3.4	3.9	1.3
	Pichilingue 7726 (Ecuador)	4.3	1.8-7.3	5.2	-	6.0	6.8	1.6
	Poza Rica 7726 (Mexico)	4.8	2.8-6.8	5.9	-	5.0	7.9	1.3
	Suwan 7726 (Thailand)	4.9	2.7-6.6	5.8	-	5.6	6.8	1.4
	Across 7726 (6 Loc.)	4.6	- -	5.3	4.9	5.1	6.5	-
Amarillo Dentado 2 IPTT-28 Tropical Late Yellow Dent (TLYD)	Chuquisaca 7728 (Bolivia)	5.3	2.5-8.8	6.7	-	4.4	5.1	2.7
	Sete Lagoas 7728 (Brazil)	3.8	1.6-6.5	5.2	-	3.0	4.7	1.7
	Poza Rica 7728 (Mexico)	5.3	3.1-7.6	6.3	-	3.8	4.9	1.5
	La Calera (1)7728(Nicaragua)	4.9	2.3-7.0	6.0	-	4.5	5.3	1.9
	La Calera 7728 (Nicaragua)	4.9	2.3-7.0	6.2	-	4.5	5.3	1.9
	Tocumen 7728 (Panama)	3.4	0.8-7.1	5.0	-	1.8	3.3	2.2
	Across 7728 (5 Loc.)	4.5	- -	5.2	4.9	3.5	4.7	-
Tuxpeño Caribe IPTT-29 Tropical Late White Dent (TLWD)	Guanacaste 7729 (Costa Rica)	4.5	2.1-7.0	5.6	-	4.0	5.5	1.6
	Poza Rica 7729 (Mexico)	5.6	3.3-7.5	7.0	-	4.5	6.1	1.4
	Ilonga 7729 (Tanzania)	3.7	1.9-6.4	4.9	-	3.6	4.1	2.0
	Kisanga 7729 (Zaire)	4.3	0.5-10.7	6.4	-	4.5	5.5	1.8
	Across 7729 (4 Loc.)	4.6	- -	5.3	4.9	4.0	5.2	-
Cogollero IPTT-36 Tropical Late Yellow Dent (TLYD)	Chuquisaca 7736 (Bolivia)	4.5	1.8-8.6	5.6	-	3.7	5.6	2.4
	Petrolina 7736 (Brazil)	5.0	3.2-7.5	6.3	-	4.1	5.3	2.0
	Poza Rica 7736 (Mexico)	4.7	2.7-6.5	5.7	-	4.1	5.8	1.3
	Tlaltizapan 7736 (Mexico)	6.7	4.0-9.8	8.4	-	4.7	6.2	2.0
	Suwan 7736 (Thailand)	5.3	2.5-7.5	6.3	-	4.4	5.3	1.4
	Across 7736 (5 Loc.)	5.2	- -	5.5	5.6	4.2	5.6	-
Blanco Subtropical IPTT-34 Sub-Tropical Temperate Intermediate White Flint Dent (STnIWFD)	Sids 7734 (Egypt)	5.9	2.4-8.4	7.6	-	6.4	7.9	2.2
	Pantnagar 7734 (India)	3.8	0.9-6.6	4.8	-	4.0	4.8	1.9
	Obregon 7734 (Mexico)	2.5	0.7-4.6	3.7	-	2.1	3.2	1.4
	Tlaltizapan 7734 (Mexico)	6.6	3.2-9.7	8.1	-	4.7	5.8	2.3
	Pirsabak (1)7734 (Pakistan)	5.4	2.6-7.7	6.4	-	2.9	4.0	1.9
	Njombe (1) 7734 (Tanzania)	4.6	1.9-8.8	6.6	-	12.3	14.9	1.9
	Across 7734 (6 Loc.)	4.7	- -	5.3	5.0	5.4	6.8	-
Compuesto de Hungary IPTT-48 Temperate Early Yellow Dent (TmEYD)	Dholi 7748 (India)	1.7	0.4-3.8	2.4	-	2.3	2.9	1.0
	Obregon 7748 (Mexico)	1.9	0.7-4.3	3.0	-	3.8	7.1	1.0
	Across 7748	1.8	- -	2.7	2.1	3.1	5.0	-

IPTT data from the Opaque 2 Population are given in the Quality Protein Report

PROGENY TESTING TRIALS IN 1977, WITH POPULATIONS, 10 BEST FAMILIES, SELECTED YIELD, DAYS TO FLOWER, AND PLANT HEIGHT

		DAYS TO SILK						PLANT HEIGHT					
C.V.	Best Check	Pop. $\bar{X}$ 250 Fams.	Pop. Range	Exp. Var. X 10 Fams.	Sel. Fams. X 100 Fams.	Checks $\bar{X}$	Best Check $\bar{X}$	Pop. $\bar{X}$ 250 Fams.	Pop. Range	Exp. Var. X 10 Fams.	Sel. Fams. X 100 Fams.	Checks $\bar{X}$	Best Check $\bar{X}$
20	H-5	59	54-63	58	-	58	60	201	152-239	207	-	223	255
20	H-5	59	54-63	58	-	58	60	201	152-239	203	-	223	255
15	H-5	56	53-58	56	-	55	55	214	180-255	206	-	226	240
16	Sint. Tuxpeño	54	53-56	54	-	55	54	220	182-265	227	-	265	285
16	" "	54	53-56	54	-	55	54	220	182-265	216	-	265	285
17	H-507	63	59-68	63	-	65	67	199	160-232	203	-	198	247
23	-	57	53-63	56	-	57	57	222	177-265	226	-	245	252
23	-	57	53-63	56	-	57	57	222	177-265	223	-	245	252
15	Tuxp.ETO C_1	60	55-64	60	-	61	60	208	113-247	205	-	220	216
15	Tuxp.ETO C_1	58	-	58	58	59	59	211	-	210	212	230	249
13	Tico H-1	69	65-75	68	-	73	73	185	153-229	180	-	208	221
13	" "	69	65-75	68	-	73	73	185	153-229	184	-	208	221
21	Olote Rosado	55	50-61	54	-	57	56	204	175-250	199	-	210	225
18	H-507	62	58-69	62	-	65	66	197	150-227	203	-	204	257
34	-	63	55-71	61	-	64	58	208	159-245	216	-	229	215
13	Salongo 2	67	64-72	66	-	68	70	211	156-259	200		210	229
-	-	62	-	62	63	65	65	199	-	198	201	212	230
17	Tuxpeño PB	57	53-64	56	-	60	61	221	165-265	220		259	217
15	AG65	61	56-67	61	-	65	65	184	147-227	194	-	197	220
16	-	58	52-65	58	-	63	62	143	112-175	157	-	171	180
18	Pichilingue 513	53	51-58	53	-	56	57	235	198-269	230	-	266	263
14	H-507	58	42-64	56	-	62	67	197	95-232	201	-	213	270
14	Thai.Comp.3	54	50-59	52	-	54	53	193	160-209	190	-	209	208
-	-	57	-	57	57	60	61	196	-	201	197	219	227
25	Cubano Am.	62	59-65	61	-	62	63	241	185-305	234	-	252	280
23	AG65	65	59-70	65	-	64	64	204	152-240	199	-	191	215
14	Across 7428	62	57-67	63	-	64	63	233	185-167	231	-	218	230
19	Tuxp.P.B. Honduras	57	53-61	57	-	56	58	202	177-230	206	-	196	187
19	"	57	53-61	57	-	56	58	202	177-250	203	-	196	187
32	Tocumen PB	52	50-56	51	-	53	52	223	195-247	222	-	220	212
-	-	60	-	59	60	60	60	221		215	222	215	225
18	X304B	45	42-50	43	-	45	44	168	125-206	178	-	173	160
13	H-507	63	58-68	64	-	66	69	203	162-232	211	-	199	257
27	-	57	54-63	57	-	58	58	221	172-255	224	-	262	310
22	PNM1 C-1	72	68-79	71	-	74	73	207	158-259	201	-	228	239
-	-	55	-	55	60	56	61	197	-	198	202	211	242
27	Cubano Col.	60	56-65	59	-	61	60	261	167-322	218	-	280	285
20	-	60	30-56	59	-	57	61	205	160-245	204	-	222	215
14	H-507	62	31-68	63	-	65	68	235	105-270	227	-	227	272
15	Cuyuta 7536	69	61-76	68	-	72	70	234	202-255	227	-	237	242
13	Thai.Comp.3	56	51-64	54	-	55	54	230	202-263	229	-	218	224
-	-	61	-	60	61	62	63	233	-	222	232	237	248
18	VC80	66	61-76	65	-	64	66	287	229-342	278	-	296	312
26	-	58	53-62	57	-	57	58	275	230-315	260	-	270	275
29	H-509	61	54-67	60	-	61	64	193	162-215	186	-	191	180
17	H-507	67	61-73	65	-	69	73	223	200-247	220	-	222	240
18	Sarhady	59	55-67	57	-	52	55	-	-	-	-	-	-
20	H630 2B	93	89-97	94	-	103	103	-	-	-	-	-	-
-	-	63	-	61	63	63	70	245	-	233	240	245	252
30	Local	48	46-57	46	-	53	47	157	125-183	155	-	170	175
27	H-509	53	50-61	53	-	60	70	172	140-197	174	-	174	173
50	-	50	-	50	50	56	59	164	-	165	165	172	174

TABLE 3.2 DISTRIBUTION: EXPERIMENTAL

(NUMBER OF TRIALS SENT

	EXPERIMENTAL VARIETY TRIALS (EVT)	Trial Number	SOUTH AMERICA 1 Argentina	2 Bolivia	3 Brazil	4 Chile	5 Colombia	6 Ecuador	7 Guyana	8 Peru	9 Surinam	10 Venezuela	CENTRAL AMERICA 11 Belize	12 Costa Rica	13 El Salvador	14 Guatemala	15 Honduras	16 Nicaragua	17 Panama	N. AMER. 18 Canada	19 U.S.A.	MEXICO 20 Batan	21 Obregon	22 Poza Rica	23 Tlaltizapan	24 Toluca	25 INIA	CARIBBEAN 26 Antigua	27 Bahamas	28 Barbados	29 Dominica	30 Dominican R.	31 Grenada	32 Haiti	33 Jamaica	34 St. Kitts	35 Trinidad
1	TLWD	12		1	1		1						1	1	1	1	1	1					1	1	1							1					1
9	TLYD - TLYF	13	1	1	1		1	1		2			1	1	1	1	1	1	1				1	1								1		1	1		1
	TIYF - TIYD	14 A	1	1	1		1	1		2			1	1	1	1	1	1	1				1	1	1		1					1		1	1		1
	TIWF - TIWD	B		1	1		2						1	1	1	1	1	1					1	1	1		1					1					1
7	OPAQUE 2	15	1	1	1		1	1		1			1	2	1	1	1	1	1					1	1							1		1	1		1
6	TEMPERATE	16	1	1				1								1									1												
	HIGHLAND	17		1			2	1		1					1							1				1	4										

1	TLWD	12	1	1	1		1					1	1	1	1	1	1						1	1	1		4	1										1
9	TLWD - TLYF	13	1	1	4		1	1		2			1	1	1	1	1		1				1	1								1		2	1		1
	TIYF - TIWF - TIWD	14 A	1	1	4		1	1		2		1	1	1	1	1	1	1	1				1	1	1		2					1		2	1		1
		B		1	1		2						1	1	1	1	1	1					1	1	1		5											1
7	OPAQUE 2	15	1	1	1		1	1		1			1	1	1	1	1	1	1				1	1	1		3					1		2	1		1
7	TEMPERATE	16	1	1	1	1		1																	1												

TLWD = TROPICAL LATE WHITE DENT

TLYD = TROPICAL LATE YELLOW DENT

TLYF = TROPICAL LATE YELLOW FLINT

TIYF = TROPICAL INTERMEDIATE YELLOW FLINT

VARIETY TRIALS (EVT) 1976 AND 1977
TO EACH COUNTRY)

36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
										A	F	R	I	C	A																		A	S	I	A							
Cameron	Benin	Botswana	Egypt	Ethiopia	Ghana	Guinea-Bissau	Ivory Coast	Kenya	Malawi	Mozambique	Nigeria	Rep.C.Africa	Rep.S.Africa	Senegal	St. Helena	Sudan	Swaziland	Tanzania	Tehad	Togo	Tunisia	Uganda	Upper Volta	Zaire	Zambia		Afghanistan	Bangladesh	India	Indonesia	Iran	Iraq	Malaysia	Nepal	Pakistan	Philippines	Saudi Arabia	Sri Lanka	Syria	Thailand	Turkey	Yemen A.R.	Hungary
2			1		1		1		1		3							1		1					1																			
							1				1																	1	2									1		1			
							1				1																																
1			1	1	1		1	1			2						1		1						1			1	1						1	2		1		1	2		
																												1	1					1	1	2		1					
1			1	1			1	1			2								1						1			1	1						1	2				1			
1			1	1							1								1						1		1	1	2					1	1			1			2		
				1				1			1								1																								
1			1		1		1		1		2	1							1						1																		1	
							1				1	1																1	1	1								1		2		1	
		1	1				1				1	1			1	2												1	1	1			1	1	1		1	1		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						1				1	1						1					1		1	
1	1	1	1	1							1	1			1			1						1			1	1	1		1	3		1			1	1		2	3	1

TIWF = TROPICAL INTERMEDIATE WHITE FLINT

TIWD = TROPICAL INTERMEDIATE WHITE DENT

TIYD = TROPICAL INTERMEDIATE YELLOW DENT

TABLE 3.2.A DISTRIBUTION: ELITE EXPERIMENTAL

(NUMBER OF TRIALS SENT

	ELITE EXPERIMENTAL VARIETY TRIAL (ELVT)	TRIAL NUMBER	SOUTH AMERICA										CENTRAL AMERICA							N. AMER.		MEXICO					CARIBBEAN								
			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
			Argentina	Bolivia	Brazil	Chile	Colombia	Ecuador	Guyana	Peru	Surinam	Venezuela	Belize	Costa Rica	El Salvador	Guatemala	Honduras	Nicaragua	Panama	Canada	U.S.A.	Batan	Obregon	Poza Rica	Tlaltizapan	Toluca	INIA	Antigua	Bahamas	Barbados	Dominica	Dominican R.	Grenada	Haiti	Jamaica
1976	TROPICAL	18		1	1		2	1	3	2			1	3	2	2	3	2	3				1	1	1		1					1		2	2
	OPAQUE 2	19	1	1	1		2	1		2			1	2	1	2	3	1	2		1		1	1	1		1					1		2	2
	TEMPERATE	20	1	1				1								2							1		1		1								2

1977	TROPICAL	18	1	1	8		2	1	3	2	1	1		3	2	2	3	2	3				1	1	1	3		1	1			1		2	2
	OPAQUE 2	19	1	1	2		2	1		2				1	1	2	3	1	2				1	1	1	3						1	1	2	2
	TEMPERATE	20	1	1	6			1															1		1	3									2

VARIETY TRIALS (ELVT) 1976-1977

TO EACH COUNTRY)

AFRICA

36 Algeria	37 Cameron	38 Benin	39 Botswana	40 Egypt	41 Ethiopia	42 Ghana	43 Guinea-Bissau	44 Ivory Coast	45 Kenya	46 Malawi	47 Mozambique	48 Nigeria	49 Rep.C.Africa	50 Rep.S.Africa	51 Senegal	52 St. Helena	53 Sudan	54 Swaziland	55 Tanzania	56 Tehad	57 Togo	58 Tunisia	59 Uganda	60 Upper Volta	61 Zaire	62 Zambia
	3	1	1	1		1		2		1		3	2		1		1		1		1		1	1		1
	1	1		1				2		1		1							1				1			1
	1	1		1					1			1							1				1			1

ASIA

63 Afghanistan	64 Bangladesh	65 India	66 Indonesia	67 Iran	68 Iraq	69 Malaysia	70 Nepal	71 Pakistan	72 Philippines	73 Saudi Arabia	74 Sri Lanka	75 Syria	76 Thailand	77 Turkey	78 Yemen A.R.	79 Hungary
	1	2					1	3	2		1		1	1	2	
	1	2					9	1	2				1		2	
1	1	2					[illegible]	3			1			1	5	

36 Algeria	37 Cameron	38 Benin	39 Botswana	40 Egypt	41 Ethiopia	42 Ghana	43 Guinea-Bissau	44 Ivory Coast	45 Kenya	46 Malawi	47 Mozambique	48 Nigeria	49 Rep.C.Africa	50 Rep.S.Africa	51 Senegal	52 St. Helena	53 Sudan	54 Swaziland	55 Tanzania	56 Tehad	57 Togo	58 Tunisia	59 Uganda	60 Upper Volta	61 Zaire	62 Zambia
	1	1		2		1	1	2		1		2	2	1			1		1		1		1	1	1	1
	1			2			1	2		1		2		1					1							1
1	1			2	1		1		1			1		1					1					1	1	1

63 Afghanistan	64 Bangladesh	65 India	66 Indonesia	67 Iran	68 Iraq	69 Malaysia	70 Nepal	71 Pakistan	72 Philippines	73 Saudi Arabia	74 Sri Lanka	75 Syria	76 Thailand	77 Turkey	78 Yemen A.R.	79 Hungary
	1	1	1			1	2	2					2		1	
	1	1					2	2					1		1	
1		1		1	3					1		1		2	3	

Handling seed shipments for over 500 collaborators is an exacting task.

Table 3.3 Experimental variety trial No. 12. Across location means of late tropical-subtropical white dent experimental varieties tested at 13 locations in 1976 and at 17 locations in 1977.

ENTRY NO. AND NAME	PARENT POPULATION	KG./HA.	RANK	DAYS FLOWER	PLANT HT (CM)
Tested 1976					
1 Pantnagar 7421	Tuxpeño 1	4890	6	65	213
2 Cotaxtla 7421	"	4808	11	65	209
3 Across 7421	"	4799	12	64	213
4 Guanacaste 7521	"	4727	16	66	210
5 Poza Rica 7521	"	4861	10	66	213
6 Ica 7422	"	4934	5	66	238
7 Across 7422	Mezcla Tropical Blanco	5062	2	65	225
8 Guaymas 7522	"	4960	4	65	228
9 Poza Rica 7522	"	4868	9	65	232
10 Ica 7429	Tuxpeño Caribe 2	4591	17	65	218
11 Cotaxtla 7429	"	4991	3	65	227
12 Pichilingue 7429	"	5074	1	66	228
13 Across 7429	"	4930	7	64	219
14 Cotaxtla 7543	La Posta	4745	15	68	244
15 Poza Rica 7529	Tuxpeño Caribe	4518	20	65	221
16 Ica 7431	Braquiticos	4238	29	68	199
17 Cotaxtla 7431	"	4221	30	69	192
18 Across 7431	"	4315	25	67	201
19 Cuyuta 7531/1	"	4073	33	68	201
20 Poza Rica 7531	"	4474	21	68	202
21 Obregon 7531	"	4559	19	66	206
22 Tlaltizapan 7531	"	4346	25	67	200
23 Across 7531	"	4289	28	67	197
24 Cotaxtla 7432	Tuxpeño Caribe 1	4753	13	66	228
25 Palmira 7443	La Posta	4465	22	68	246
26 Poza Rica 7543	"	4970	6	67	249
27 Obregon 7543	"	4560	18	66	241
28 Across 7543	"	4746	14	68	249
29 Gemeiza 7544	AED x Tuxpeño	4075	32	66	230
30 Tlaltizapan 7544	"	4096	31	65	236
31 Cotaxtla 7531	Braquiticos	4451	23	68	207
32 Cuyuta 7531/2	"	4382	24	67	196
33 Across 7544	AED x Tuxpeño	4299	27	65	228
Tested 1977					
1 Ilonga 7521	Tuxpeño 1	4547	9	63	207
2 Palmira 7522	Mezcla Tropical Blanco	4697	4	63	218
3 Maracay 7522	"	4657	8	63	225
4 Across 7522	"	5047	1	62	224
5 Delhi 7622/1	"	4698	2	62	222
6 Guaymas 7529	Tuxpeño Caribe	4692	5	63	224
7 Ferke 7529/1	"	4986	3	63	226
8 Ilonga 7529	"	4651	7	62	222
9 Across 7529	"	4666	6	63	223
10 Cotaxtla 7531/2	Braquiticos	4479	12	64	200
11 Maracay 7543	La Posta	4581	10	65	242
12 Cotaxtla 7543/2	"	4555	11	65	241
13 Obregon 7544	AED x Tuxpeño	3787	15	64	231
14 Poza Rica 7544	"	4059	14	63	226
15 Poza Rica 7422	Mezcla Tropical Blanco	4356	13	63	225

Table 3.4 Experimental variety trial No. 13. Across location means of late tropical-subtropical yellow flint and dent experimental varieties tested at 24 locations in 1976 and at 19 locations in 1977.

ENTRY NO. AND NAME	PARENT POPULATION	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
Tested 1976					
1 CEIAT 7527	Amarillo Cristalino	4500	8	63	232
2 Poza Rica 7427	"	4317	10	62	227
3 Across 7428	Amarillo Dentado 2	4875	2	62	234
4 San Andres 7528/1	Amarillo Dentado	5038	1	62	225
5 Cuyuta 7430	Amarillo Dentado 1	4493	9	63	233
6 Suwan 7430	"	4707	4	63	234
7 Suwan 7436	Cogollero	4712	3	63	235
8 Palmira 7436	"	4275	11	63	239
9 Across 7436	"	4656	5	63	239
10 Cuyuta 7536	"	4470	7	61	232
11 Poza Rica 7536	"	4538	6	62	236
Tested 1977					
1 Pichilingue 7527	Amarillo Cristalino 1	4224	15	61	226
2 Managua 7527	"	4181	16	61	227
3 Suwan 7527	"	4326	13	61	233
4 Poza Rica 7527	"	3884	17	62	226
5 Across 7527	"	4327	14	62	231
6 S. Andres 7528/2	Amarillo Dentado	4413	10	62	227
7 San Ramon 7528	"	4658	5	62	231
8 Guanacaste 7528	"	4642	4	61	227
9 Suwan 7528	"	4700	3	62	232
10 Ludhiana 7528	"	4592	6	62	226
11 Poza Rica 7528	"	4489	7	62	233
12 Across 7528	"	4718	1	62	229
13 Pichilingue 7536	Cogollero	4414	8	62	235
14 Tocumen 7536	"	4311	12	61	232
15 Chindwara 7536	"	4377	11	62	234
16 Across 7536	"	4685	2	62	231
17 Tocumen 7428	Amarillo Dentado 2	4408	9	63	241

Table 3.5 Experimental variety trial No. 14A. Across location means of late and intermediate tropical-subtropical yellow dent and flint experimental varieties tested at 23 locations in 1976 and at 22 locations in 1977.

ENTRY NO. AND NAME	PARENT POPULATION	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
Tested 1976					
1 Pantnagar 7424	Antigua x Ver. 181	4379	1	62	217
2 Suwan 7424	"	4214	2	62	217
3 Pichilingue 7424	"	3913	12	61	209
4 Across 7424	"	4127	7	61	205
5 La Maquina 7524	"	3769	13	61	197
6 Ceiat 7524	"	4029	10	62	210
7 Poza Rica 7524	"	4156	6	61	210
8 Obregon 7524	"	4093	9	61	219
9 Across 7524	"	4171	4	61	213
10 Across 7535	Antigua x Rep. Dom.	3676	15	58	196
11 Poza Rica 7526	Mezcla x Amarilla	4131	8	59	201
12 Palmira 7435	I D R N	4207	3	59	220
13 Across 7435	"	4160	5	59	227
14 Across 7426	Mezcla Amarilla	3911	11	59	206
15 San Andres 7535	Antigua x Rep. Dom.	3664	16	58	198
16 Poza Rica 7535	"	3744	14	57	194
Tested 1977					
1 Sta. Rosa 7624/1	Antigua x Ver. 181	4105	2	60	204
2 Sta. Rosa 7624/2	"	3968	7	61	202
3 Yousafwala 7624/1	"	3922	10	60	183
4 Turipana 7535	Antigua x Rep.Dom.	3843	14	57	190
5 Pichilingue 7535	"	4032	5	58	194
6 Suwan 7535	"	3997	6	57	191
7 Delhi 7535	"	3854	13	57	186
8 La Maquina 7635	"	3976	8	57	185
9 Ludhiana 7635/1	"	3941	11	56	180
10 Ferke 7635/1	"	4074	4	57	187
11 Poza Rica 7635	"	3735	16	57	189
12 Tocumen 7635	"	3959	9	58	187
13 Ferke 7526/1	Mezcla Amarilla	4194	1	58	202
14 Ludhiana 7526	"	3744	15	59	198
15 Across 7526	"	3899	12	59	202
16 Poza Rica 7435	Antigua x Rep. Dom.	4083	3	60	225

Table 3.6 Experimental variety trial No. 14B. Across location means of late tropical-subtropical white flint experimental varieties tested in 1976 at 24 locations.

ENTRY NO. AND NAME	PARENT POPULATION	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
1 Managua 7423	Blanco Cristalino 1	4577	6	64	217
2 Ica 7423	"	4513	8	65	220
3 Cuyuta 7523	"	4306	18	64	213
4 Gemeiza 7523/1	"	4351	15	65	215
5 Gemeiza 7523/2	"	4474	10	65	221
6 Cotaxtla 7530	Blanco Cristalino 2	4567	7	65	232
7 Poza Rica 7523	Blanco Cristalino 1	4609	5	64	215
8 Across 7523	"	4677	2	64	217
9 Pantnagar 7425	(Mix.1 x Col.Gpo.1)ETO	4667	4	66	210
10 Alajuela 7425	"	4456	11	66	211
11 Ica 7425	"	4323	17	66	211
12 Across 7425	"	4705	1	65	212
13 San Andres 7530/2	Braquiticos	4450	12	65	233
14 Pirsabak 7525/2	(Mix.1 x Col.Gpo.1)ETO	4349	16	65	202
15 Poza Rica 7525	"	4489	9	65	212
16 Poza Rica 7423	Blanco Cristalino 1	4291	19	64	214
17 Across 7443	La Posta	4242	21	69	238
18 Across 7530	Blanco Cristalino 2	4415	13	65	234
19 Poza Rica 7425	(Mix.1 x Col.Gpo.1)ETO	4402	14	66	212
20 La Maquina 7422	Mezcla trop. Blanco	4677	3	67	224
21 Poza Rica 7532	ETO Blanco	4230	22	65	214
22 Obregon 7532	"	4318	20	65	212
23 Across 7532	"	4154	23	65	215

Table 3.7 Experimental variety trial No. 15. Across location means of late tropical-subtropical white and yellow opaque-2 experimental varieties tested at 22 locations in 1976 and at 21 locations in 1977.

ENTRY NO. AND NAME	PARENT POPULATION	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
Tested 1976					
1 Guanacaste 7437	Tuxpeño 0_2	3970	3	63	230
2 Cotaxtla 7437	"	3873	5	62	224
3 Sids 7537	"	4017	2	62	225
4 Cotaxtla 7537	"	3829	6	63	220
5 Poza Rica 7537	"	4089	1	62	227
6 Across 7537	"	3900	4	62	226
7 Pichilingue 7439	Yellow H.E. 0_2	3727	12	62	24[illegible]
8 Suwan 7439	"	3743	10	62	24[illegible]
9 Cotaxtla 7439	"	3788	9	61	237
10 Across 7439	"	3674	14	60	227
11 La Maquina 7539	"	3665	15	60	232
12 Amar Dent HE 02	-	3789	8	60	227
13 CIMMYT HE02	-	3410	19	60	231
14 Across 7539	Yellow H.E.0_2	3700	13	60	232
15 Temp x Trop HE 02	-	3181	23	59	223
16 Across 7440	White H.E. 0_2	3609	16	61	230
17 La Maquina 7540	"	3588	17	61	232
18 San Andres 7440	"	3347	21	61	238
19 Ferke 7537/2	Tuxpeño 0_2	3830	7	63	223
20 Tuxpeño 02	-	3730	11	63	225
21 Yellow HE 02	-	3549	18	61	237
22 White HE 02	-	3389	20	62	234
23 PD(MS) 6 HE 02	-	3321	22	59	226
Tested 1977					
1 Ferke 7537/1	Tuxpeño 0_2	3797	1	62	202
2 Cotaxtla 7537/2	"	3609	2	62	204
3 CIMMYT H.E. 0_2	CIMMYT H.E. 0_2	3409	7	59	206
4 Ferke 7539/1	Yellow H.E. 0_2	3483	5	60	213
5 Suwan 7539	"	3577	4	60	218
6 Poza Rica 7539	"	3384	8	60	219
7 Ant. x Ver.181 H.E.0_2	Ant. x Ver.181 H.E. 0_2	3574	3	59	206
8 Poza Rica 7540	White H.E. 0_2	3170	9	61	215
9 Across 7437	Tuxpeño 0_2	3467	6	62	211

Table 3.8 Experimental variety trial No. 16. Across location means of intermediate and early, subtropical and temperate, white and yellow, flint and dent, experimental varieties tested at 13 locations in 1976 and at 11 locations in 1977.

ENTRY NO. AND NAME	PARENT POPULATION	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
Tested 1976					
1 Palmira 7433	Amarillo Subtropical	4745	13	71	235
2 Across 7433	"	5034	4	72	244
3 Rampur 7433	"	4976	5	73	243
4 Obregon 7434	Blanco Subtropical	4734	14	71	236
5 Tlaltizapan 7533	Amarillo Subtropical	4925	6	73	238
6 Across 7533	"	4878	8	72	236
7 Palmira 7434	Blanco Subtropical	4773	11	78	227
8 Across 7434	"	4843	10	71	241
9 Sids 7534	"	5067	3	73	236
10 Tlaltizapan 7534	"	4905	9	79	227
11 Obregon 7534	"	4575	16	79	219
12 Across 7534	"	4770	12	78	225
13 Across 7542	ETO x Illinois	4900	7	77	228
14 Sids 7542	"	5315	1	76	229
15 Tlaltizapan 7542	"	4620	15	76	222
16 Obregon 7542	"	5107	2	71	233
17 Samsun 7448	Compuesto de Hungary	3964	23	72	209
18 Across 7442	ETO x Illinoic	4038	22	71	206
19 Delhi 7548	Compuesto de Hungary	4140	20	71	220
20 Tlaltizapan 7548	"	4305	19	62	211
21 Obregon 7548	"	4097	21	69	203
22 Amarillo Subtropical	-	4360	18	69	201
23 Blanco Subtropical	-	4512	17	72	238
Tested 1977					
1 Chimal 7533	Amarillo Subtropical	4393	10	68	224
2 Obregon 7533	"	4545	9	69	225
3 Khumaltar 7633/1	"	4749	7	68	213
4 Ukiriguru 7534	Blanco Subtropical	4762	6	68	223
5 Ukiriguru 7542	ETO x Illinois	5000	2	66	215
6 Pirsabak 7642/1	"	4884	4	65	204
7 Pirsabak 7642/2	"	4843	5	67	210
8 Pirsabak 7642/3	"	4892	3	68	212
9 Khumaltar 7642/1	"	4655	8	67	205
10 Across 7548	Compuesto de Hungary	4107	11	62	199
11 Obregon 7442	ETO x Illinois	5048	1	68	219

Table 3.9 Experimental variety trial No. 17. Across location means of normal and opaque-2 tropical highland material tested at 9 locations in 1976.

ENTRY NO. AND NAME	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
1 Pool 1 (HEWF)	3261	16	97	187
2 Pool 2 (HEWD)	3562	12	95	184
3 Pool 3 (HEWFI)	3732	10	101	200
4 Pool 4 (HEYF)	3439	15	95	183
5 Pool 5 (HEYD)	3453	13	95	177
6 Pool 7 (HIWD)	4385	7	109	211
7 Pool 8 (HIWFI)	4555	3	103	211
8 Pool 9 (HIYF)	4440	5	106	200
9 Pool 10 (HIYD)	4385	6	107	199
10 Puebla O_2 Composite	3946	8	110	218
11 Compuesto I O_2	4458	4	115	226
12 Mezcla Amarilla P.B. x lineas Illinois	3687	11	120	190
13 Pool 13 (HLYF)	4806	2	114	218
14 O_2 Floury 1 Composite	3458	14	106	202
15 Mezcla Amarilla P.B. x lineas Illinois x precoces	3791	9	110	195
16 Pool 14 (HLYD)	4869	1	113	220

Table 3.10 Elite experimental variety trial No. 18. Across location means of late and intermediate, tropical-subtropical, white and yellow, flint and dent elite experimental varieties tested at 38 locations in 1976 and at 33 locations in 1977.

ENTRY NO. AND NAME	PARENT POPULATION	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
Tested 1976					
1 Gemiza 7421	Tuxpeño 1	3968	16	64	206
2 La Maquina 7422	Mezcla Tropical Blanco	4547	1	65	226
3 Poza Rica 7422	"	4478	3	63	223
4 Tlaltetapan 7322	"	4489	2	64	230
5 Poza Rica 7423	Blanco Cristalino 1	3919	17	61	210
6 Poza Rica 7425	(Mix.1 x Col. Gpo.1)ETO	4089	9	63	211
7 Across 7426	Mezcla Amarilla	3995	14	61	204
8 Poza Rica 7427	Amarillo Cristalino 1	4030	12	63	228
9 Tocumen 7428	Amarillo Dentado 2	4333	4	65	236
10 Obregon 7328	"	4282	5	63	223
11 Poza Rica 7428	"	4195	7	64	230
12 Yousafwala 7428	"	4056	11	63	222
13 Across 7432	Tuxpeño Caribe 1	4141	8	64	231
14 Yousafwala 7435	I D R N	3959	15	62	228
15 Poza Rica 7435	"	3999	13	61	230
16 Poza Rica 7436	Cogollero	4058	10	64	230
17 Across 7443	La Posta	4207	6	66	242
Tested 1977					
1 Across 7422	Mezcla Tropical Blanco	4884	5	62	228
2 Poza Rica 7523	Blanco Cristalino	4653	9	59	216
3 Gemiza 7523/2	"	4471	11	60	226
4 Across 7524	Ant. x Ver. 181	4427	12	61	223
5 Pantnagar 7424	"	4496	10	62	223
6 Across 7425	(Mix.1 x Col.Gpo.1) ETO	4283	14	61	216
7 Poza Rica 7526	Mezcla Amarilla	4327	13	59	214
8 S. Andres 7528/1	Amarillo Dentado	4703	7	61	231
9 Cotaxtla 7429	Tuxpeño Caribe 2	4894	2	61	228
10 Pichilingue 7429	"	4897	1	62	223
11 Across 7429	"	4829	3	61	217
12 La Maquina 7422	Mezcla Tropical Blanco	4829	4	62	234
13 Tocumen 7428	Amarillo Dentado 2	4726	6	63	244
14 Across 7443	La Posta	4667	8	64	251

Table 3.11 Elite experimental variety trial No. 19. Across location means of late tropical-subtropical, white and yellow opaque-2 elite experimental varieties tested at 38 locations in 1976 and at 28 locations in 1977.

ENTRY NO. AND NAME	PARENT POPULATION	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
Tested 1976					
1 Poza Rica 7437	Tuxpeño O_2	4219	1	67	226
2 Across 7437	"	4025	3	68	230
3 Delhi 7439	Yellow H.E. O_2	4105	2	65	231
4 Poza Rica 7439	"	3727	5	67	233
5 San Andres 7440	White H.E. O_2	3687	7	65	237
6 Poza Rica 7441	Comp. K (H.E.) O_2	3704	6	65	233
7 Across 7441	"	4017	4	65	234
Tested 1977					
1 Cotaxtla 7437	Tuxpeño O_2	4053	1	61	216
2 Poza Rica 7537	"	3696	7	62	219
3 Across 7537	"	3927	4	61	219
4 La Maquina 7539	Yellow H.E. O_2	3801	6	59	225
5 Across 7539	"	3901	5	59	227
6 Across 7440	White H.E. O_2	3501	8	60	221
7 Poza Rica 7437	Tuxpeño O_2	3970	3	62	223
8 Across 7441	Comp. K.H.E. O_2	4037	2	60	233

Table 3.12 Elite experimental variety trial No. 20. Across location means of intermediate subtropical and temperate, white and yellow, flint and dent elite experimental varieties tested at 22 locations in 1976 and at 16 locations in 1977.

ENTRY NO. AND NAME	PARENT POPULATION	KG/HA	RANK	DAYS FLOWER	PLANT HT (CM)
Tested 1976					
1 Rampur 7433	Amarillo Subtropical	4612	2	69	220
2 Obregon 7434	Blanco Subtropical	4529	3	67	217
3 Pirsanak 7442	ETO x Illinois	4447	4	67	222
4 Obregon 7442	"	4838	1	67	218
5 Obregon 7446	Amarillo Pakistan	4375	5	63	207
6 Tlaltizapan 7446	"	4170	6	63	215
Tested 1977					
1 Tlaltizapan 7533	Amarillo Subtropical	4486	8	66	236
2 Palmira 7434	Blanco Subtropical	4893	6	65	240
3 Across 7542	ETO x Illinois	4902	4	65	237
4 Sids 7542	"	5162	1	65	241
5 Tlaltizapan 7542	"	5131	2	65	245
6 Obregon 7542	"	4897	5	65	238
7 Obregon 7442	"	5095	3	66	242
8 Rampur 7433	Amarillo Subtropical	4692	7	66	240

Table 3.13 Experimental variety trial No. 12. Across site means of late tropical-subtropical white dent experimental varieties tested at each of 13 locations in 1976 and at 17 locations in 1977.

COUNTRY	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT (CM)	C.V. (FOR YIELD)
Tested 1976					
1 Mexico	Poza Rica	2082	67	178	28
2 Mexico	Obregon	5080	65	204	9
3 Mexico	Tlaltizapan	8110	67	226	10
4 Egypt	Gemeiza	5309	71	224	15
5 El Salvador	San Andres	4126	63	237	11
6 Dom. Rep.	San Cristobal	3089	56	230	25
7 Honduras	Omonita	2604	57	217	22
8 Ghana	Kuadaso	3502	64	220	23
9 Mexico	Nayarit (Fansa)	5002	76	289	13
10 Zaire	Kisanca	5605	83	199	13
11 Brazil	Sete Lagoas	5520	65	220	11
12 Guatemala	Cuyuta	4489	63	215	10
13 Cote D'Ivoire	Ferkessedougou	5387	66	194	11
OVERALL MEAN		4608	66	219	
BEST CHECKS MEAN		4931	66	239	
Tested 1977					
1 Mexico	Obregon	2033	65	193	15
2 Honduras	Guaymas	4359	57	239	14
3 Guatemala	Cuyuta	4576	57	246	14
4 Mexico	Tlaltizapan	8702	70	229	9
5 Mexico	Poza Rica	5841	64	224	10
6 Egypt	Sakha	3576	76	223	32
7 Mexico	La Huerta (Jal.)	5379	62	227	15
9 El Salvador	Santa Cruz	2939	53	238	18
9 Philippines	Kisolon	3494	62	225	13
10 Mexico	Cotaxtla (INIA)	4311	60	218	16
11 Zaire	Gandajika	7106	62	227	17
12 Costa Rica	Los Diamantes	3930	64	234	33
13 Bolivia	Abapo-Izozog	2472	61	174	44
14 Tanzania	Ilonga	1289	61	255	23
15 Swaziland	Malkerns	6093	--	---	13
16 Yemen A.R.	Zabid	7361	57	196	12
17 Rep.S.Africa	Potchefstroom	4431	81	231	10
OVERALL MEAN		4581	63	224	
BEST CHECKS MEAN		4589	63	226	

Table 3.14 Experimental variety trial No. 13. Across site means of late tropical-subtropical yellow flint and dent experimental varieties tested at each of 24 locations in 1976 and at 19 locations in 1977.

COUNTRY Tested 1976	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT (CM)	C.V. (FOR YIELD)
1 Panama	Tocumen	5135	54	222	10
2 Mexico	Poza Rica	3326	62	248	14
3 Mexico	Obregon	4717	64	228	11
4 Jamaica	Bodles	5416	60	243	12
5 Mexico	Tlaltizapan	7215	66	252	9
6 Honduras	Catacamas	5818	62	228	12
7 Dom. Rep.	San Cristobal	3172	54	262	17
8 India	Ludhiana	4326	65	178	1
9 Thailand	Suwan	3008	57	214	1.
10 Ecuador	Pichilingue	5193	61	296	10
11 Bolivia	Gran Saavedra	5240	62	252	11
12 Mexico	Nayarit (Fansa)	[illegible]549	66	243	16
13 Peru	Satipo	5826	59	269	15
14 Peru	La Molina	4578	77	220	21
15 Brazil	Sete Lagoas	4795	67	225	18
16 Belize	Central Farm	2996	64	202	27
17 Argentina	Tocuman	3278	63	287	24
18 Brazil	Londrina	4766	62	265	14
19 Sri Lanka	Illuppallama	5900	60	234	7
20 Guatemala	La Maquina	5069	54	250	9
21 Brazil	Uberaba	2549	64	214	26
22 Brazil	Goiania	1481	68	151	20
23 Cote D'Ivoire	Ferkessedougou	4903	66	198	9
24 Brazil	Petrolina	7000	61	214	8
OVERALL MEAN		4598	63	234	
BEST CHECKS MEAN		4956	63	243	
Tested 1977					
1 Mexico	Tlaltizapan	7570	69	235	9
2 Mexico	Poza Rica	5462	64	236	12
3 Jamaica	Grove Place	3953	72	223	17
4 Guatemala	La Maquina	4691	54	263	10
5 Panama	Tocumen	4038	53	225	17
6 Mexico	Obregon	2004	64	200	19
7 Honduras	Danli	1817	59	221	60
8 Mexico	La Huerta (Jal.)	3975	59	231	29
9 El Salvador	Santa Cruz	2851	56	237	21
10 Philippines	Kisolon	4501	62	240	11
11 Costa Rica	Guanacaste	4381	51	214	14
12 Haiti	Cayes	6188	62	200	15
13 Thailand	Suwan	5538	59	227	8
14 Peru	San Ramon	4672	70	210	37
15 Bolivia	Sta. Cruz	4614	60	253	13
16 Ecuador	Pichilingue	4903	58	289	16
17 Peru	Satipo	3948	64	233	23
18 Yemen A.R.	Zabid	5749	56	201	14
19 Rep.S.Africa	Potchefstroom	3363	80	246	12
OVERALL MEAN		4432	62	231	
BEST CHECKS MEAN		4570	63	236	

Table 3.15 Experimental variety trial No. 14A. Across site means of late intermediate tropical-subtropical yellow dent and flint experimental varieties tested at each of 23 locations in 1976 and at 22 locations in 1977.

COUNTRY Tested 1976	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT (CM)	C.V. (FOR YIELD)
1 Mexico	Obregon	4733	64	206	10
2 Jamaica	Bodles	4263	58	224	15
3 Mexico	Tlaltizapan	6766	68	239	12
4 Thailand	Suwan	3051	55	193	17
5 Ecuador	Porto Viejo	6344	62	224	8
6 Costa Rica	Guanacaste	2182	50	209	23
7 Dom. Rep.	San Cristobal	3397	53	217	14
8 Bolivia	Gran Saavedra	5891	60	231	10
9 Guatemala	La Maquina	5411	51	238	9
10 Honduras	Danli	2016	67	196	20
11 Mexico	Nayarit (Fansa)	5797	64	262	14
12 Peru	La Molina	4961	76	199	20
13 Belize	Central Farm	3100	62	181	23
14 Peru	Satipo	4688	56	230	19
15 Brazil	Sete Lagoas	4051	65	194	12
16 Argentina	Tocuman	2687	60	215	18
17 Sri Lanka	Illuppallama	5888	58	213	7
18 Philippines	Uplb	3485	56	199	16
19 Panama	Tocumen	4484	52	209	15
20 Brazil	Goiania	1243	66	139	29
21 Cote D'Ivoire	Ferkessedougou	4462	63	175	19
22 Brazil	Teresina	2234	53	218	20
23 Mexico	Poza Rica	2322	61	197	27
OVERALL MEAN		4063	60	209	
BEST CHECKS MEAN		4580	62	237	
Tested 1977					
1 Mexico	Tlaltizapan	6759	63	215	7
2 Mexico	Poza Rica	5111	58	197	10
3 Honduras	Guaymas	4027	55	218	12
4 Nicaragua	La Calera	4596	54	158	12
5 Mexico	Obregon	2147	59	184	14
6 Guatemala	La Maquina	4166	52	220	12
7 Panama	Tocumen	4217	51	197	13
8 El Salvador	Santa Cruz	3787	51	224	11
9 Egypt	Sakha	1835	65	157	41
10 Costa Rica	Guanacaste	3355	54	163	29
11 Thailand	Suwan	5132	54	183	10
12 India	Ludhiana	3310	59	158	23
13 Jamaica	Grove Place	3595	57	180	17
14 Malaysia	Serdang	4908	53	203	13
15 Peru	San Ramon	4190	65	178	26
16 Argentina	Tocuman	4120	60	231	12
17 Bolivia	Sta. Cruz	4635	55	207	11
18 Ecuador	Pichilingue	4712	54	257	12
19 Peru	Satipo	2755	60	186	30
20 Botswana	Good Hope	2915	62	170	13
21 Philippines	Laguna	3628	62	168	21
22 Rep.S.Africa	Potchefstroom	3170	78	215	14
OVERALL MEAN		3958	58	194	
BEST CHECKS MEAN		4355	62	224	

Table 3.16 Experimental variety trial No. 148. Across site means of late tropical-subtropical white flint experimental varieties at each of 24 locations tested in 1976.

	COUNTRY	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
1	Egypt	Gemeiza	4825	69	245	15
2	Mexico	Tlaltizapan	6973	69	226	12
3	Colombia	Palmira	5949	66	250	17
4	El Salvador	San Andres	3841	60	238	18
5	Guatemala	Cuyuta	4159	61	218	12
6	Dom. Rep.	San Cristobal	3661	53	251	14
7	Honduras	Comayagua	3756	59	210	13
8	Sudan	Halima	1049	79	147	33
9	Ghana	Kwadaso	2940	57	218	22
10	India	Pantnagar	2561	58	221	10
11	Bolivia	Gran Saavedra	6151	65	222	13
12	Pakistan	Pirsabak	4548	62	206	15
13	Mexico	Nayarit (Fansa)	5427	64	265	11
14	Nepal	Janakpur	6208	96	172	12
15	Zaire	Kaniama	7148	67	184	9
16	Brazil	Sete Lagoas	5413	63	214	12
17	Sri Lanka	Illuppallama	4870	59	222	15
18	Bangladesh	Joydebpur	2585	116	192	28
19	Philippines	Uplb	2796	56	202	22
20	Mexico	Obregon	4818	63	215	8
21	Mexico	Poza Rica	3132	61	221	14
22	Costa Rica	Los Diamantes	4980	59	236	23
23	Belize	Cayo	4386	53	206	29
24	Venezuela	Acarigua	4504	50	236	10
	OVERALL MEAN		4445	65	218	
	BEST CHECKS MEAN		4461	66	224	

In Tanzania, CIMMYT works on maize in cooperation with our sister institute, IITA.

Table 3.17 Experimental variety trial No. 15. Across site means of late tropical white and yellow opaque-2 experimental varieties tested at each of 22 locations in 1976 and at 21 locations in 1977.

COUNTRY	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
Tested 1976					
1 Mexico	Obregon	4155	62	219	9
2 Egypt	Sakha	3095	73	258	22
3 Mexico	Tlaltizapan	6118	65	249	12
4 Colombia	Palmira	4067	59	237	17
5 El Salvador	San Andres	3712	59	249	15
6 Dom. Rep.	San Cristobal	2803	52	256	13
7 Thailand	Suwan	2454	56	214	22
8 Honduras	Omonita	2327	56	218	22
9 Costa Rica	Guanacaste	1774	50	232	22
10 Ecuador	Pichilingue	4525	62	268	10
11 Pakistan	Pirsabak	3597	62	209	18
12 Jamaica	Bodles	4796	60	226	18
13 India	Pantnagar	2554	59	233	24
14 Zaire	Kisanga	5562	78	224	14
15 Bolivia	Gran Saavedra	4974	60	249	10
16 Peru	La Molina	5107	76	212	17
17 Brazil	Sete Lagoas	3813	68	200	16
18 Argentina	Tocuman	5553	65	287	19
19 Philippines	UPLB	2541	58	193	22
20 Panama	Tocumen	4677	53	214	10
21 Mexico	Poza Rica	1569	64	206	28
22 Belize	Cayo	3262	53	211	31
OVERALL MEAN		3683	61	230	
BEST CHECKS MEAN		4208	64	240	
Tested 1977					
1 Mexico	Poza Rica	4982	61	224	9
2 Mexico	Obregon	1865	65	195	17
3 Mexico	Tlaltizapan	5639	66	224	14
4 Nicaragua	La Calera	3503	56	197	18
5 Panama	Tocumen	2621	50	197	17
6 Guatemala	San Jeronimo	4195	65	190	[illegible]
7 Egypt	Sakha	1072	70	164	55
8 El Salvador	San Andres	3028	58	227	15
9 Costa Rica	Guanacaste	3005	51	234	24
10 India	Ludhiana	5556	60	173	10
11 Mexico	Cotaxtla (INIA)	4031	58	244	12
12 Thailand	Suwan	4874	56	235	8
13 Pakistan	Pirsabak	3987	61	178	15
14 Jamaica	Grove Place	2573	60	222	15
15 Argentina	Tocuman	3602	69	266	16
16 Bolivia	Chuquisaca	2899	64	181	32
17 Ecuador	Pichilingue	3391	57	266	16
18 Peru	Satipo	2239	66	204	28
19 Tanzania	Ilonga	1399	58	212	15
20 Philippines	Laguna	3583	64	197	17
21 Yemen A.R.	Zabid	5378	56	182	10
OVERALL MEAN		3497	60	210	
BEST CHECKS MEAN		3709	59	206	

Table 3.18 Experimental variety trial No. 16. Across site means of intermediate and early, subtropical and temperate, white and yellow, flint and dent, experimental varieties tested at each of 13 locations in 1976 and at 11 locations in 1977.

COUNTRY	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
Tested 1976					
1 Ecuador	Porto Viejo	5500	62	234	12
2 Colombia	Palmira	3391	62	256	24
3 Iraq	Bagdad	6850	65	237	12
4 Afganistan	Jalalabad	1772	60	226	19
5 Pakistan	Pirsabak	4210	58	213	18
6 India	Pantnagar	2737	55	232	23
7 Chile	La Platina	8428	82	290	15
8 Bolivia	Chuquisaca	4397	55	239	17
9 Zaire	Kaniama	6298	62	196	11
10 Argentina	Pergamino	5390	70	280	13
11 Mexico	Tlaltizapan	6340	64	215	12
12 Egypt	Sakha	3105	68	243	18
13 Nepal	Newakot	3467	72	144	27
OVERALL MEAN		4760	64	231	
BEST CHECKS MEAN		4859	66	240	
Tested 1977					
1 Mexico	Obregon	1601	62	185	21
2 Mexico	Tlaltizapan	6976	64	236	7
3 Egypt	Sakha	3596	71	205	29
4 Zaire	Kaniama	7157	65	233	11
5 Chile	La Platina	9776	84	249	10
6 Argentina	Pergamino	6895	67	237	9
7 Bolivia	Chuquisaca	1654	61	169	23
8 Brazil	Novaprata	2261	70	110	15
9 Ecuador	Pichilingue	3814	54	264	13
10 Botswana	Gaborone	3896	63	232	19
11 Rep. S. Africa	Potchefstroom	4255	76	231	9
OVERALL MEAN		4716	67	214	
BEST CHECKS MEAN		4984	66	214	

Table 3.19 Experimental variety trial No. 17. Across site means of normal and opaque-2 tropical highland materials at each of 9 locations tested in 1976.

COUNTRY	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
1 El Salvador	Las Pilas	3701	82	159	20
2 Colombia	Tibaitata	2100	133	166	28
3 Mexico	Toluca	2431	135	246	37
4 Ethiopia	Alemaya	9184	71	277	16
5 Mexico	Perote	1235	116	160	28
6 Peru	Carhuaz	5465	89	188	19
7 Mexico	El Batan	7047	93	246	14
8 Lesotho	Thaba	1910	102	183	25
9 Colombia	Tibaitata (2)	3055	138	186	19
OVERALL MEAN		4014	106	201	
BEST CHECK MEAN		5214	108	234	

Table 3.20 Elite experimental variety trial No. 18. Across site means of late and intermediate, tropical – subtropical, white and yellow, flint and dent elite experimental varieties tested at each of 50 locations in 1976 and at 33 locations in 1977.

	COUNTRY Tested 1976	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
1	Panama	Ceiat	5454	53	228	9
2	Panama	Tocumen	2846	54	161	24
3	Haiti	Cayes	4395	63	205	22
4	Dom. Rep.	San Cristobal	4945	57	293	12
5	Mexico	Poza Rica	3419	62	238	13
6	Mexico	Obregon	4763	65	220	14
7	Haute-Volta	Farako-Ba	5032	59	215	17
8	Egypt	Sids	7055	73	312	10
9	Mexico	Nayarit (INIA)	4175	54	216	17
10	Mexico	Tlaltizapan	7307	68	228	14
11	El Salvador	San Andres	3685	61	248	12
12	Costa Rica	Alajuele	7372	73	230	8
13	Thailand	Suwan	2866	57	203	19
14	Honduras	Danli	8027	65	262	8
15	Honduras	Catacamas	6420	64	241	13
16	Nepal	Rampur	2330	63	215	21
17	Ecuador	Porto Viejo	5851	65	239	10
18	India	Hyderabad	4310	70	179	13
19	Guatemala	La Maquina	5190	55	236	11
20	Costa Rica	Site 5	3505	53	203	14
21	Trinidad	Texaco	1619	57	238	39
22	Sudan	Halima	3186	57	174	24
23	Ecuador	Pichilingue	5602	63	273	14
24	Ghana	Kwadaso	1841	55	234	28
25	Turkey	Samsun	3076	101	312	19
26	Pakistan	Pirsabak	5138	65	203	11
27	Jamaica	Grove Place	4083	68	227	13
28	Panama	Guarare	2624	59	248	18
29	Uganda	Kawanda	4270	70	178	10
30	Jamaica	Bodles	5703	63	212	13
31	India	Pantnagar	4279	62	230	21
32	Mexico	Cotaxtla (INIA)	4196	58	230	13
33	Cent.Afr.Rep.	Soumse	2202	64	185	33
34	Mexico	Nayarit (Fansa)	5950	65	286	9
35	Peru	La Molina	5182	78	211	17
36	Peru	Motupe	4775	78	185	18
37	Brazil	Sete Lagoas	4574	66	212	21
38	Brazil	Chapeco	3773	66	271	13
39	Brazil	Londrina	4597	64	262	14
40	Botswana	Good Hope	2036	72	169	21
41	Sri Lanka	Illuppallama	4942	60	219	11
42	Guatemala	Cuyuta	358	51	251	13
43	Brazil	Sao Simao	2056	76	201	28
44	Brazil	Goiania	1213	67	154	18
45	Brazil	Teresina	2029	57	217	22
46	Costa Rica	Los Diamantes	4508	60	231	26
47	Malaysia	Serdang	1960	52	134	37
48	Venezuela	Acarigua	4388	52	230	12
49	Cote D'Ivoire	Ferkessedougou	5419	64	174	18
50	Cote D'Ivoire	Bouake	3540	66	276	14
	OVERALL MEAN		4161	63	224	
	BEST CHECKS MEAN		4755	63	225	

	COUNTRY Tested 1977	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
1	Guatemala	Cuyuta	4604	56	257	11
2	Guatemala	La Maquina	4760	55	239	10
3	Nicaragua	La Calera	3518	57	194	19
4	Mexico	Poza Rica	5624	63	219	10
5	Mexico	Obregon	1847	65	188	20
6	Mexico	Tlaltizapan	7983	68	227	7
7	Costa Rica	Alajuela	6851	71	216	7
8	Panama	Tocumen	4292	51	212	13
9	El Salvador	San Andres	3615	61	231	13
10	Egypt	El Gemmeiza	6651	74	286	15
11	Egypt	Sids	5034	76	288	9
12	Costa Rica	Guanacaste	4098	50	228	14
13	El Salvador	San Andres (2)	3732	59	230	15
14	Venezuela	Maracay	4828	52	252	15
15	Panama	Rio Hato	3411	54	247	18
16	Panama	Tocumen (2)	3090	53	242	16
17	Nigeria	Ibadan	3371	56	242	25
18	Zaire	Gandajika	6878	62	223	19
19	Thailand	Suwan	5664	58	216	7
20	Jamaica	Grove Place	3124	60	204	16
21	Uganda	Kawanda	3326	77	172	25
22	Peru	San Ramon	4195	69	203	38
23	Malaysia	Serdang	4320	58	223	15
24	Surinam	Coebiti	5211	60	189	17
25	Surinam	Tijerkreek	8763	60	216	8
26	Surinam	Paramaribo	7818	55	197	18
27	Costa Rica	Los Diamantes	3437	62	2471	40
28	Bolivia	Sta. Cruz	5307	60	247	12
29	Ecuador	Pichilingue	4661	57	277	14
30	Peru	Satipo	1907	63	191	39
31	Tanzania	Ilonga	1563	60	251	16
32	Yemen A.R.	Zabid	6286	56	196	14
33	Rep.S.Africa	Potchefstroom	3504	82	230	10
	OVERALL MEAN		4645	61	227	
	BEST CHECKS MEANS		4711	62	241	

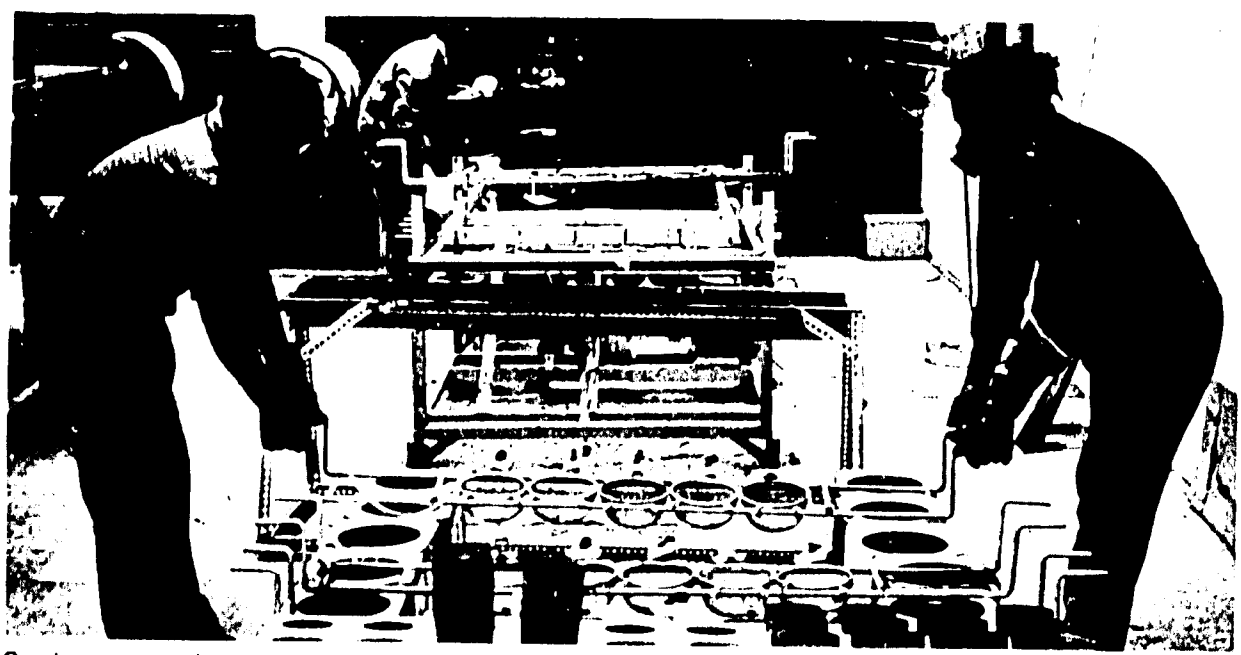
Table 3.21 Elite experimental variety trial No. 19. Across site means of late tropical-subtropical, white and yellow opaque-2 elite experimental varieties tested at each of 38 locations in 1976 and at 28 locations in 1977.

COUNTRY Tested 1976	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
1 Haiti	Cayes	4677	61	234	26
2 Dom. Rep.	San Cristobal	4518	56	305	12
3 Nepal	Khumaltar	4475	81	211	17
4 Mexico	Poza Rica	2264	63	234	21
5 Mexico	Obregon	3903	64	225	13
6 Mexico	Tlaltizapan	6095	69	251	15
7 Egypt	Sids	6348	72	307	13
8 India	Delhi	1603	62	173	40
9 Nicaragua	Santa Rosa	4145	56	232	21
10 El Salvador	San Andres	3407	61	246	19
11 Costa Rica	Alajuele	5031	79	172	24
12 Thailand	Suwan	1980	57	202	24
13 Honduras	Danli	7078	64	268	8
14 Nepal	Rampur	2222	62	210	19
15 Ecuador	Porto Viejo	5508	61	273	8
16 Guatemala	Cuyuta	4020	59	258	17
17 Trinidad	Texaco	1539	57	240	29
18 Ecuador	Pichilingue	4546	63	295	7
19 Bolivia	Gran Saavedra	4575	66	222	14
20 Nepal	Janakpur	5820	66	231	18
21 Pakistan	Pirsabak	2997	63	222	21
22 Uganda	Kawanda	2471	73	155	16
23 Panama	Guarare	1577	59	224	29
24 Costa Rica	Guanacaste	3485	52	215	17
25 India	Pantnagar	4693	62	234	12
26 Mexico	Cotaxtla (INIA)	4106	56	234	12
27 Jamaica	Bodles	4257	63	241	15
28 Peru	La Molina	4210	76	213	25
29 Peru	Motupe	4142	79	183	19
30 Brazil	Sete Lagoas	5010	65	223	12
31 Argentina	Tocuman	2824	67	303	20
32 Guatemala	La Maquina	4383	54	245	13
33 Panama	Tocumen	4823	54	227	6
34 Cote D'Ivoire	Bouake	3944	66	252	14
35 Brazil	Teresina	1639	59	217	26
36 Nepal	Kakani	3843	76	171	37
37 Nepal	Khumaltar (2)	5868	74	282	15
38 Cote D'Ivoire	Ferkessedougou	2623	64	202	11
OVERALL MEAN		3964	66	232	
BEST CHECKS MEAN		4743	65	232	

COUNTRY Tested 1977	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
1 Nicaragua	La Calera	4045	58	166	17
2 Mexico	Obregon	1715	64	200	16
3 Mexico	Poza Rica	5062	63	230	10
4 Mexico	Tlaltizapan	6463	68	232	10
5 Guatemala	Cuyuta	3560	55	243	15
6 Guatemala	La Maquina	4234	53	250	9
7 Panama	Tocumen	3615	53	209	15
8 Honduras	La Ceiba	3809	53	188	18
9 Egypt	Sids	3911	72	287	14
10 Egypt	El Gemmeiza	5529	73	303	20
11 El Salvador	San Andres	2996	61	233	14
12 Panama	Rio Hato	2932	53	245	18
13 Nigeria	Ibadan	2928	56	218	20
14 Philippines	Kisolon	2432	62	215	15
15 Mexico	Cotaxtla (INIA)	3230	59	280	15
16 Pakistan	Yousafwala	5364	57	218	22
17 Thailand	Suwan	4830	57	235	8
18 Pakistan	Pirsabak	3472	60	165	24
19 Jamaica	Grove Place	2508	64	208	18
20 Peru	San Ramon	3570	69	205	26
21 Argentina	Pergamino	4405	75	275	15
22 Bolivia	Sta. Cruz	4442	63	252	11
23 Ecuador	Pichilingue	3204	59	259	20
24 Peru	Satipo	1603	63	187	34
25 Windward Isl.	Mirabeau, Grenada	7648	50	227	21
26 Tanzania	Ilionga	1305	58	212	24
27 Yemen A.R.	Zabid	5287	56	191	11
28 Rep.S.Africa	Potchefstroom	4002	-	162	12
OVERALL MEAN		3861	61	223	
BEST CHECKS MEANS		4638	60	229	

Table 3.22 Elite experimental variety trial No. 28. Across site means of intermediate subtropical and temperate, white and yellow, flint and dent elite experimental varieties tested at each of 22 locations in 1976 and at 16 locations in 1977.

	COUNTRY	SITE NAME	YIELD KG/HA	DAYS SILK	PLANT HT(CM)	C.V. (FOR YIELD)
	Tested 1976					
1	Nepal	Khumaltar	3965	72	170	18
2	Mexico	Tlaltizapan	5956	64	252	16
3	Egypt	Sids	6643	66	295	10
4	India	Bajaura	6109	66	217	11
5	India	Ludhiana	2410	56	120	18
6	Nepal	Rampur	2439	59	203	17
7	Ecuador	Porto Viejo	5701	59	246	12
8	Guatemala	Chimaltenango	3912	92	200	17
9	Turkey	Samsun	4661	91	269	14
10	Nepal	Janakpur	3376	65	197	21
11	Pakistan	Pirsabak	6118	60	219	9
12	Uganda	Kawanda	2473	66	162	24
13	Jamaica	Bodles	5410	67	208	10
14	Bolivia	Chuquisaca	5589	55	249	17
15	Brazil	Chapeco	4658	60	273	12
16	Brazil	Sete Lagoas	4438	61	219	13
17	Argentina	Pergamino	5785	72	278	10
18	Mexico	Obregon	4578	62	219	8
19	Haute-Volta	Farako-Ba	4536	57	203	19
20	Nepal	Kakani	3271	71	148	20
21	Nepal	Kumaltar (2)	5864	68	263	13
22	Brazil	Cascavel	977	55	155	43
	OVERALL MEAN		4495	66	217	
	BEST CHECKS MEAN		4938	69	238	
	Tested 1977					
1	Mexico	Obregon	1820	61	196	20
2	Mexico	Tlaltizapan	7544	65	225	8
3	Egypt	Sids	5706	70	288	11
4	Egypt	El Gemmeiza	5597	70	287	12
5	Mexico	Zacatepec	6545	55	292	8
6	Nigeria	Ibadan	3615	53	266	15
7	Pakistan	Yousafwala	5194	55	233	19
8	Pakistan	Pirsabak	3454	57	188	21
9	Argentina	Pergamino	6820	71	263	10
10	Zaire	Kaniama	7369	67	234	18
11	Bolivia	Chuquisaca	1918	62	191	26
12	Brazil	Novaprata	2468	69	204	16
13	Chile	Antumapu	6785	99	230	17
14	Ecuador	Pichilingue	4110	52	281	12
15	Brazil	Encruzilhada S.	5705	63	233	22
16	Rep.S.Africa	Potchefstroom	3868	77	227	13
	OVERALL MEAN		4907	66	240	
	BEST CHECKS MEAN		5452	66	250	



Seed treatment is necessary to insure good stands in worldwide trials.

The protein quality laboratory at CIMMYT analyzed 23,000 samples of grain in 1977. Approximately 75 per cent of these samples were maize, most of which were analyzed for total protein and for the amino acid tryptophan.

3.3 PROTEIN QUALITY

3.3.1 SUMMARY

Normal materials in Advanced and Back-up units continued to be converted to opaque-2 types. The e selected from nineteen Advanced unit population during 1976A sustained further selection during 1976 and 1977, using different schemes of S_1, half-sib, and full-sib selection.

A total of 3604 families were handled during 1976B; and 2857 in 1977A in the Advanced unit conversion program.

In the conversion program with normal Back-up materials during 1976B, this process included a total of 1,454 hard endosperm opaque-2 families from eight tropical pools; there were 1,209 such families in 1977A, and 1,144 in 1977B. There were 192 families from four temperate pools planted during 1977A, and 496 families in 1977B. Kernel hardness continued to be improved, without sacrificing protein quality, in all opaque-2 versions of the different gene pools, and Advanced Unit materials. In addition to selection for kernel hardness and for maintenance of protein quality, there was intense selection pressure for plant and ear characteristics. Hard endosperm opaque-2 versions of most of the Advanced unit materials and pools had ears of good quality and appearance.

A number of opaque-2 versions also were backcrossed to corresponding normal materials. The BC_1 crosses were advanced and a number of segregating $BC_1(F_2)$ ears were rejected on the basis of kernel weight comparison of normal and opaque-2 segregates.

The conversion program also has begun in four tropical and four temperate pools that have been formed more recently.

Highland gene pools continued to be converted to opaque-2, with a total of 2,095 F_2 families planted during 1976. The major emphasis was placed on selection for modified opaque-2 endosperm (except in pools 3 and 8).

In addition to tropical and temperate materials in the Back-up stages, twelve highland opaque-2 materials were subjected to further mixing and selection. Except for five soft opaque-2 populations, the major emphasis was on changing the endosperm from soft to hard endosperm.

The floury-opaque-2 conversion program has developed a floury-opaque-2 composite, opaque-2 versions of Pools 3 and 8, and some very large-seeded opaque-2 families. The emphasis in work with floury 1/opaque-2 materials was on selection for large kernels. A complete amino-acid analysis of endosperm and whole grain in the floury-opaque-2 composite indicated that the levels of lysine and tryptophan in protein were relatively high.

In the development and improvement of broadbased hard endosperm opaque-2 populations, twelve tropical and temperate materials completed one or more additional cycles of recombination and selection. Four materials from this program have been promoted to the Advanced unit. These materials are PD(MS)6 H.E. 0_2; CIMMYT H.E. 0_2; Temperate x tropical H.E. 0_2; and full sib families from the White opaque-2 Back-up pool.

Population improvement work centered on four materials: 250 full-sib families from Tuxpeño opaque-2; PD(MS)6 H.E. 0_2; CIMMYT H.E.0_2; and White opaque-2. Back-up pools were evaluated at three locations within Mexico. The selection differentials (in per cent) in across-location data were: Tuxpeño opaque-2 (10.44 per cent), PD(MS)6 H.E. 0_2 (9.97 per cent), CIMMYT H.E. 0_2 (9.66 per cent) and White opaque-2 (9.12 per cent). The selected families in all populations had a lower mean value indicating that they were shorter in plant height, and were a day earlier to flower, as compared to the tested population.

The full-sibs from Yellow H.E. 0_2 (pop. 39) were evaluated at six sites. However, the selection of families with good performance was not completed, due to lack of results from some locations.

On the basis of 1976 progeny trial data, four experimental varieties were developed. These experimental varieties were included in EVT-15 during the year 1977.

Families from several opaque-2 materials were analyzed for protein and tryptophan in endosperm. The mean values for protein and tryptophan in protein in most opaque-2 materials were very good in general.

Since 1977B, a new strategy has been used in planting hard endosperm opaque-2 families in different locations, to screen families stable for modified opaque-2 appearance.

Hard endosperm opaque-2 families of Advanced and Back-up materials have been planted at Poza Rica and Obregon to select for stable modified endosperm opaque-2 families.

The conversion program of Special Project populations continued, focusing on earliness, plant efficiency, and adaptation. A total of 916 ears were saved during 1977A. These were planted at Tlaltizapan and Obregon during 1977B.

The sugary-2/opaque-2 conversion program was begun only recently. The double mutant segregates have been recovered from many normal and opaque-2 genetic backgrounds; 800 sugary-2/opaque-2 families entered in the first cycle of recombination during 1977A to form a sugary-2/opaque-2 composite. The selected ears were planted for the second cycle of recombination. Biochemical analyses of sugary-2/opaque-2 segregates indicated that they have a higher protein content than do the soft opaque-2 segregates. The levels of the two essential amino-acids, however, did not differ greatly in the two types of segregates. Differences were observed in levels of glutamic acid, leucine and tryosine. The glutenin fraction of the protein was found to be much higher in sugary-2/opaque-2 segregates, and it formed about one-half of the total protein.

Biochemical analyses of many promising hard endosperm opaque-2 materials indicated acceptable levels of lysine and tryptophan. An analysis of protein fractions showed that each of the fractions (alcohol soluble, acid

soluble, and alkali soluble) constituted about one-third of the total protein. The hard endosperm opaque-2 materials, in general, had less glutamic acid.

During 1976, Experimental Variety Trial (EVT) 15 was sent to 36 locations. The results from EVT-15 showed that experimental varieties derived from Pop. 37 generally performed very well in different locations. Across 7539, La Maquina 7539, and Cotaxtla 7439 also performed fairly well, as did White H.E. O_2, Across 7440, and La Maquina 7540. Populations Amarillo Dentado H.E. O_2 and CIMMYT H.E. O_2 also performed fairly well. In the Elite Experimental Variety Trial (ELVT) 19, the experimental varieties from Pop. 37 were top yielders. In many locations, the opaque-2 entries were equal to or comparable to normal and opaque-2 check entries included in the trial.

The international testing program during 1977 consisted of variety trials EVT-15 and ELVT-19. The 250 full-sibs from 3 different populations were sent to different countries for evaluation. EVT-15 was sent to 38 locations and ELVT-19 was sent to 55 locations.

3.3.2 CONVERSION PROGRAM

3.3.2.1 Conversion of Advanced Unit Materials, 1976: The F_4 ears saved from Advanced unit opaque-2 conversions during 1975B were shelled separately, and the most promising vitreous segregates were sorted from each ear for planting during 1976A. At this point, the hard endosperm opaque-2 families from Advanced unit materials were advanced to F_5 (half-sib or full-sib). Similarly, the ears selected from 1976A harvest from different materials were handled through sibbing (full-sib and half-sib) or selfing. Table 3.3.1 shows the number of ears saved in each generation. Selection pressure was high for kernel hardness, as well as for plant height, ear height, lodging, ear rots and other ear characteristics considered essential in quality protein breeding.

Based on 1974 data, three new normal materials–Blanco Cristalino-2 (Pop. 30), Eto Blanco (Pop. 32), and Antigua x Republica Dominicana (Pop. 35)–were added to the Advanced unit. The Pop. 32 and Pop. 35 were crossed to different sources of hard endosperm opaque-2 donors during 1975A. The nicking between families of normal and opaque-2 materials was not satisfactory, thus some early families of normal materials could not be used in pollination. However, sufficient F_1 crosses were developed and then advanced to F_2 during 1976A.

The cross of the short plant selection Tuxpeño-1 with white hard endosperm opaque-2 was re-made during 1975B and then advanced to F_2 in isolation. At harvest time, only ears with no segregation for soft kernels were selected for further work.

Table 3.3.1 shows the number of ears saved from each of the above segregating materials. Opaque-2 kernels were sorted from each ear separately and their 100-kernel weight was compared with that of the normal counterpart. This comparison is shown in Table 3.3.2. The average kernel weight of opaques was lower than that of the normal counterpart. The per cent decrease in kernel weight of opaques, as compared to the normals, varied from 5.24 per cent to 11.25 per cent. There was considerable variation in weight of opaques and normals within each population. The variation ranged from 0 to 38 per cent. There were several families within each opaque-2 population with a negligible decrease in kernel weight.

Kernel weight comparison data was used in eliminating families from the above materials. Only those families were rejected which had opaque-2 segregates with kernel weights considerably lower than those of their normal counterpart. Some families with very low kernel weight also were rejected, even though the difference between normal and opaque-2 segregates was within the selection range. The selected F_2 families were planted during 1976B in a half-sib crossing block, to undergo another cycle of selection. Table 3.3.1 shows the number of F_3 ears saved from these two populations.

3.3.2.2 Conversion of Advanced Unit Materials, 1977: A total of 2,857 ears were saved from 1976B harvest. These ears were shelled individually and seed prepared in exactly the same manner as in 1976A, for planting during 1977A. A ten-kernel sample of each family from all the materials was sent to the laboratory for analysis. The data returned from the laboratory were used in rejecting families before pollination.

During 1977A, S_1 lines developed from Tuxpeño Caribe and La Posta were handled in two separate half-sib recombination blocks. Two other materials (Tuxpeño-1 and Eto Blanco H.E. O_2) were handled in two separate half-sib crossing blocks. The rest of the Advanced unit opaque-2 conversions were handled in a full-sib scheme. Very intense selection for plant and ear type was practiced at harvest, and a total of 3,474 ears were saved to continue further selection and improvement in these materials.

The harvest of 1977A was good and very encouraging in terms of the quality and appearance of ears. For the first time, some of the materials did not produce a single ear that was segregating for soft endosperm. The results suggested that opaque-2 modifiers were probably accumulated to a relatively high frequency in many opaque-2 converted materials. Thus, a revised strategy was followed during 1977B, with a strong pressure to screen for families that would have stable modifiers within many environments. Hard endosperm opaque-2 segregates from each family were planted in at least two locations. The families from tropical materials were planted in Poza Rica and Obregon, while those from subtropical materials were planted at Tlaltizapan and Obregon. At flowering time, the pollinations were made only in Poza Rica and Tlaltizapan. Reciprocal plant-to-plant pollinations were made within

each family to capitalize on plant and ear variation within each family. At harvest, the pollinated ears from only those families that showed stability for kernel hardness were saved for planting the following season.

Objectives of this new strategy include: planting the same families at two or more locations to permit screening and selection of families that are stable for vitreous endosperm; reducing the bulk of experimental material that has been built up in the last 4 to 5 years; reciprocal plant-to-plant sib pollinations within a family to capitalize on within family variation for height, ear rots, and kernel characteristics, while families for modified endosperm character are being identified; and increasing the area of adaptation of these materials to other environments.

A number of opaque-2 versions of Advanced unit materials also were backcrossed to corresponding normal populations. Table 3.3.3 shows the number of backcrossed ears saved from each cross. These backcrossed ears were planted (on a family basis) next to hard endosperm opaque-2 families from the same material. Bulk pollen from the latter was used to pollinate the BC_1 families. Ears that segregated well were saved at harvest. In most of the selected ears, there was no segregation for soft opaque-2 kernels. Selected ears were shelled separately, and normal and modified opaque-2 kernels were sorted from each ear. The 100-kernel weight of normal and modified opaque-2 kernels from each ear was recorded and compared. Based on this data, families were rejected which showed a difference of more than 10 per cent between opaques and normal. Tables 3.3.4 and 3.3.5 show comparisons of kernel weight, volume, and density for normal and hard endosperm opaque-2 segregates recovered from segregating populations. Tables 3.3.6 and 3.3.7 show the number of families rejected on the basis of weight comparisons. Generally opaque-2 segregates were lower in kernel weight, volume and density. Variation exists, however, and families must be selected from the higher kernel weight class where the differences between opaques and normals are the least.

3.3.2.3 Conversion of Back-up Materials: All pools in the Back-up unit are being converted to opaque-2. Two additional generations of selection were completed in tropical and temperate pools during 1976. A total of 1,943 families from pools 19 through 26 were saved from 1975B and planted during 1976A. The number of selfed ears with modified appearance saved from each pool is shown in Table 3.3.1 . Depending on the number of isolations available some were recombined in a half-sib recombination block, while others were hand-pollinated so that each family was crossed with as many other families as possible. Table 3.3.10 shows the number of ears saved from each pool during 1976B.

The ears harvested from four temperate pools during 1975B were planted on a family basis in 1976A. Intercrosses were made among families on a plant-to-plant basis. A total of 201 ears were saved at harvest; these were planted on a family basis during 1976B at Tlaltizapan. Plant-to-plant sib pollinations between families again were made in each pool separately. The harvested ears were generally satisfactory, but only 280 good-sized ears with acceptable kernel appearance were selected. Table 3.3.8(B) shows the number of ears saved during 1976A and 1976B.

During 1975, segregating F_2 ears were selected from pools 1 through 14 (except pool 6). The F_2 segregating ears were sorted for opaques and modified opaque-2 kernels. The 100-kernel weight of opaques and normal kernels also was recorded for each ear. A number of ears were rejected based on weight comparisons. (especially where the difference between opaques and normals was over 15 per cent). Table 3.3.9 shows the 100-kernel weights of opaques and normal kernels. Opaque kernels, in general, were lighter than normal kernels. The per cent decrease in weight of opaque kernels, as compared to their normal counterparts, ranged from 4.4 per cent to 19.0 per cent. There was, however, considerable variation from ear to ear, ranging from 0 to 19 per cent. Following the selection on a weight basis, a total of 2,095 F_2 families were finally selected and planted in Batan during 1976. Plant-to-plant crosses were made among families within each conversion, separately.

Work is underway to convert all tropical and temperate gene pools to hard endosperm opaque-2 types. Some conversions have reached the F_4 or F_5 generation. All tropical opaque-2 conversions are being handled at Poza Rica. A total of 1,454 ears were saved from the harvest of 1976A. These ears were shelled individually and sorted for the best hard endosperm opaque-2 segregates. Selected segregates from each material were planted on a family basis in 1976B. Four pools (22, 23, 24 and 26 H.E. O_2) were separately handled in half-sib recombination blocks. In the other pools, plant-to-plant crosses were made among different families to generate full-sibs.

A total of 1,209 ears with modified endosperm were selected from the harvest of 1976B at Poza Rica. The selected ears were planted on a family basis in 1977A. Plant-to-plant crosses were made between selected plants, among selected families. At harvest, 1,144 ears were saved. The selected ears were planted at Poza Rica and Obregon during 1977B to select for modified-endosperm stable families.

Full-sib ears saved from 1976A harvest at Tlaltizapan were planted on a family basis during 1976B. Full-sib crosses were made between selected plants, among selected families. In 1977A, 192 selected ears were advanced by one generation to continue improvement for kernel hardness and other agronomic characteristics. At harvest, 486 vitreous ears were selected. These were shelled and good vitreous segregates were sorted out from each for planting during 1977B.

The eight tropical pools were backcrossed during

1977A. Table 3.3.8(A) shows the number of ears harvested from each backcross. The BC_1 families from each cross were planted beside the hard endosperm opaque-2 families of the same pool in 1977B. The pollinations were made according to the plan used for the Advanced unit materials.

Four tropical early pools and four temperate pools have been formed in recent cycles. One or more sources of opaque-2 donors were crossed with these pools in 1976 or 1977; Table 3.3.12 shows the number of ears saved from each cross. The F_1 crosses with three temperate pools were advanced during 1977A. A total of 209 F_2 segregating ears saved from three pools were shelled and sorted separately for normal and opaque-2 segregates. A 100-kernel weight comparison of normals and opaques was made to eliminate families with differences of more than 10 per cent. F_1 or F_2 families from these pools were advanced to the next generation in 1977B.

Conversion of highland gene pools to opaque-2 was continued. Except for pools 3 and 8, the selection emphasis in the highland materials has been for vitreous opaque-2 kernels. To date, most of the conversions from the highland pools have not produced satisfactory modifiers. A total of 295 F_2 families from the pools were planted during 1976. Plant-to-plant crosses were made among families and Table 3.3.10 shows the number of ears selected from each pool. Intense selection pressure was exerted on modified opaque-2 ears (except in pools 3 and 8). The selection pressure in pools 3 and 8 was on selecting ears with large kernels. The selected ears from 1976 harvest were planted both at Batan and Toluca.

3.3.2.4 Conversion of Populations that are Being Selected for Plant Efficiency and Adaptation, 1976: Two additional generations were advanced during 1976 in six opaque-2 versions of special project materials. Selection emphasis was mainly placed on kernel hardness, plus plant and ear characteristics. The number of ears saved from each population in each season is indicated in Table 3.3.11.

3.3.2.5 Conversions of Populations that are Being Selected for Earliness, Plant Efficiency and Adaptation, 1977: Table 3.3.11 shows the number of hard endosperm opaque-2 families saved from each population during different seasons. Most of these materials (except Selección Preco7) looked very good. The families from these materials also have been planted in Tlaltizapan and Obregon to exert more pressure for stability of genetic modifiers controlling kernel hardness in opaque-2 materials.

3.3.3 POPULATION IMPROVEMENT

3.3.3.1 1976 Program: During 1976A, 250 full-sib families were developed in four different opaque-2 populations at Poza Rica: Tuxpeño opaque-2 (Pop. 37); PD(MS)6 H.E. O_2 (Pop. 38); CIMMYT H.E. O_2; and White opaque-2 Back-up pool. The 250 full-sibs plus six check entries were tested in 16 x 16 simple lattice designs at three locations within Mexico during 1976B, at Poza Rica, Tlaltizapan and Obregon. Table 3.3.12 shows the performance of these four populations. The mean yield of the selected families is greater than the mean of tested families in all four populations, in both site-specific and across-location data. The selection differential (in per cent) was Tuxpeño opaque-2 (10.44 per cent); PD(MS)6 H.E. O_2 (9.97 per cent) CIMMYT H.E. O_2 (9.66 per cent) and White opaque-2 Back-up pool (9.12 per cent).

In all four populations, the data show the selected families to be shorter in plant height and one day earlier, as compared to the tested families. A total of 250 families from Yellow H.E. O_2 were sent to six different countries for progeny evaluation.

PD(MS)6 H.E. O_2—On the basis of progeny trial data, 93 full-sib families were selected. The mean yield of selected families showed a superiority of 8.17 per cent, 9.62 per cent, 11.37 per cent and 9.97 per cent in Poza Rica, Tlaltizapan, Obregon, and across-location data, respectively. The mean plant height of selected families was 1 to 2 cm shorter than that of tested population; the selected families were also one day earlier to flower. The selected families were planted in 1977A at Poza Rica to generate a new set of 250 reciprocal full-sibs. The 250 full-sibs, along with six checks, were sent to six different countries.

CIMMYT H.E. O_2—Grain yield, plant height, kernel hardness, and other agronomic characters, were considered in selecting 96 full-sib families, using data from three locations. The mean of the selected families showed selection differentials of 8.62 per cent in Poza Rica; 7.56 per cent in Tlaltizapan, 12.69 per cent in Obregon and 9.66 per cent in across-location data. The mean plant height of selected families was 2 to 3 cm shorter than the mean of tested families, and the selected families were about one day earlier to flower. The selected families were planted in Poza Rica during 1977A to generate a new set of 250 full-sibs. At harvest, not one ear in this population was segregating for soft endosperm. The new full-sibs have been planted in progeny trials within Mexico at three locations (Table 3.3.13). Based on the progeny trial data, the selected families could replace old Pop. 39.

White Opaque-2 Back-up Pool (Full-sibs)—Table 3.3.16 lists the means for yield and other characters of 250 tested families. Based on the performance of 250 families, 99 full-sibs were selected. The mean of selected families showed grain yield superiority of 7.54 per cent at Poza Rica; 10.92 per cent at Tlaltizapan; 8.30 per cent at Obregon, and 9.12 per cent in across location data, as compared to the means of tested families. The selected families also were, on average, about one centimeter shorter in plant height and one day earlier to flower. The selected families were used to generate 250 new full-sib families in Poza Rica

during 1977A. The families of this material were sent to six different locations in replacement of white hard endosperm opaque-2 (Pop. 40). Table 3.3.14 shows the distribution of progeny trials.

Tuxpeño Opaque-2 (Pop. 37)—Tuxpeño opaque-2 is the only soft opaque-2 material in the tropical-lowland program. The full-sib families generated in Poza Rica during 1976A were tested at three locations within Mexico. Based on the performance of 250 full-sibs, 84 families were selected. These were planted in Poza Rica during 1977A to generate a new set of 250 reciprocal full sibs. The new full-sibs, along with six check entries, were planted in progeny trials at Poza Rica and Tlaltizapan during 1977B.

Yellow H.E. O_2 (Pop. 39)—During 1976, 250 full-sib families from Yellow H.E. O_2 were sent to six countries for evaluation.

3.3.4 DEVELOPMENT OF EXPERIMENTAL VARIETIES

3.3.4.1 1976 Development: On the basis of 1975 data, a number of site-specific and across-site experimental varieties were developed. A total of 14 experimental varieties were developed from three Advanced unit opaque-2 populations; these are listed in Table 3.3.15. The table also shows the mean grain yield and other agronomic traits of experimental varieties developed by recombining the best 10 families from each of the three Advanced unit populations on the basis of site-specific and across-site data. The mean of these experimental varieties was superior to the mean of the population and to the mean of check entries. The experimental varieties superioritv in yield ranged from 10.3 to 80.0 per cent when compared to the mean of the population, and from 4.5 to 296.1 per cent when compared to the mean of the checks. The experimental varieties, on average, were either equal to or one to two days earlier than the population. The plant height of experimental varieties varied 1 to 9 cm shorter than that of the population.

3.3.4.2 1977 Development: On the basis of 1976 data, four experimental varieties were developed from Yellow H.E. O_2 (Pop. 39). On average, the 10 families making up the experimental varieties showed yield advantages of 32.2 per cent and 22.3 per cent over the population yields in varieties Santa Rosa 7639 and Tocumen 7639, respectively (Table 3.3.16). Similarly, the experimental varieties were 1 to 2 cm shorter, and had 8.0 to 9.8 per cent less ear rot as compared to the population.

The four experimental varieties developed from Yellow H.E. O_2 are listed in Table 3.3.16. The table also shows the mean grain yield and other agronomic traits of experimental varieties that were developed by recombining the best 10 families on the basis of site-specific and across-location data. On average, the four experimental varieties developed from Yellow H.E. O_2 were superior to the population and the check entries. In yield, the experimental varieties were superior to the population by 22.3 per cent to 60.2 per cent, and were superior to the checks by 16.5 per cent to 174.6 per cent. In days-to-silk, the experimental varieties were either equal to or one day [illegible] than the mean of the population. However, the [illegible] height of all the experimental varieties was greater [illegible] to 3 cm than that of the population. There was less ear rot incidence in all the experimental varieties, as compared to the mean of the 250 tested families.

The experimental varieties developed above were included in EVT-15 during 1977.

3.3.5 DEVELOPMENT OF BROADBASED OPAQUE-2 MATERIALS AT BACK-UP STAGES OF THE PROGRAM

3.3.5.1 Development 1976-77: Several broadbased germplasm sources developed in the last four years are listed in Table 3.3.17. These materials are described briefly below.

Intensive research efforts have been under way for the last four years to develop hard endosperm opaque-2 materials with modifiers accumulated from a wide range of maize materials being grown in different areas of the world. The major emphasis has been on increasing kernel vitreosity, while maintaining the same protein quality as that of soft opaque-2 materials. The pressure on these materials has been somewhat mild for other characters in the initial cycles; however, because these materials have fairly good kernel type and acceptable appearance, considerable pressure is now being exerted for important agronomic traits, in addition to improving kernel vitreosity and maintaining protein quality. In some materials where kernel appearance is acceptable, more pressure will be exerted on the stability of opaque-2 modifiers responsible for changing soft endosperm to hard endosperm. Table 3.3.17 provides a brief description and lists the stage of development of some materials of tropical and temperate origin.

PD(MS)6 H.E. O_2—After the fourth cycle of selection, 467 ears selected in 1975 were planted on family basis at Poza Rica during 1976A. Reciprocal plant-to-plant crosses were made among families to develop full-sibs. These full-sibs were evaluated in progeny trials at different locations within Mexico. Plans were underway to use this material as the regular Advanced unit (Pop. 38) in six different locations.

CIMMYT H.E. O_2—Following the fourth cycle of selection, 402 half-sib ears were saved for planting on a family basis during 1976A at Poza Rica. Before pollination some of the families were rejected on the basis of protein and tryptophan analyses. In families that had acceptable values,

reciprocal plant-to-plant crosses were made. At harvest, 250 full-sib pairs were saved. These were evaluated in progeny trials at 3 locations within Mexico during 1976B.

White Opaque-2 Back-up Pool—This material has white flint and dent grain type with an attractive hard endosperm texture. Two additional cycles of genetic mixing were achieved in a half-sib crossing block during 1976B and 1977A at Poza Rica. Following each cycle of recombination, half-sib ears with good appearance were selected from short, disease-free plants. Selection of modified opaque-2 kernels from each ear separately for the next planting was continued, along with elimination of families with low protein quantity and quality as in the previous cycles.

This pool has been further broadened by the addition of some very good hard-endosperm opaque-2 families identified in Advanced and Back-up conversions. These materials were added as female rows only in the recombination block of 1977A. The selected ears from these families will enter as male and female families in the next season's recombination block.

A number of good families from this pool were taken out and handled separately in the breeding nursery. In 1976A, 250 full-sibs were developed in a reciprocal manner. These were evaluated in progeny trials as described in a separate section.

Yellow Opaque-2 Back-up Pool—This material is yellow, and has a mixture of flint and dent grain types. Two additional cycles of recombination were completed during 1976B and 1977A. The number of families saved after each cycle of recombination is shown in Table 3.3.17. The ears were shelled individually and sorted for the best modified opaque-2 segregates from each ear, separately, for the next planting. In addition to enhancing the frequency of favorable modifiers and maintaining the protein quality, a very intense selection pressure was exerted for shorter plant type, in male and female rows.

During the year 1977A, some additional hard endosperm opaque-2 materials were added to this pool as female entries only. The selected ears from these newly added materials will enter into next year's recombination block in exactly the same way as half-sib ears from the core of the pool.

After the third cycle of recombination, some outstanding families from the yellow opaque-2 back-up pool were handled separately in the breeding nursery. Full-sib pollinations were made during 1976A and 1976B. Table 3.3.17 shows the number of ears saved in each generation. In 1977A, the 108 full-sib ears saved during 1976B were planted on a family basis. Only short and disease-free plants in good families were self-pollinated. At harvest, a total of 82 promising S_1 ears were saved for further selection in the next season. The harvested ears were relatively good and were planted at Poza Rica and Obregon during 1977B to put more pressure on achieving stability of modifiers.

Yellow Flint H.E. O_2—This material was produced by the recombination of 207 hard endosperm opaque-2 families from five different materials. The recombinations were made in a full-sib mating system among families of different groups. At harvest, 237 full-sib ears were saved that had very good endosperm hardness. The selected ears were planted both at Poza Rica and Obregon to screen families that are stable in modified endosperm character. Reciprocal plant-to-plant crosses within families are being made to exploit variation for plant and ear characteristics.

Late White Dent H.E. O_2—White dent hard endosperm opaque-2 families from a number of materials were genetically mixed to form this population. From the harvest in 1976B, 176 full-sib ears were saved. The selected ears were subjected to a second cycle of recombination during 1977A at Poza Rica. Following the second cycle of recombination, 146 full-sibs were selected, which have been planted in Poza Rica and Obregon to increase the frequency of favorable modifiers stable over environments.

Temperate x Tropical H.E. O_2—In the subtropical-temperate program, Temperate x Tropical H.E O_2 is perhaps the most advanced opaque-2 population; it has excellent plant type, good yielding ability, and acceptable ear and kernel characteristics. Two additional cycles of recombination were achieved in a half-sib crossing block during 1976B and 1977A. The number of half-sib ears saved in each cycle of recombination is shown in Table 3.3.17. The harvested ears from 1977A cycle have been separated into flint and dent groups, which were planted in two separate recombination blocks during 1977B. Also, the half-sib families from flint and dent groups have been planted at Poza Rica and Obregon for observation to examine the stability of modifiers and reaction to some of the leaf diseases that normally do not occur at Tlaltizapan.

Promising families from this population also are being handled separately in a full-sib selection scheme. This selected fraction of Temperate x Tropical H.E. O_2 population could produce a new Advanced unit population.

3.3.5.2 Highland Opaque-2 Materials: A number of highland composites and other highland opaque-2 materials have been developed over the past few years. Three highland opaque-2 composites (Composite I, High Altitude Opaque-2 Composite and Puebla Opaque-2 Composite) completed the fourth cycle of recombination during 1976. The number of families involved in recombination in these materials are listed in Table 3.3.18. The half-sib ears selected from the fourth cycle of recombination have been planted at Batan and Toluca to undergo a fifth cycle of genetic mixing and to increase adaptation of these materials. Since two of the highland composites are very similar in plant type, maturity and ear characteristics, 242 families of Composite I and 174 families of High Altitude O_2 Composite have been planted in the same recombination block to achieve the fifth cycle of mixing and selection.

In addition to the above composites, a new composite (Highland Modified Opaque-2 Composite) was formed from F_2 hard endosperm opaque-2 families identified from the conversion of different highland pools to opaque-2. From the first cycle of recombination in Batan, 205 ears were saved that were completely modified, or that were segregating for modified kernels. The vitreous segregates were carefully sorted from each ear separately, and these have been planted both in Batan and Toluca to undergo a second cycle of mixing.

There is a need for some early opaque-2 materials for very high altitude areas above 2,500 meters. The cross of Puebla O_2 composite with Barraza was made with this objective. The F_1 was advanced to F_2 at Toluca. Opaque-2 kernels were sorted from 200 selected segregating ears, and planted in a half-sib crossing block at Toluca during 1976. A total of 157 F_3 half-sib ears were selected which were planted at Toluca in 1977 to undergo another generation of mixing and selection for earliness and other agronomic characters.

A number of modified hard endosperm opaque-2 families from a number of materials also are being handled by full sib selection. The families planted in each of these materials are listed in Table 3.3.18. These materials will be merged with other appropriate materials.

3.3.6 PROTEIN CONTENT AND QUALITY

3.3.6.1 Protein Content and Quality of Opaque-2 Materials in the Back-up stage of the program: The families analyzed for protein and for tryptophan in protein in several opaque-2 materials in the Back-up unit are listed in Table 3.3.19. The mean values for protein and tryptophan in protein also are listed. The mean of analyzed families for protein content was above 7 per cent; and the mean for tryptophan in protein was 0.70 per cent and above in endosperm.

The bulk samples of opaque-2 conversions of the most promising Back-up and Special Project materials from 1976A harvest were analyzed for protein, lysine and tryptophan in the whole grain. The results are shown in Table 3.3.20.

A complete amino-acid analysis of the whole grain in some promising hard endosperm opaque-2 materials indicated that protein content in these materials ranged from 9.6 to 11.2 per cent. The levels of lysine were fairly good, and these ranged from 3.4 to 3.8 per cent in protein in the whole grain. The levels of other amino-acids were in general fairly consistent though these varied somewhat in different materials (Table 3.3.21).

3.3.6.2 The Protein Content and Quality of Opaque-2 Converted Materials: The ears selected in each generation further underwent selection for the best vitreous segregates that are available in each ear. In general, 10 seeds from each family were analyzed for protein and tryptophan content. The families that did not meet the minimum acceptable levels are eliminated before pollination. This means that pollinations were restricted among selected families. The mean values of families analyzed for both protein content and quality in each population from different cycles were generally fairly good.

In some materials, a Dye Binding Capacity (DBC) analysis was made. The quality of protein in such materials was indicated by a quality index value that was calculated by dividing DBC value by per cent protein in the whole grain. Values above 3.5 represent a good quality of protein. Table 3.3.21, shows that most of the materials analyzed by this method had good protein quality.

3.3.7 BIOCHEMICAL ANALYSES OF SOME PROMISING HARD ENDOSPERM OPAQUE-2 MATERIALS

Some of the most promising hard endosperm opaque-2 materials have been analyzed for complete amino-acid analysis (Table 3.3.21). In general, there were acceptable levels of lysine and tryptophan in protein.

The same six materials were analyzed for different protein fractions in the endosperm (Table 3.3.23). In general, the alcohol-soluble fraction formed about one-third of the total protein in the endosperm. Each of the other two fractions also constituted about one-third of the total protein.

3.3.8 SUGARY-2/OPAQUE-2 CONVERSION

Since 1975, all important normal and opaque-2 materials in CIMMYT's maize improvement program have been crossed to a sugary-2/opaque-2 source in a half-sib crossing block. The resulting F_1 crosses were harvested from both normal and opaque-2 materials. Since that time, F_1 crosses of normal and opaque-2 materials have been handled slightly differently to recover sugary-2/opaque-2 segregates.

The double mutant segregates were recovered from the crosses of normal and sugary-2/opaque-2, in a two-step program. The F_1's were advanced to F_2, and then soft opaque-2 kernels were selected from each F_2 ear. The recovered segregates were planted the following season on a family basis. A number of plants were selfed in each family. At harvest, only those selfed ears were saved that were segregating for sugary-2 kernels.

The sugary-2/opaque-2 segregates were recovered in the second group involving crosses between opaque-2 and sugary-2/opaque-2 materials. Hard endosperm opaque-2 segregates were sorted from the F_1 crosses, on a family basis, in each material separately. These were planted in the next season and the pollinations were made in a full-sib procedure. Promising ears segregating for sugary-2 kernels were selected at harvest. The selected ears from each material were shelled individually, and then sorted for opaque-2 and sugary-2/opaque-2 segregates. Detailed

observations were recorded on several characters to compare opaque-2 segregates with sugary-2/opaque-2.

Comparisons of one-hundred kernel weight, volume in c.c., and kernel density of opaques and sugary-2/opaque-2 from several materials are shown in Table 3.3.24. Sugary-2/opaque-2 segregates, in general, had lower kernel weight and reduced kernel volume compared to opaque-2 segregates. The segregates of double mutant combination, however, registered a higher kernel density as compared to the counterpart opaques.

The two kinds of segregates from each material also were subjected to protein, lysine, and DBC analyses of the whole grain. The results are shown in Table 3.3.25. The two segregates, in general, did not differ greatly. The same was true for lysine and DBC. In some materials, however, differences were apparent, but there seemed to be no consistent trend.

A complete amino-acid analysis was made of the whole grain of opaque-2 and sugary-2/opaque-2 segregates in eight selected materials (Table 3.3.26). The results indicate that sugary-2/opaque-2 segregates had somewhat higher protein content than did the soft opaque-2 segregates. In some materials, however, the differences were negligible. The two important amino acids—lysine and tryptophan—did not differ greatly between the two types of segregates. Other amino acids—glutamic acid, leucine and tryosine—were found in somewhat larger amounts in opaque-2 segregates as compared to the sugary-2/opaque-2 segregates.

Correlation coefficients (r) among several characters of opaque-2 and sugary-2/opaque-2 segregates recovered from 27 segregating populations were calculated separately for each type of segregate (Table 3.3.27). Kernel weight and volume were positively correlated—whereas kernel volume and density were negatively correlated—in both types of segregates. There also was a negative and significant correlation between protein and lysine levels in the endosperm.

The protein fractions in the endosperm of eight sugary-2/opaque-2 materials were analyzed also (Table 3.3.28). Alcohol soluble and acid soluble fractions each constituted about one-fourth of the total protein. The glutelin fraction was much greater and formed about one-half of the total protein.

Based on the above findings, and observations made in the field, these general conclusions can be made about the sugary-2/opaque-2 segregates:

– Sugary-2/opaque-2 segregates vary considerably in their phenotypic appearance in different genetic backgrounds. The segregates of double mutant combination varied in grain size. In general, they were smaller than their counterpart opaques, but exceptions were observed.

– Sugary-2/opaque-2 segregates in dent backgrounds were dented, but failed to show soft starch in the dented portion.

– The double mutant segregates had a vitreous appearance, but there was often existence of the inner soft endosperm characteristic of the opaque-2 gene.

– In some backgrounds, the sugary-2/opaque-2 segregates had intensified color.

– Mosaic phenotypic appearance in sugary-2/opaque-2 segregates also was observed in some segregates.

– Ears homozygous for sugary-2/opaque-2 tended to shell easily.

– Spaces between and within kernel rows were clearly visible as a result of the failure of sugary-2/opaque-2 segregates to attain normal grain size, probably due to early curtailing of dry matter accumulation.

– The protein content and protein quality of sugary-2/opaque-2 segregates was as good or better than the soft opaque-2 segregates.

– In developing the double mutant combination, it was decided that the selected segregates should have acceptable appearance and be comparable in size to the normal counterparts.

The sugary-2/opaque-2 segregates of families originating from normal and opaque-2 materials were recombined during 1977A at Tlaltizapan to produce a sugary-2/opaque-2 composite. About 800 families from several materials were included in the first cycle of recombination. The ears selected from the first cycle of recombination have been planted at Tlaltizapan during 1977B to undergo the second cycle of recombination.

3.3.9 TRANSFER OF OPAQUE-2 GENE INTO FLOURY-1 BACKGROUNDS

3.3.9.1 1976 Program: Conversion of floury-1 materials with big-seeded kernel types from the Andean region is well under way. F_1 crosses of a number of materials from different countries with opaque-2 were advanced to F_2. In the segregating F_2 materials, the opaque-2 segregates were identified by a Ninhydrin test on individual kernels. The selected segregates were planted as bulks, or on a family basis, at Batan during 1976. Large kernels also were selected with a Ninhydrin test, from segregating generations of crosses between opaque-2 and Pools 3 and 8. Selected kernels from each ear were planted on family basis. Crosses were made only among families. At harvest, only those ears with big kernels were selected to continue selection during 1977.

From the second cycle of recombination of floury-

opaque-2 composite in 1975, 300 ears with big kernel type were saved from harvests at El Batan and Toluca. These ears were shelled individually and large kernels were sorted from each to plant recombination blocks in Batan and Toluca during 1976. A total of 479 large kernel floury type ears were selected from both locations to continue the next cycle of selection.

Complete amino-acid analysis was made of a floury-opaque-2 composite from the second cycle of recombination (Table 3.3.22). This material had a protein content of 9.7 per cent, and a lysine content of 4.1 per cent in protein, in the whole kernel analysis.

3.3.9.2 1977 Program: Conversion of two floury pools in the highland program continues. Crosses of Pools 3 and 8 with a number of soft opaque-2 donors were advanced to F_2 in 1975. From the segregating ears, large kernels were selected and subjected to a Ninhydrin test. The selected segregates having quality protein were planted either as bulks or on a family basis at Batan during 1976. Plant-to-plant sib pollinations were made among families. At harvest, only ears with large kernels were selected. Some other materials, including Cacahuacintle, Amarillo harinoso and some promising varieties from the Andean countries, are being converted to opaque-2 by a similar method.

Table 3.3.29 shows the number of ears saved from opaque-2 versions of Pool 3 and Pool 8. From each of the 393 ears saved from Pool 3, large kernels were selected to plant in a half-sib recombination block both at Batan and Toluca during 1977. The selected ears from Pool 8 have been planted similarly, as Pool 3.

Families with very large seeds were selected separately during the 1976 harvest. Fifty-three such families have been planted at Batan for recombination during 1977.

Recombination of half-sib families, along with simultaneous selection for plant and ear characteristics, was continued in the floury-opaque-2 composite. At harvest and seed preparation time, considerable pressure was exerted for large seeds of floury types. From the third cycle of recombination, 479 ears were saved during 1976. The selected half-sib ears were planted at Batan and Toluca to undergo the fourth cycle of recombination and selection.

A bulk sample of the floury-opaque-2 composite was analyzed for per cent protein, different protein fractions, and complete amino-acid analysis of protein. The alcohol-soluble fraction (zein) formed 34.3 per cent of the protein. The acid-soluble and glutelin fractions constituted 28.4 per cent and 28.3 per cent of the protein, respectively. (Table 3.3.30.)

Complete amino-acid analyses of endosperm and whole grain in floury-opaque-2 composite indicated that the levels of lysine and tryptophan in protein were relatively high (Table 3.3.31).

3.3.10 INTERNATIONAL TESTING – 1976

CIMMYT's international program with opaque-2 materials consisted of three major components in 1976:

3.3.10.1 International Progeny Testing Trials: In 1976, the 23 Advanced unit materials were divided into two groups to make full use of data from all the locations around the world (see Appendix). In this division, Yellow H.E. O_2 will be handled in Group I; White H.E. O_2 and Tuxpeño opaque-2 will form part of the Group II. This grouping will permit the handling of opaque-2 materials in each group, every other year.

During the year 1976A, a new set of full-sib families was developed in Yellow H.E. O_2 (Pop. 39). The resulting full-sibs were sent out for evaluation in six different countries.

3.3.10.2 Experimental Variety Trial No. 15: A total of 15 Experimental Varieties were developed from three Advanced unit populations on the basis of 1975 IPTT data. These EVT's formed EVT-15, along with others developed on the basis of 1974 IPTT data arriving late. EVT-15 was sent to 36 different locations as shown in Table 3.3.32.

The trial consisted of 25 entries replicated four times and the results are shown in Table 3.3.33. The experimental varieties derived from Pop. 37 were top yield performers in many locations. The experimental varieties derived from Pop. 39, in general, did fairly well: the highest yielder was Cotaxtla 7439, followed by Across 7539 and Suwan 7439. Of the experimental varieties derived from White H.E. O_2, Across 7440 and La Máquina 7540 were the better performers. Amarillo Dentado H.E. O_2 and CIMMYT H.E. O_2 also performed relatively well on a population basis.

A number of entries in each location performed as well or better than the local checks.

3.3.10.3 Elite Experimental Variety Trial (ELVT-19): Seven varieties were selected as Elite varieties based on 1975 data from Experimental Variety Trial 15. The seven Elites, plus three checks, formed Elite Experimental Variety Trial (ELVT-19) which has been sent to 60 locations in different parts of the world. The trial consisted of 10 entries replicated four times, with four row plots; Table 3.3.32 shows the distribution and Table 3.3.34 shows the results.

The results available from 29 out of 60 locations indicate that experimental varieties derived from Pop. 37 were the top yielders, and that they outyielded the local opaque-2 check entry in many locations. The performance of these two varieties was slightly lower than the mean of the normal check entry. The performance of two Elite Experimental Varieties from Yellow H.E. O_2 was fairly similar, though their relative superiority differed in different locations. The performance of Across 7441 (Composite K), San Andres 7440 and Poza Rica 7441 also was fairly good.

3.3.11 INTERNATIONAL TESTING OF OPAQUE-2 MATERIALS – 1977

The international testing of opaque-2 materials in 1977 consisted of the following trials:

3.3.11.1 Progeny Trials: During 1977, 250 full-sib families of three different opaque-2 materials were sent to different countries for evaluation. The populations were: PD(MS)6 H.E. O_2 (Pop. 38), Temperate x Tropical H.E. O_2 (Pop. 41) which are new additions to the Advanced unit, and White H.E. O_2 (Pop. 40). The distribution of the trials is shown in Table 3.3.14.

3.3.11.2 EVT-15: This trial consists of 11 entries. Thirty-eight sets of this trial have been distributed to different countries. The distribution of the trial is shown in Table 3.3.32.

3.3.11.3 ELVT-19: This trial consists of 10 entries and has been distributed to 55 sites for planting. The distribution of this trial is shown in Table 3.3.32.

3.3.11.4 Distribution of Other Opaque-2 Materials: In addition to progeny and experimental variety trial seed shipments, opaque-2 maize samples in experimental quantities were shipped to 29 different countries. During the period January to June 1976, 84.3 kilos of opaque-2 maize seed was shipped.

For the period July to December 1976, 352.42 kilos of opaque-2 maize seed was shipped to 24 different countries.

3.4 INSECT RESISTANCE

3.4.1 SCREENING FOR INSECT RESISTANCE

In 1976B, sufficient insect larvae were produced by the laboratory to artificially infest five Advanced unit populations with fall armyworm, *Spodoptera frugiperda*, and for infestation of two Advanced unit populations with *Diatraea saccharalis* larvae. These infestations were made with a new technique which uses larvae instead of egg masses for infestation of plants to be evaluated. For the above infestations over 500,000 fall armyworm larvae were used in the field to determine the reaction of 12,500 plants; over 200,000 borer larvae were used to evaluate the reaction of 5,000 plants (Figures 3.4.A, 3.4.B and 3.4.C).

In addition, over 100,000 fall armyworm and 300,000 borer larvae were produced and used for infesting plots used by a Ph.D. candidate.

A Back-up unit goal in 1977 was to provide increasing levels of insect resistance, so that as progenies move through the system to the Advanced unit, they would be equal to or superior for this character.

In work with five tropical pools (21, 22, 23, 24, 25), half of each row was infested with fall armyworm larvae so that outstanding families and plants could be identified and selected, while the most susceptible could be discarded. Over several cycles of such selection, levels of resistance to this insect should improve.

3.4.2 INSECTICIDE TRIALS

Plant protection activities also include testing of newly developed insecticides. These trials identify more effective chemicals for protecting CIMMYT yield trials, breeding nurseries, and other plantings. Four such trials were conducted at Tlaltizapan and Poza Rica, where insect infestations are sometimes severely damaging. These trials were artificially infested with fall armyworm larvae. About a week after infestation, plants showing active larvae feeding were counted, then granular insecticides were applied with dispensing machines (bazookas). The bazooka places equal amounts of insecticide in the whorl of each plant. To determine length of effectiveness of the chemicals, plots were re-infested at weekly intervals (one or two additional re-infestations).

Results, as shown in Tables 3.4.1 and 3.4.2, indicate that these chemicals significantly reduce initial infestation, (as compared to the unprotected control plots) and some chemicals gave significant control for up to 3 weeks, in spite of deliberate re-infestations.

In 1977, plant protection activities included: (1) efforts to increase the amount and efficiency of production of the insect rearing laboratory; (2) small-scale field trials to refine the new method of larval infestation with regard to timing (plant stage), levels (number of larvae per plant) and placement (location on plant); (3) taking of periodic ratings on these trials to gain additional experience in evaluating and differentiating plant reaction to insect attack.

3.4.3 REARING TECHNIQUES

Advancements in the laboratory included identifying improved artificial diets and developing more efficient procedures for handling of the laboratory colonies. New oviposition substrates—waxed paper for fall armyworm, and plastic for borers—speeded up egg mass removal. The armyworm egg masses were scraped, and borer egg masses "popped", from the substrates much more efficiently than the traditional time-consuming methods of cutting or "punching" egg masses. Through changes in handling of adult corn earworms (*Heliothis zea*) a colony was established and mass production begun for the first time. Field trials determined optimal timing, levels, and placement in infestation for armyworm, borers and earworms. Rating scales were modified to distinguish difference in type and amount of damage, as well as to determine the best time to make evaluations after infestation.

TABLE 3.3.1.- Conversion of advanced unit materials to opaque-2 (1976-77).

Population	Pedigree	No. of hard endosperm o_2 ears saved			No. of families stable for kernel hardness
		1976A	1976B	1977A	1977B
21	Tuxpeño - 1	93	211	401	220
22	Mezcla tropical blanca	320	126	154	94
23	Blanco cristalino-1	256	361	266	-
24	Ant. x Ver. 181	295	225	233	126
25	Mix.1- Col.Gpo.1 x	160	79	189	147
26	Mezcla Amarilla	254	191	162	104
27	Amarillo Cristalino	399	212	148	66
28	Amarillo Dentado	256	144	228	144
29	Tuxpeño Caribe	336	175	233	107
30	Blanco Cristalino-2	109	-	49	-
32	Eto Blanco	240**	293	234	211
33	Amarillo sub-tropical	271	226	243	134
34	Blanco sub-tropical	96	56	165	32
35	Ant. x Rep. Dominicana	199**	312	209	118
36	Cogollero	-	-	36	4
42	Eto x Illinois	29	90	74	32
43	La Posta	216	114	288	147
48	Compuesto de Hungría	65***	42	62	39

** F_2 ears harvested in 1976A.

*** F_3 ears harvested in 1976A.

TABLE 3.3.2.- One hundred kernel weight comparison of normals and opaques in some segregating materials.

S. No.	Pedigree	No. of samples	100 kernel weight(g) Normal	100 kernel weight(g) Opaques	Range*	Mean decrease in weight of opaques over normal (%)
1	(Tuxpeño-1 x White H.E.o_2)-#	331	26.53	24.42	0.0-38.5	7.95
2	(Ant.Gpo.2-Rep.Dom. x H.E.o_2)xPD(MS)6 H.E.o_2	68	31.81	29.70	0.0-20.2	6.63
3	(Ant.Gpo.2-Rep.Dom. x PD(MS)6 H.E.o_2) x PD(MS)6 H.E.o_2	58	28.72	26.75	0.0-24.9	6.86
4	(White H.E.o_2 x Eto Blanco)-#	112	35.17	31.22	0.0-25.2	11.25
5	(PD(MS)6 H.E.o_2 x Eto Blanco)-#	129	36.47	32.59	0.0-26.8	10.65
6	(H.E.o_2 x Ant.Gpo.2-Rep.Dom.)-#	71	26.42	25.04	0.0-19.4	5.24
7	(Ver.181-Ant.Gpo.2xVen. $1o_2$ x Eto Blanco)-#	125	28.89	26.99	0.0-21.7	6.58

* Percent decrease in weight of opaques over normals.

TABLE 3.3.3.- Conversion of Tropical gene pools to opaque-2 (1976-77).

Pool No.	Name	No. of hard endosperm opaque-2 ears saved 1976A	1976B	1977A	No. of BC_1 ears saved during 1977A	No. of stable H.E.o_2 fam. 1977B
Pool 15	Tropical early white flint	--	--	15*	--	29**
Pool 16	Tropical early white dent	--	--	31*	--	70**
Pool 17	Tropical early yellow flint	--	--	9*	--	17**
Pool 18	Tropical early yellow dent	--	--	15*	--	34**
Pool 19	Tropical intermediate white flint	208	87	99	31	38
Pool 20	Tropical intermediate white dent	157	92	86	26	38
Pool 21	Tropical intermediate yellow flint	154	97	97	30	34
Pool 22	Tropical intermediate yellow dent	211	178	145	30	84
Pool 23	Tropical late white flint	221	268	264	28	133
Pool 24	Tropical late white dent	151	154	163	30	72
Pool 25	Tropical late yellow flint	112	71	86	17	47
Pool 26	Tropical late yellow dent	240	262	204	30	118

* F_1 ears.
** F_2 ears.

TABLE 3.3.4.- Kernel weight, volume and density comparisons of normal and hard endosperm opaque-2 segregates recovered from segregating populations (1977).

Population	Origin	No. of ears	100 kernel weight in gms. normal	opaques	diff. (%)	Volume in ml. normal	opaques	diff. (%)	Density (gms/ml) normal	opaques	diff (%)
Amarillo Dentado H.E.o_2	PR-77A 308	62	34.08	29.70	12.51**	27.12	25.29	6.38**	1.26	1.17	6.46**
Mix.1-Col.Gpo.1 x Eto H.E.o_2	309	65	31.32	28.43	8.78**	25.53	24.34	4.18**	1.23	1.17	4.59**
Mezcla Amarilla H.E.o_2	311	35	30.85	27.57	9.98**	23.89	23.21	2.06	1.29	1.19	7.98**
Cogollero H.E.o_2	329	28	27.77	24.77	10.27**	22.51	21.53	3.91**	1.23	1.15	6.45**
(Blanco Cristalino x Blanco Cristalino H.E.o_2)-F_2	330	49	31.79	26.92	15.15**	25.76	23.71	7.81**	1.24	1.14	7.86**
Tuxpeño 1 H.E.o_2	Lote 93	61	34.17	30.52	10.54**	27.32	26.51	2.69**	1.25	1.15	7.91**
Tuxpeño Caribe H.E.o_2	Lote 94	57	35.61	32.79	7.72**	29.00	28.03	3.10**	1.23	1.17	4.65**

** Significant at 1% level of probability.

TABLE 3.3.5.- Means of 100-kernel weight, volume, and density of normals and opaques from segregating ears of different populations (1977).

Population	Origin	No. of ears	100-kernel weights in grams normals	opaques	diff. (%)	Volume in ml. normals	opaques	diff. (%)	Density (gms/ml.) normals	opaques	diff. (%)
Pool 27 H.E.o_2	TL-77A 1304	27	30.97	28.82	6.66**	25.96	25.04	3.28**	1.19	1.15	3.44**
Pool 34 H.E.o_2	1305	12	34.02	31.63	6.90**	28.08	28.05	0.04	1.21	1.13	6.82**
Blanco subtropical H.E.o_2	1312	96	35.86	32.02	10.53**	29.29	28.63	2.15**	1.23	1.12	8.52**
Hungarian Composite H.E.o_2	1316	44	31.91	29.62	7.02**	26.38	26.32	0.23	1.21	1.13	6.99**
Pool 30 H.E.o_2	1317	14	33.41	31.69	5.03**	28.04	27.91	0.47	1.19	1.14	4.53**
Pool 33 H.E.o_2	1318	31	32.60	30.27	6.96**	26.40	26.06	1.17	1.24	1.16	5.78**
Pool 29 H.E.o_2	1319	34	29.79	27.84	6.50**	24.31	23.58	2.92**	1.23	1.18	3.59**
(Pool 31 x Temp.Trop.H.E.o_2)F_2	1320	66	33.38	30.10	9.68**	27.09	26.84	0.94	1.23	1.12	8.72**

** Significant at the 1% level of probability.

TABLE 3.3.6.- Number of families rejected on the basis of kernel weight comparison of normals and opaques in different segregating populations (1977).

Material	Origin	No. of segregating ears	No. of ears rejected in each population*
	PR-77A		
Amarillo Dentado H.E.o_2	308	62	19
Mix.1-Col.Gpo.1 x Eto H.E.o_2	309	65	18
Mezcla Amarilla H.E.o_2	311	35	11
Cogollero H.E.o_2	329	28	11
(Blanco Cristalino-2 x Blanco Cristalino H.E.o_2) -F_2	330	49	24
Tuxpeño 1 H.E.o_2	Lote 93	61	22
Tuxpeño Caribe H.E.o_2	Lote 94	57	15

* Kernel weight difference in normals and opaques more than 10%.

TABLE 3.3.7.- No. of ears with more than 10% difference in 100-kernel weight between normals and opaques in segregating materials (1977).

Material	Origin	Total No. of ears	No. of ears with more than 10% diff. between normals and opaques.
	TL-77A		
Pool 27 H.E.o_2	1304	27	6
Pool 34 H.E.o_2	1305	12	2
Blanco subtropical H.E.o_2	1312	96	40*
Hungarian Comp. H.E.o_2	1316	44	9
Pool 30 H.E.o_2	1317	14	1
Pool 33 H.E.o_2	1318	31	6
Pool 29 H.E.o_2	1319	34	12
(Pool 31 x Temp.xTrop. H.E.o_2)-F_2	1320	66	28*

* Ears with more than 11% difference between normals and opaques.

TABLE 3.3.8.- Conversion of tropical and temperate gene pools to opaque-2 (1976-77).

Pool No.	Name	No. of hard endosperm opaque-2 ears saved 1976A	1976B	1977A	No. of BC_1 ears saved during 1977A
A)	TROPICAL POOLS				
19	Tropical intermediate white flint	208	87	99	31
20	Tropical intermediate white dent	157	92	86	26
21	Tropical intermediate yellow flint	154	97	97	30
22	Tropical intermediate yellow dent	211	178	145	30
23	Tropical late white flint	221	268	264	28
24	Tropical late white dent	151	154	163	30
25	Tropical late yellow flint	112	71	86	17
26	Tropical late yellow dent	240	262	204	30
	TOTAL	1454	1209	1144	222
B)	TEMPERATE POOLS				
27	Temperate early white flint	74	43	109	--
28	Temperate early white dent	--	--	14*	--
29	Temperate early yellow flint	--	19*	61**	--
30	Temperate early yellow dent	--	30*	47**	--
31	Temperate intermediate white flint	--	39*	101**	--
32	Temperate intermediate white dent	96	60	165	--
33	Temperate intermediate yellow flint	21	24	86	--
34	Temperate intermediate yellow dent	109	65	126	--
	TOTAL	300	280	709	--

* F_1 ears

** F_2 ears

TABLE 3.3.9 .- Comparison of 100 kernel weight of normals and opaques in segregating F_2 ears of highland materials undergoing conversion program.

S. No.	Pedigree	No. of samples	Normal	Opaques	Difference	Percent decrease over Normal
1	(Pool 1 x Mat.o_2 Comp.)-#	36	35.7	30.6	5.1	14.3
2	(Pool 1 x Hungarian o_2 Comp.)-#	33	36.7	31.6	5.1	13.9
3	(Pool 1 x Puebla o_2 Comp.)-#	83	39.5	34.2	5.3	13.4
4	(Pool 2 x Mat.o_2 Comp. H.E.)-#	27	29.6	26.4	3.2	10.8
5	(Pool 2 x Syn.A+Comp.I H.E.o_2)-#	56	32.9	29.0	3.9	11.9
6	(Pool 2 x Hungarian o_2 Comp.)-#	51	32.4	27.9	4.5	13.9
7	(Pool 2 x Puebla o_2 Comp.)-#	70	40.3	33.8	6.5	16.1
8	(Pool 3 x floury-1 o_2 Comp.)-#	42	49.3	45.4	3.9	7.9
9	(Pool 3 x Hungarian o_2 Comp.)-#	32	49.9	43.9	6.0	12.0
10	(Pool 3 x Mat.o_2 Comp.)-#	55	49.0	42.8	6.2	12.7
11	(Pool 3 x Puebla o_2 Comp.)-#	57	54.5	49.4	5.1	9.4
12	(Pool 4A x Mat.o_2 Comp.)-#	19	30.9	27.2	3.7	12.0
13	(Pool 4A x Hungarian o_2 Comp.)-#	45	36.0	32.2	3.8	10.6
14	(Pool 4A x Puebla o_2 Comp.)-#	49	39.2	34.2	5.0	12.8
15	(Pool 4B x Mat.o_2 Comp.)-#	44	32.7	28.1	4.6	14.1
16	(Pool 4B x Hungarian o_2 Comp.)-#	54	33.3	29.1	4.2	12.6
17	(Pool 4B x Puebla o_2 Comp.)-#	58	37.8	30.9	6.9	18.3
18	(Pool 5A x Mat.o_2 Comp.)-#	81	33.7	28.7	5.0	14.8
19	(Pool 5A x Syn.A+Comp.I)-#	60	36.0	31.0	5.0	13.9
20	(Pool 5A x Puebla o_2 Comp.)-#	43	40.1	32.5	7.6	19.0
21	(Pool 5B x Mat.o_2 Comp.)-#	33	32.0	28.1	3.9	12.2
22	(Pool 5B x Syn.A+Comp.I)-#	24	34.0	29.8	4.2	12.4
23	(Pool 5B x Puebla o_2 Comp.)-#	28	38.2	33.8	4.4	11.5
24	(Pool 5B x Hungarian o_2 Comp.)-#	27	33.6	31.2	2.4	7.1
25	(Pool 7 x Syn.A+Comp.I)-#	26	34.7	31.2	3.5	10.1
26	(Pool 7 x Mat.o_2 Comp.)-#	22	36.9	33.1	3.8	10.3
27	(Pool 7 x Hungarian o_2 Comp.)-#	24	33.1	30.8	2.3	6.9
28	(Pool 7 x Puebla o_2 Comp.)-#	34	40.9	36.5	4.4	10.8
29	(Pool 8A x floury 1 o_2 Comp.)-#	23	55.1	51.6	3.5	6.4
30	(Pool 8A x Hungarian o_2 Comp.)-#	16	44.6	40.8	3.8	8.5
31	(Pool 8A x Mat.o_2 Comp.)-#	21	46.9	44.3	2.6	5.5
32	(Pool 8A x Puebla o_2 Comp.)-#	33	54.9	50.2	4.7	8.6
33	(Pool 8B x floury 1 o_2 Comp.)-#	23	53.6	50.0	3.6	6.7
34	(Pool 8B x Mat.o_2 Comp.)-#	36	47.7	44.3	3.4	7.1
35	(Pool 8B x Hungarian o_2 Comp.)-#	35	48.2	44.7	3.5	7.3
36	(Pool 8B x Puebla o_2 Comp.)-#	46	51.3	47.9	3.4	6.6
37	(Pool 9 x Mat.o_2 Comp.)-#	34	31.1	28.9	2.2	7.1
38	(Pool 9 x Hungarian o_2 Comp.)-#	36	32.8	30.8	2.0	6.1
39	(Pool 9 x Syn.A+Comp.I)-#	40	35.2	32.2	3.0	8.5
40	(Pool 9 x Puebla o_2 Comp.)-#	48	38.7	34.1	4.6	11.9
41	(Pool 9 x Syn.B+Comp.I)-#	44	33.4	30.9	2.5	7.5
42	(Pool 10 x Syn.A+ Comp.I)-#	46	31.4	28.2	3.2	10.2
43	(Pool 10 x Hungarian o_2 Comp.)-#	25	34.8	31.4	3.4	9.8
44	(Pool 10 x H.E.o_2)-#	66	34.4	31.1	3.3	9.6
45	(Pool 10 x Mat.o_2 Comp.)-#	24	37.6	32.4	5.2	13.8
46	(Pool 10 x Puebla o_2 Comp.)-#	29	37.0	31.8	5.2	14.1
47	(Pool 10B x Syn.A+ Comp.I)-#	14	34.0	30.7	4.2	12.0
48	(Pool 10B x Hungarian o_2 Comp.)-#	16	32.3	29.9	2.4	7.4
49	(Pool 10B x Comp.I H.E.o_2)-#	16	33.5	31.6	1.9	5.7
50	(Pool 10B x Mat.o_2 Comp.)-#	20	34.9	30.3	4.6	13.2
51	(Pool 10B x Puebla o_2 Comp.)-#	16	37.5	33.1	4.4	11.7
52	(Pool 11 x Syn.B+Comp.I)-#	10	34.2	29.8	4.4	12.9
53	(Pool 11 x Puebla o_2 Comp.)-#	11	39.1	36.4	2.7	6.9
54	(Pool 11 x High altitude o_2 Comp.)-#	3	39.3	36.0	3.3	8.4
55	(Pool 12 x Syn.A+Comp.I)-#	13	33.8	31.1	2.7	8.0
56	(Pool 12 x Mat.o_2 Comp.)-#	12	38.5	32.7	5.8	15.1
57	(Pool 12 x Hungarian o_2 Comp.)-#	9	36.4	33.8	2.6	7.1
58	(Pool 12 x Comp.I H.E.o_2)-#	20	34.2	31.1	3.1	9.1
59	(Pool 13 x High altitude o_2 Comp.)-#	24	34.8	30.9	3.9	11.2
60	(Pool 13 x Puebla o_2 Comp.)-#	30	35.2	30.7	4.5	12.8
61	(Pool 13 x Mat.o_2 Comp.)-#	16	34.5	31.3	3.2	9.3
62	(Mezcla amarilla P.B.-Lin. Ill. x Mat.o_2 Comp.)-#	16	27.9	25.3	2.6	9.3
63	(Mezcla amarilla P.B.-Lin. Ill. x Hungarian o_2 Comp.)-#	20	33.6	30.1	3.5	10.4
64	(Mezcla amarilla P.B.-Lin. Ill. x Syn.B+Comp.I)-#	17	35.8	32.5	3.3	9.2
65	(Mezcla amarilla P.B.-Lin. Ill.x Puebla o_2 Comp.)-#	31	36.1	31.2	4.9	13.6
66	(Mezcla amarilla P.B.-Lin.Ill.x Mat.o_2 Comp.)-#	20	29.1	27.1	2.0	6.9
67	(Mezcla amarilla P.B.-Lin.Ill.x precoces)-# x Hungarian o_2 Comp.	12	28.7	26.7	2.0	7.0
68	(Mezcla amarilla P.B.-Lin.Ill.x precoces)-# x Syn. B+ Comp. I	32	29.4	26.8	2.6	8.8
69	(Mezcla Amarilla P.B.- Lin.Ill. x precoces)-# x Puebla o_2 Comp.	35	33.8	29.7	4.1	12.1
70	(Pl. Peq. Maz. grande x Mat.o_2 Comp.)-#	22	29.1	26.0	3.1	10.7
71	(Pl. Peq. Maz. grande x Hungarian o_2 Comp.)-#	20	32.4	29.8	2.6	8.0
72	(Pl. Peq. Maz. grande x Puebla o_2 Comp.)-#	56	36.3	32.2	4.1	11.3
73	(Pl. Peq. Maz. grande x Syn. A Comp.I)-#	46	36.0	29.3	6.7	18.6
74	(Pool 3 x floury 1 o_2 Comp.)-#	13	59.4	56.8	2.6	4.4

TABLE 3.3.10.- Conversion of highland gene pools to opaque-2 (1976-77).

Pool No.	Name	No. of ears selected for planting next year		
		1975	1976	1977
1	Highland early white flint	147	68	94
2	Highland early white dent	198	91	160
3	Highland early white floury	205	393	349
4	Highland early yellow flint	270	226	309
5	Highland early yellow dent	292	129	188
7	Highland intermediate white dent	107	63	94
8	Highland intermediate white floury	238	185	262
9	Highland intermediate yellow flint	202	158	198
10	Highland intermediate yellow dent	273	132	194
11	Highland late white flint	24	9	27
12	Highland late white dent	55	40	63
13	Highland late yellow flint	71	47	62
14	Highland late yellow dent	13	54	64
	T O T A L	2095	1595	2064

TABLE 3.3.11.- Conversions of populations that are being selected for earliness, plant efficiency and adaptation (1977).

Material	No. of ears saved during			
	1976A	1976B	1977A	1977B
Amarillo Bajío	408	190	280	114
Amarillo Bajío x varios templados	83	73	131	90
Amarillo Bajío x Mezcla Tropical	63	88	144	77
Mezcla Amarilla P.B. x Lin. Ill.	204	97	131	56
Planta pequeña mazorca grande	21	21	30	62
Amarillo Bajío x Maíces Argentina	41	51	92	59
Selección Precoz	42*	41	28	44
Maíces Tropicales Sel. Batan	40	45	80	86
T O T A L	902	606	916	588

* F_1 ears.

TABLE 3.3.12 .- Summary of performance of full-sib families from four different opaque-2 populations (1977).

Population	test site	No. of families		Mean yield in ton/ha		Selection differential (%)	C.V.	L.S.D. (.05)	Plant height in cms.		Days to flower	
		tested	selected	tested	selected				tested	selected	tested	selected
Tuxpeño opaque-2 (IPTT-37)	Poza Rica	250	84	1958	2117	8.12	26.0	1051	193	190	59	59
	Tlaltizapan	250	84	3870	4373	13.00	27.0	2093	172	170	73	72
	Obregón	250	84	4372	4772	9.15	18.0	1647	220	218	63	63
	Across	250	84	3400	3755	10.44	-	-	195	193	66	65
PD(MS)6 H.E.o$_2$ (IPTT-38)	Poza Rica	250	93	1677	1814	8.17	27.1	915	200	197	57	56
	Tlaltizapan	250	93	3751	4113	9.62	23.3	1742	201	200	67	66
	Obregón	250	93	3174	3535	11.37	20.0	1329	230	229	61	60
	Across	250	93	2868	3154	9.97	-	-	211	209	62	61
CIMMYT H.E.o$_2$	Poza Rica	250	96	1832	1990	8.62	31.7	1163	204	200	53	58
	Tlaltizapan	250	96	3942	4240	7.56	18.2	1429	213	210	68	67
	Obregón	250	96	3326	3748	12.69	17.8	1191	235	232	62	61
	Across	250	96	3034	3327	9.68	-	-	217	215	63	62
White opaque-2 Back-up Pool	Poza Rica	250	99	2760	2968	7.54	26.5	1458	214	212	53	58
	Tlaltizapan	250	99	4003	4440	10.92	26.7	2130	182	183	72	71
	Obregón	250	99	3867	4188	8.30	17.4	1348	220	323	63	63
	Across	250	99	3543	3868	9.12	-	-	208	207	65	64

TABLE 3.3.13.- Progeny trials conducted within Mexico (1976).

Population	No. of families	Type of families	Locations: Poza Rica	Tlaltizapan	Obregón	Total
Tuxpeño opaque-2	250	Full sibs	X	X	X	3
PD(MS)6 H.E.o_2	250	"	X	X	X	3
CIMMYT H.E.o_2	250	"	X	X	X	3
Full sibs from white o_2 back-up pool	250	"	X	X	X	3

TABLE 3.3.14.- Distribution of progeny trials (1977). (Quality protein materials).

IPTT	Population	South America: Bolivia	Colombia	Central America: Guatemala	Panama	Mexico: Poza Rica	Tlaltizapan	Obregon	Africa: Egypt	Ivory Coast	Tanzania	Asia: India	Nepal	Philippines	Thailand	Total
38	PD(MS)6 H.E.o_2			X	X	X		X				X			X	6
41	Temperate x Tropical H.E.o_2	X	X				X		X			X	X			6
40	White H.E.o_2					X	X	X		X	X			X		6
37	Tuxpeño opaque-2					X		X								2
--	CIMMYT H.E.o_2					X	X	X								3
	T O T A L															23

TABLE 3.3.15.- Mean grain yield and other agronomic traits of experimental varieties developed by recombining the best families from advanced unit opaque-2 populations on the basis of IPTT data 1975.

IPTT No.	Population	Experimental Variety	Grain Yield Kg/ha. Pop. $\bar{x}$	Sel. Fam. $\bar{x}$	Checks $\bar{x}$	% Superiority of Sel. Fam. population $\bar{x}$	% over Check $\bar{x}$	Days to flower. Pop. $\bar{x}$	Sel. Fam. $\bar{x}$	Pl. Height in cms. Pop. $\bar{x}$	Sel. Fam. $\bar{x}$
37	Tuxpeño opaque-2	Sids 7537	5305	6602	9736	62.1	-11.6	73	73	283	292
		Ferke 7537	7727	8521	7261	10.3	16.9	62	63	234	[illegible]
		Poza Rica 7537	6225	7681	5857	19.0	31.1	61	61	234	234
		Cotaxtla 7537	5043	6493	4633	28.8	40.2	56	56	248	239
		Across 7537	6076	7355	7037	21.1	4.5	63	62	252	253
39	Yellow H.E.o_2	La Máquina 7539	3020	4349	3250	44.0	33.8	57	55	220	211
		Ferke 7539	6405	7870	7258	22.9	8.7	60	60	256	250
		Poza Rica 7539	4891	6362	4535	30.1	40.3	59	59	256	255
		Suwan 7539	3986	5356	5478	34.4	- 2.2	56	56	260	258
		San Ramón 7539	3952	5163	3645	31.1	42.2	69	68	205	205
		Across 7539	4773	5843	5066	22.4	14.9	59	58	220	215
40	White H.E.o_2	La Máquina 7540	3201	4561	3238	42.5	40.9	56	56	230	228
		Poza Rica 7540	5270	0511	4959	23.5	31.3	59	59	250	255
		La Granja 7540	1840	3312	836	80.0	296.1	58	55	226	220
		Across 7540	3437	3993	3011	16.2	32.6	57	57	239	223

TABLE 3.3.16.- Development of experimental varieties from Yellow H.E.o_2 (IPTT-39) on the basis of 1976 data.

IPTT No.	Population	Experimental Variety		Grain yield KG/ha Pop. $\bar{X}$	Sel. fam $\bar{X}$	Checks $\bar{X}$	% superiority of Sel.fam $\bar{X}$ / Pop. $\bar{X}$	% superiority of Sel.fam $\bar{X}$ / Check $\bar{X}$	Days to flower Pop. $\bar{X}$	Days to flower Sel.fam $\bar{X}$	Plant ht. in cm. Pop. $\bar{X}$	Plant ht. in cm. Sel.fam $\bar{X}$	% ear rot Pop. $\bar{X}$	% ear rot Sel.fam $\bar{X}$
39	Yellow H.E.o_2	Santa Rosa	7639	4262	5634	2052	32.2	174.6	56	55	209	211	30.0	20.2
		Tocumen	7639	4293	5250	4507	22.3	16.5	55	55	209	210	17.4	9.4
		Poza Rica	7639	1949	3123	1645	60.2	89.8	60	59	197	199	2.5	2.1
		Acrosa	7639	3501	4298	2735	22.8	57.0	57	57	205	208	-	-

TABLE 3.3.17.- Tropical and temperate opaque-2 materials in the back-up stages of the program (1976-77).

Population	Breeding scheme	Recombination or sel. cycle	No. of families saved 1976A	1976B	1977A
White opaque-2 back-up pool	H.S.	C_6	624	443	624
Yellow opaque-2 back-up pool	H.S.	C_6	720	430	667
Temperate x tropical H.E.o_2	H.S.	C_6	507	774	615
Yellow flint H.E.o_2	F.S.	C_1	-	-	237
Late White dent H.E.o_2	F.S.	C_2	-	176	146
F.S. from Yellow o_2B.U. Pool (C_3)-##	S_1	C_1	-	108	82
F.S. from White o_2 B.U. Pool (C_3)	F.S.	C_3	-	250	220
PD(MS)6 H.E.o_2 (H.S.)C_4		C_2	250	Progeny trial	250
CIMMYT H.E.o_2 (H.S.)C_4	F.S.	C_2	250	"	250
F.S. from Temperate x Trop. H.E.o_2 (H.S.)C_4	F.S.	C_1	318*	264	250

* H.S. ears.

TABLE 3.3.18.- Highland opaque-2 materials in the Back-up stages of the program (1976-77).

Population	Method of recombination	Cycle of recombination	No. of fam. involved in recombination 1976	1977
Highland modified opaque-2 composite	H.S.	C_2	205	288
Floury opaque-2 composite	H.S.	C_4	365	475
Puebla opaque-2 composite	H.S.	C_5	287	384
Composite I	H.S.	C_5	359	242
High altitude opaque-2 composite	H.S.	C_5	234	174
Puebla o_2 x Barraza	H.S.	F_3	200	157
Mezcla Amarilla P.B. x Lin.Ill.H.E.o_2	F.S.	F_3	57	79
Mezcla Amarilla P.B.-Lin.Ill.x precoces H.E.o_2	F.S.	F_3	42	53
Planta pequeña mazorca grande H.E.o_2	F.S.	F_3	70	46
Composite I H.E.o_2	F.S.	F_5	114	122
Modified o_2 families resulting from intercrosses among different fam.	F.S.	F_2	58	77
Highland White H.E.o_2 families	F.S.	F_1	-	57

TABLE 3.3.19.- Protein and tryptophan content of some opaque-2 materials in the Back-up stages of the program (1976).

Pedigree	No. of fam.	Protein (%)	Tryptophan in protein (%)
Yellow o_2 B.U. Pool (H.S.) C_3	108	7.7	0.81
White o_2 B.U. Pool (H.S.) C_3	93	7.8	0.78
Late White Dent H.E.o_2	133	7.9	0.87
Yellow flint H.E.o_2	55	9.2	0.74
Temperate x tropical H.E.o_2	250	8.7	0.70
Temperate x tropical H.E.o_2(flint)	242	7.7	0.72
Temperate x tropical H.E.o_2(dent)	434	7.5	0.75
Highland modified o_2 comp.	312	9.3	0.81
Floury opaque-2 Composite	324	8.9	4.5*

* Quality index

Laboratory data is essential in guiding the maize nutritional improvement work. Levels of all amino acids are determined only on the most oustanding materials selected for protein quality as well as superior agronomic characteristics.

TABLE 3.3.20.- Protein, lysine tryptophan, DBC and quality index value in the whole grain of hard endosperm opaque-2 conversions of advanced and back-up materials.

S.N.	Pedigree	Protein (%)	Lysine in protein (%)	Tryptophan* in protein (%)	DBC	Quality index DBC/% protein
	Tuxpeño-1 H.E.o_2	10.4	3.8	0.83	48	4.6
	Mezcla tropical blanca H.E.o_2	10.2	3.8	0.74	47	4.6
	Blanco Cristalino H.E.o_2	10.5	3.9	0.86	50	4.8
	Ant. x Ver.181 H.E.o_2	10.0	4.0	0.86	42	4.2
	Mix.1-Col.Gpo.1 x Eto H.E.o_2	10.2	4.0	0.95	50	4.9
	Mezcla Amarilla H.E.o_2	10.0	4.1	0.83	44	4.4
	Amarillo CristalinoH.E.o_2	9.8	4.1	0.88	42	4.3
	Amarillo Dentado H.E.o_2	10.6	3.9	0.96	52	4.9
	Tuxpeño Caribe H.E.o_2	10.0	3.8	0.77	44	4.4
	Eto Blanco H.E.o_2	9.9	4.1	0.92	50	5.0
	Braquíticos H.E.o_2	9.4	4.2	0.89	44	4.7
	Ant.x Rep. Dom. H.E.o_2	9.6	3.7	0.76	45	4.7
	La Posta H.E.o_2	9.4	4.1	0.80	44	4.7
	Amarillo subtropical H.E.o_2	10.2	3.9	0.65	50	4.9
	Blanco subtropical H.E.o_2	10.1	4.0	0.74	50	5.0
	Eto x Illinois H.E.o_2	10.2	3.9	0.68	50	4.9
	Hungarian Comp. H.E.o_2	10.0	3.9	0.66	48	4.8
	Pool 19 H.E.o_2	9.5	3.8	0.77	45	4.7
	Pool 20 H.E.o_2	9.8	3.7	0.81	46	4.7
	Pool 21 H.E.o_2	9.4	4.0	0.81	48	5.1
	Pool 22 H.E.o_2	10.4	3.8	0.91	48	4.6
	Pool 23 H.E.o_2	10.9	3.9	0.89	52	4.8
	Pool 24 H.E.o_2	9.8	4.2	0.89	54	5.5
	Pool 25 H.E.o_2	9.9	4.3	0.84	50	5.0
	Pool 26 H.E.o_2	10.1	3.9	0.84	50	5.0
	Pool 27 H.E.o_2	9.8	3.8	0.80	48	4.9
	Pool 34 H.E.o_2	10.2	3.7	0.81	53	5.2
	Amarillo Bajío H.E.o_2	10.6	4.0	0.76	53	5.0
	Amarillo Bajío x varios templados H.E.o_2	9.4	3.8	0.76	44	4.7
	Amarillo Bajío x tropical H.E.o_2	10.0	3.9	0.65	48	4.8
	Mezcla amarilla P.B. x Líneas Ill. H.E.o_2	10.6	3.9	0.79	52	4.9

* Tryptophan in protein in endosperm.

TABLE 3.3.21.- Complete amino-acid analysis of the endosperm in some promising hard endosperm opaque-2 materials (1976).

Amino-acid	PD(MS)6 H.E.o_2	Amarillo Dent. H.E.o_2	CIMMYT H.E.o_2	White opaque-2 Back-up pool	Ant.xVer.181 H.E.o_2	Temp.xTrop H.E.o_2	Tuxpeño Normal
Lysine	2.98	3.13	3.09	2.85	3.14	3.04	1.90
Histidine	4.15	4.19	4.30	3.94	4.66	3.93	2.45
Arginine	3.99	5.22	4.78	4.75	4.69	4.53	3.28
Aspartic acid	7.35	8.01	7.50	7.02	7.51	7.75	5.92
Threonine	3.99	4.06	3.99	3.76	4.08	3.94	3.15
Serine	4.28	5.12	4.83	4.76	4.95	5.06	3.47
Glutamic acid	20.08	20.12	19.64	18.10	20.22	18.96	24.89
Proline	11.79	13.06	11.68	11.23	11.75	11.06	11.21
Glycine	4.36	4.47	4.42	4.25	4.51	4.29	2.92
Alanine	8.06	8.13	7.89	7.18	8.06	7.49	9.26
Cystine	2.07	2.25	1.94	2.14	2.17	2.01	0.76
Valine	5.69	5.74	5.93	4.94	5.95	5.31	4.01
Methionine	1.70	1.55	1.35	1.37	1.51	1.40	1.43
Isoleucine	3.82	3.91	3.94	3.19	4.02	3.46	3.17
Leucine	13.07	13.02	12.77	11.39	13.05	11.66	14.58
Tyrosine	4.18	4.61	4.38	4.25	4.52	3.96	4.15
Phenylalanine	4.91	5.33	5.02	4.71	5.33	4.56	5.17
Tryptophan	0.70	0.77	0.73	0.83	0.83	0.88	--
% Protein	8.9	8.7	8.8	8.4	8.4	8.0	9.2

TABLE 3.3.22.- Amino acid composition of the whole grain in floury opaque-2 composite (1976).

Amino acid	Amino acid in g/100 g protein	Amino acid	Amino acid in g/100 g protein
Lysine	4.1	Cystine	1.1
Histidine	2.9	Valine	5.0
Arginine	5.6	Methionine	1.5
Aspartic acid	10.2	Isoleucine	3.1
Threonine	3.5	Leucine	8.6
Serine	4.6	Tyrosine	3.7
Glutamic acid	15.9	Phenylalanine	4.2
Proline	8.0	Tryptophan	1.0
Glycine	4.4	% Protein	9.7
Alanine	6.8		

TABLE 3.3.23.- Percent protein, tryptophan and different protein fractions in the endosperm (1976).

Material	% Protein in endosperm	% Tryptophan in protein in endosperm	Protein fractions in endosperm protein (%) Acid soluble	Alcohol soluble	Glutenin
PD(MS)6 H.E.o_2	8.9	0.70	28.4	34.3	28.8
Amarillo dentado H.E.o_2	8.7	0.77	31.5	36.0	30.0
CIMMYT H.E.o_2	8.8	0.73	29.4	34.8	30.6
White opaque-2 back-up pool	8.4	0.83	30.3	29.8	28.8
Temperate x tropical H.E.o_2	8.0	0.88	32.2	33.7	31.6
Ant. x Ver. 181 H.E.o_2	8.4	0.83	32.0	37.4	30.2

TABLE 3.3.24 Kernel weight, volume and density comparison of opaques and sugary-2-opaque-2 segregates in different opaque-2 backgrounds (1976).

S.No.	Pedigree	No. of samples	100 kernel wt. in grams: o_2o_2	$su_2su_2o_2o_2$	Difference (%)	Volume (C.C.): o_2o_2	$su_2su_2o_2o_2$	Difference (%)	Density*: o_2o_2	$su_2su_2o_2o_2$	Difference (%)
1	(Ver.181-Ant.Gpo.2xVen.1o_2 x su_2o_2)-#	56	28.8	26.7	7.3	24.5	21.9	10.6	1.179	1.221	3.6
2	(Yellow H.E.o_2 x ")-#	37	28.1	26.5	5.7	23.6	21.5	8.9	1.191	1.242	3.4
3	(White H.E.o_2 x ")-#	27	29.0	26.6	8.3	24.6	21.1	14.2	1.214	1.260	3.8
4	(Yellow o_2 B.U.Pool x ")-#	33	27.4	25.7	6.2	23.4	20.5	12.4	1.170	1.254	7.2
5	(White o_2-B.U.Pool x ")-#	24	29.3	25.6	12.6	25.3	20.6	18.6	1.266	1.236	3.3
6	(Temperate-tropical H.E.o_2 x ")-#	47	28.1	26.2	6.8	24.0	20.8	13.3	1.170	1.255	7.3
7	(Ant.xVer.181 H.E.o_2 x ")-#	27	28.4	26.7	6.0	24.5	21.2	13.5	1.158	1.253	8.6
8	(Mezcla antiguo H.E.o_2 x ")-#	31	27.8	25.9	6.8	23.8	20.4	14.3	1.168	1.267	8.5
9	(Amarillo Cristalino H.E.o_2 x ")-#	35	26.3	24.7	6.1	22.6	19.5	13.7	1.160	1.263	9.3
10	(Amarillo dentado H.E.o_2 x ")-#	33	27.5	26.0	5.5	24.1	21.0	12.9	1.141	1.241	8.5
11	(Tuxpeño Caribe H.E.o_2 x ")-#	36	30.5	28.6	6.2	26.6	22.7	14.7	1.143	1.253	10.0
12	(Mezcla tropical blanca H.E.o_2 x ")-#	45	28.7	27.0	5.9	24.8	21.5	13.3	1.157	1.253	8.3
13	(Blanco Cristalino H.E.o_2 x ")-#	26	28.5	26.5	7.0	24.4	21.6	11.5	1.167	1.232	5.6
14	(La Posta H.E.o_2 x ")-#	20	27.3	25.7	5.9	22.5	20.4	9.3	1.214	1.262	3.9
15	(Pool 21 H.E.o_2 x ")-#	37	27.3	25.4	7.0	23.5	20.1	14.5	1.163	1.267	8.9
16	(Pool22 H.E.o_2 x ")-#	42	29.5	27.5	6.8	25.4	21.8	14.2	1.163	1.263	8.6
17	(Pool23 H.E.o_2 x ")-#	27	27.8	25.4	8.6	23.6	19.9	15.7	1.178	1.275	8.2
18	(Pool 24 H.E.o_2 x ")-#	35	28.9	26.1	9.7	24.0	20.5	14.6	1.170	1.271	8.6
19	(Pool 25 H.E.o_2 x ")-#	32	23.4	25.7	9.5	23.9	20.5	14.2	1.155	1.254	8.3
20	(Pool 26 H.E.o_2 x ")-#	24	28.0	26.1	6.8	24.4	20.7	15.2	1.148	1.256	9.4
21	(PD(MS)6 H.E.o_2 x ")-#	36	27.6	24.9	9.8	23.7	19.5	17.7	1.199	1.280	6.8
22	(CIMMYT H.E.o_2 x ")-#	35	28.8	26.0	0.7	24.3	21.1	13.2	1.152	1.238	7.5
23	(TuxpeñoC_1-La Posta H.E.x ")-#	14	29.7	26.6	10.4	25.8	20.7	19.8	1.154	1.285	11.4
24	(Linea El Salvador H.E.o_2 x ")-#	36	29.1	26.5	8.9	24.5	21.1	13.9	1.190	1.257	5.6
25	(Tha: Comp.#1-PD(MS)6 H.E.o_2 x ")-#	35	27.1	25.2	7.0	23.0	20.1	12.8	1.177	1.252	6.4
26	(Amarillo Bajío H.E.o_2 x ")-#	20	28.5	26.6	6.7	24.4	21.1	13.5	1.167	1.250	7.9
27	(Amarillo Bajío x Mezcla Tropical Am.H.E.o_2 x ")-#	33	27.3	25.3	7.3	23.0	19.8	13.9	1.184	1.276	7.8
	AVERAGE**	-	28.3	26.1	7.8	24.2	20.8	14.0	1.172	1.257	7.3

* Specific gravity with respect to water at room temperature.

** Average for 100 kernel weight, volumes and specific gravities of all materials.

TABLE 3.3.25.- Percent protein, lysine and DBC values in the whole kernel of opaque-2 and sugary-2 opaque-2 segregates recovered from different materials (1976).

S.No.	Material	Protein (%)		Lysine in protein (%)		DBC	
		o_2o_2	$su_2su_2o_2o_2$	o_2o_2	$su_2su_2o_2o_2$	o_2o_2	$su_2su_2o_2o_2$
1	Ver.181-Ant.Gpo.2 x Ven. 1 o_2	11.8	10.8	3.9	3.9	54	54
2	Yellow H.E.o_2	11.1	11.1	4.4	3.8	56	59
3	White H.E.o_2	10.6	11.1	4.0	3.4	51	57
4	Yellow opaque-2 back-up pool	10.8	11.4	3.8	4.0	52	59
5	White opaque-2 back-up pool	11.5	11.5	4.2	3.9	56	60
6	Temperate x tropical H.E.o_2	11.4	11.4	4.2	3.9	57	62
7	Ant. x Ver.181 H.E.o_2	11.6	11.3	4.0	4.1	57	60
8	Mezcla amarilla H.E.o_2	11.5	11.1	3.8	3.7	52	58
9	Amarillo Cristalino -1 H.E.o_2	11.3	11.0	3.7	4.0	52	57
10	Amarillo dentado H.E.o_2	11.1	10.9	3.6	4.0	54	59
11	Tuxpeño Caribe H.E.o_2	10.6	10.6	4.6	4.2	53	57
12	Mezcla tropical blanca H.E.o_2	11.1	11.8	4.0	3.8	52	58
13	Blanco Cristalino H.E.o_2	11.0	11.2	4.4	3.5	53	58
14	La Posta H.E.o_2	11.2	10.9	4.2	4.4	52	66
15	Pool 21 H.E.o_2	11.0	11.2	3.9	4.1	52	60
16	Pool 22 H.E.o_2	11.0	10.9	4.1	4.3	52	62
17	Pool 23 H.E.o_2	10.6	10.8	4.2	4.4	50	64
18	Pool 24 H.E.o_2	11.0	11.1	4.2	3.9	52	54
19	Pool 25 H.E.o_2	11.0	11.3	4.0	4.0	54	58
20	Pool 26 H.E.o_2	11.1	11.2	3.7	4.0	54	58
21	PD(MS)6 H.E.o_2	11.1	11.4	3.6	4.1	52	62
22	CIMMYT H.E.o_2	10.5	11.4	3.7	4.1	50	60
23	Tuxpeño C_{11} x La Posta H.E.o_2	10.6	10.7	3.8	4.0	50	56
24	Lineas El Salvador H.E.o_2	10.8	10.3	4.2	4.2	51	57
25	(Thai Composite # 1 x PD(MS)6 H.E.o_2)-#	11.3	12.0	3.6	4.2	52	66
26	Amarillo Bajío H.E.o_2	11.8	11.2	-	4.1	53	61
27	Amarillo Bajío x Mezcla tropical amarilla	10.5	10.7	4.0	4.6	50	57

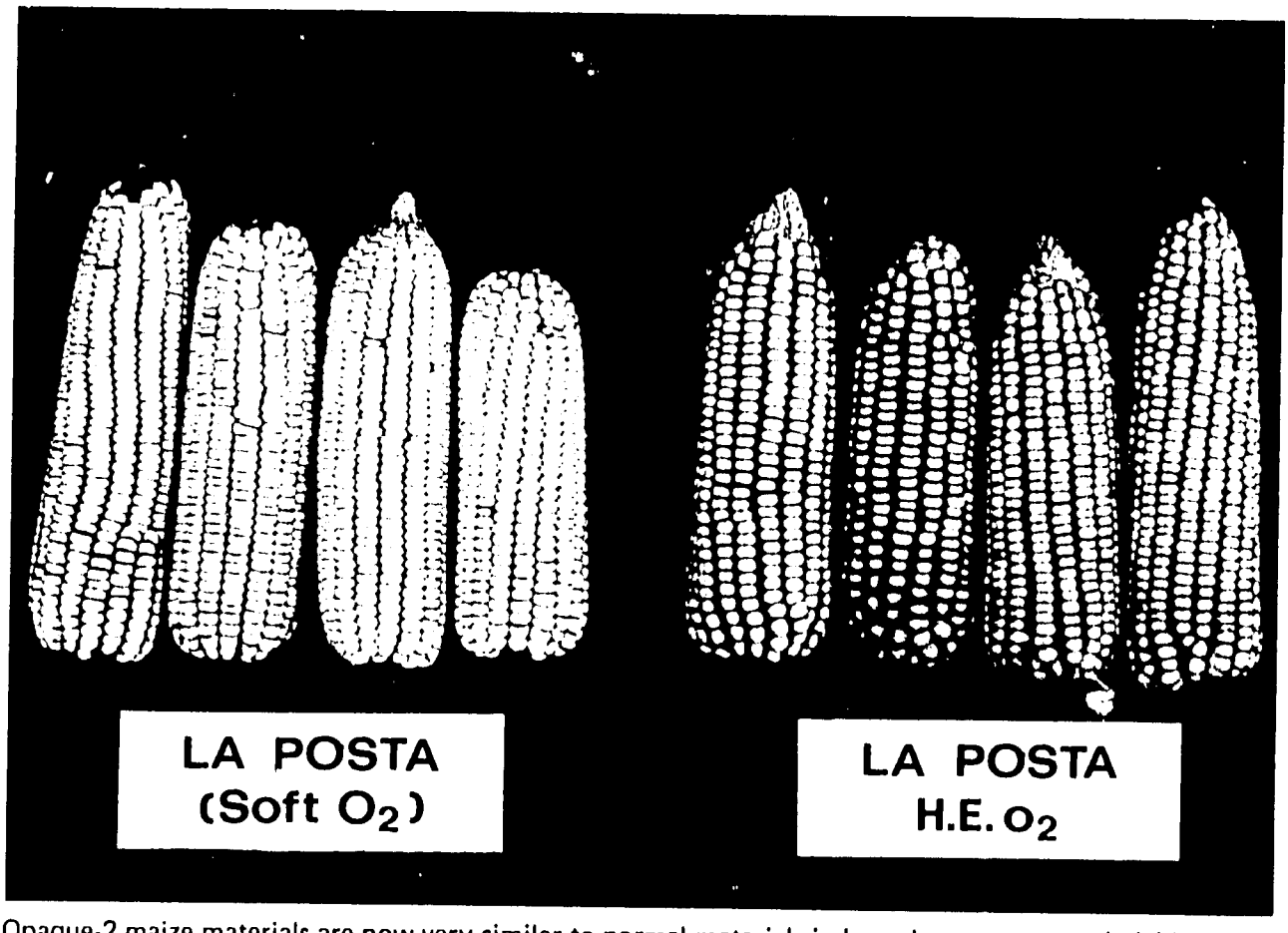
TABLE 3.3.26.- Amino acid composition of the whole grain in opaque-2 and sugary-2 opaque-2 segregates recovered from different materials (1976).

Amino acid	Ver.181-Ant.Gpo. x Ven. 1 o_2		Yellow H.E.o_2		Temperate x tropical H.E.o_2		Mezcla amarilla H.E.o_2		Amarillo dentado H.E.o_2		Tuxpeño caribe H.E.o_2		Pool 24		PD(MS)6 H.E.o_2	
	o_2o_2	$su_2su_2o_2o_2$	o_2o_2	$su_2su_2o_2o_2$	o_2o_2	$su_2su_2o_2o_2$	o_2o_2	$su_2su_2o_2o_2$	o_2o_2	$su_2su_2o_2o_2$	o_2o_2	$su_2su_2o_2o_2$	o_2o_2	su_2su_2	o_2o_2	su_2su_2
Lysine	3.7	3.8	4.0	3.8	3.7	3.9	3.7	3.9	3.9	3.7	4.0	3.9	3.5	3.8	3.7	3.8
Histidine	3.4	3.0	3.1	3.0	2.7	2.8	2.5	2.8	2.9	2.8	3.0	2.9	2.8	2.9	2.9	2.9
Arginine	6.0	6.2	6.2	6.1	6.0	5.9	5.6	5.6	6.1	5.6	6.4	5.9	5.7	5.8	6.0	5.8
Aspartic acid	9.0	9.0	9.3	8.9	9.3	8.9	9.9	9.8	9.5	8.9	10.6	10.2	8.6	9.1	9.7	9.1
Threonine	3.7	3.6	3.7	7.3	3.7	3.6	3.3	3.5	3.6	3.5	3.7	3.6	3.5	3.5	3.4	3.5
Serine	5.2	5.9	5.2	5.1	5.1	5.0	4.7	4.7	5.1	4.8	5.3	5.0	5.0	4.9	5.0	4.7
Glutamic acid	16.6	15.4	16.0	16.0	16.8	15.3	15.2	15.2	16.6	14.8	17.2	15.5	15.5	14.7	16.7	14.9
Proline	9.3	8.5	7.8	8.6	8.9	8.4	8.3	8.4	8.8	8.2	8.8	8.6	8.2	8.6	8.5	8.8
Glycine	4.9	4.6	4.8	4.7	4.5	4.6	4.4	4.6	4.8	4.6	4.8	4.7	4.5	4.7	4.7	4.5
Alanine	7.1	6.3	6.9	7.0	7.0	6.9	6.6	6.7	6.8	6.7	7.1	6.8	6.6	6.7	6.6	6.6
Cystine	1.7	1.6	1.9	2.0	1.7	1.6	1.7	1.3	1.5	1.6	1.4	1.7	1.4	1.5	1.4	1.6
Valine	3.9	3.7	3.9	3.8	3.8	3.7	3.4	4.0	3.8	3.7	3.9	3.8	3.7	3.6	3.6	3.6
Methionine	1.6	1.6	1.4	1.7	1.7	1.6	1.6	1.3	1.6	1.4	1.4	1.6	1.4	1.5	1.4	1.4
Isoleucine	2.4	2.2	2.5	2.3	2.5	2.2	2.1	2.5	2.3	2.2	2.4	2.2	2.1	2.1	2.1	2.2
Leucine	9.2	8.4	9.1	8.7	9.3	8.3	8.2	7.9	8.7	8.3	9.0	8.5	8.3	8.1	8.1	8.3
Tyrosine	4.5	3.9	4.1	3.8	4.1	3.8	4.0	3.6	4.0	3.6	3.9	3.8	3.5	3.5	3.8	3.6
Phenylalanine	5.1	4.2	4.7	4.4	4.7	4.4	4.5	4.0	4.3	4.0	4.5	4.3	4.2	4.1	4.2	4.1
Tryptophan	0.9	0.8	0.9	0.8	0.9	0.9	1.0	0.9	0.9	0.9	1.0	0.9	0.9	0.8	1.1	0.8
% Protein	11.8	12.6	13.0	13.1	13.5	13.1	12.1	13.0	12.6	12.9	12.4	12.8	12.5	12.9	2.1	13.4

TABLE 3.3.27.- Correlation coefficients (r) among several characters of opaque-2 and sugary-2 opaque-2 segregates recovered from 27 segregating populations (1976).

	Character		2	3	4	5	6	7
1	100 kernel weight	o_2o_2	0.940**	-0.186	-0.244	-0.207	0.190	0.047
		$su_2su_2o_2o_2$	0.942**	-0.221	-0.181	-0.300	-0.172	0.001
2	Kernel volume	o_2o_2		-0.504**	-0.278	-0.190	0.217	0.106
		$su_2su_2o_2o_2$		-0.535**	-0.164	-0.190	-0.220	-0.052
3	Kernel density	o_2o_2			0.180	0.030	-0.153	-0.130
		$su_2su_2o_2o_2$			0.006	-0.210	0.213	0.155
4	Protein content of endosperm	o_2o_2				0.257	-0.611**	0.077
		$su_2su_2o_2o_2$				0.188	-0.440*	0.168
5	Protein content of whole kernel	o_2o_2					-0.192	-0.448*
		$su_2su_2o_2o_2$					-0.059	-0.242
6	Lysine in protein of endosperm	o_2o_2						0.266
		$su_2su_2o_2o_2$						0.050
7	Lysine in protein of whole kernel	o_2o_2						
		$su_2su_2o_2o_2$						

* Significant at 0.05 probability level.
** Significant at 0.01 probability level.



Opaque-2 maize materials are now very similar to normal materials in kernel appearance and yield performance as shown by La Posta, one of the outstanding hard endosperm (H.E.O_2) lowland materials.

TABLE 3.3.28.- Percent protein, lysine and different protein fractions in the endosperm of eight sugary-2/opaque-2 materials (1976).

S. No.	Pedigree	Protein (%)	Lysine in protein(%)	Protein fractions in protein (%)		
				Acid soluble	Alcohol soluble	Glutelin
1	Ver.181-Ant.Gpo.2x Ven. 1 o_2	9.3	3.7	28.6	26.6	44.5
2	Yellow H.E. o_2	9.4	3.6	28.7	28.4	42.8
3	Temperate x Tropical H.E.o_2	10.2	3.6	26.5	29.4	39.6
4	Mezcla Amarilla H.E.o_2	9.4	4.3	28.3	26.8	44.4
5	Amarillo Dentado H.E.o_2	9.2	3.7	29.4	29.1	41.3
6	Tuxpeño Caribe H.E.o_2	9.4	3.4	26.4	29.5	44.0
7	Pool 24 H.E.o_2	9.0	3.8	28.0	25.7	46.0
8	PD(MS)6 H.E.o_2	9.5	3.5	26.5	28.9	44.4

TABLE 3.3.29.- Development of floury-opaque-2 materials (1977)

Population	Selection procedure	Cycle or generation	No. of fam. planted during 1977
Floury-opaque-2-Composite	H.S.	C_4	479
Pool 3 (opaque-2)-#-#	H.S.	C_1	393
Pool 8 (opaque-2)-#-#	H.S.	C_1	105
Large seeded floury-opaque-2 families	F.S.	C_1	53

TABLE 3.3.30.- Percent protein, tryptophan and different protein fractions in the endosperm (1977).

Material	Protein (%)	Tryptophan in protein (%)	Protein fraction in endosperm protein (%)		
			Acid soluble	Alcohol soluble	Glutelin
Floury 1-opaque-2 Comp.	8.9	0.70	28.4	34.3	28.3

TABLE 3.3.31.- Complete amino-acid analysis of Floury-opaque-2 Composite (1977).

Amino Acid	Whole grain	Endosperm
Lysine	4.1	3.5
Histidine	2.9	3.3
Arginine	5.6	4.9
Aspartic acid	10.2	10.9
Threonine	3.5	3.9
Serine	4.6	5.2
Glutanic acid	15.9	18.9
Proline	8.0	9.5
Glycine	4.4	4.3
Alanine	6.8	7.7
Cystine	1.1	1.6
Valine	5.0	5.3
Methionine	1.5	1.7
Isoleucine	3.1	3.7
Leucine	8.6	11.2
Tyrosine	3.7	4.5
Phenylalanine	4.2	5.0
Tryptophan	1.0	1.1
% Protein	9.7	7.2

TABLE 3.3.32.- Distribution of EVT-15 and ELVT 19 (1976 and 1977).

Trial No.	No. of entries	No. of sets distributed in different countries							Total
		South America	Central America	Caribe	Mexico	Africa	Asia	North America	
			1976						
EVT-15	25	6	8	4	3	9	6	-	36
ELVT-19	10	8	12	6	5	12	16	1	60
			1977						
EVT-15	11	6	7	5	6	8	6	-	38
ELVT-19	10	9	10	7	6	12	11	-	55

At harvest of an opaque-2 experimental variety seed increase, ears are selected for use in the EV and ELVT trials.

TABLE 3.3.33 .- Results of Experimental Variety Trial No.15 in 1976. (Grain yield in kg/ha at 15% moisture).

Entry No.	EV's and Populations	Tocumen Panamá	Bodles Jamaica	Sakha Egypt	Pantnagar India	Pichilingue Ecuador	Palmira Colombia	San Andres El Salvador	Guanacaste Costa Rica	Sn.Cristóbal Rep. Dom.	Omonita Honduras	Pirsabak Pakistan	Suwan Thailand	Poza Rica Mexico	Obregón México	Tlaltizapan Mexico	Means
1	Guanacaste 7437	4429	5784	2625	2303	5025	4794	4079	2060	3206	2630	4345	1958	1701	4291	7108	3756
2	Cotaxtla 7437	5240	4356	2840	2831	4420	4507	4291	1818	3012	2106	3751	3258	1812	4492	6487	3681
3	Sids 7537	5278	5088	2258	2871	4793	4061	4185	2237	3476	2273	4276	2791	1215	4599	7275	3842
4	Cotaxtla 7537	5091	5465	2201	2422	4820	4794	4024	2089	3003	2061	4464	1491	2219	4455	6306	3664
5	Poza Rica 7537	5473	4759	3085	3083	5097	4919	4000	2209	3612	2997	3904	2655	1440	4327	6748	3887
6	Across 7537	5070	5060	3302	2879	4783	4696	3709	2088	2649	2679	4229	1618	2241	4532	6475	3758
7	Pichilingue 7439	4654	5076	3129	2538	5333	4446	3512	1549	2667	2136	3558	2712	1458	4032	5679	3499
8	Suwan 7439	4907	4726	3817	2493	4781	3885	3394	1736	2691	2442	3820	2476	1146	4279	5709	3437
9	Cotaxtla 7439	5029	4338	3361	2286	4558	3939	3636	1823	2746	2230	3660	3038	1356	4305	6143	3534
10	Across 7439	4511	4359	3190	2653	4722	4077	3849	1625	2652	2042	3724	2558	1680	4277	5634	3427
11	La Máquina 7539	4179	4808	3354	2320	4579	3915	3949	1803	2882	2442	3158	2979	1956	4197	6127	3512
12	Amarillo Dentado H.E.o_2	4357	4464	3387	2472	3917	4492	3339	1771	3279	2649	3806	3227	1946	4591	6235	3599
13	CIMMYT H.E.o_2	4403	5581	3033	2639	4168	2973	3624	1473	2673	2533	3006	2636	1438	3338	5937	3301
14	Across 7539	5007	4701	3384	2933	4469	3834	4039	1851	2785	2794	3122	2467	1468	4137	6349	3556
15	Temp. x Trop. H.E.o_2	4074	3783	2312	2445	3463	2841	3164	989	2079	1827	3244	2206	692	3763	5307	2313
16	Across 7440	4306	5010	3392	2811	4222	3830	3321	2068	2646	1706	3411	3191	1758	4179	6043	3461
17	La Máquina 7540	5042	4775	3836	2314	4841	3786	3630	1570	2676	2206	3668	2573	1914	3903	5307	3503
18	San Andres 7440	3749	4271	3157	2475	4074	3258	3527	1654	2403	2158	3141	3133	1066	3613	5323	3134
19	Ferke 7537/2	5395	5067	2400	2718	4678	3951	3858	1986	2842	2906	3806	1897	1632	4391	6758	3622
20	Tuxpeño opaque-2	4916	5015	3012	2287	4142	4953	3933	1697	2303	2424	2952	1661	1225	4029	7113	3476
21	Yellow H.E.o_2	4397	4681	3467	2417	4546	3813	3488	1353	2342	2036	3492	1639	1753	4137	5868	3297
22	White H.E.o_2	4178	4546	2881	2187	4311	3317	3497	1526	2776	2032	3443	1900	1251	3907	5124	3128
23	PD(MS)6 H.E.o_2	3875	4093	3770	2367	4338	3653	3330	1756	2570	2173	2747	2321	1585	3693	5028	3153
24	Check 1*	3301	4780	1722	775	3293	2953	3912	451	3288	1391	2108	4315	1713	4307	6191	2967
25	Check 2*	4631	5241	3395	2491	5979	5321	3970	1559	3146	1576	2603	6573	2243	4303	6782	3988
Means		4640	4813	3052	2480	4534	4072	3730	1712	2836	2260	3498	2693	1602	4167	6148	
LSD (.05)		638	969	947	828	676	971	815	542	536	715	912	832	642	514	1008	
C.V.		9.7	14.2	21.9	23.6	10.5	16.9	15.4	22.4	13.4	22.4	18.4	21.9	28.4	3.7	11.6	

* not the same checks at each location.

TABLE 3.3.34.- Results of ELVT No. 19 in 1976. (Grain yield in kg/ha at 15% moisture)

Entry No.	Pedigree	Cayala Guatemala	La Máquina Guatemala	Sta. Rosa Nicaragua	Tocumen Panamá	Guarare Panamá	Dash Honduras	Guanacaste Costa Rica	Alajuela Costa Rica	San Andres El Salvador	San Cristóbal Rep. Dom.	Cayes Haiti	Bodles Jamaica	Tesaco Trinidad	Poza Rica Mexico	Obregón Mexico	Tlaltizapan Mexico	Cotaxia Mexico	Saavedra Bolivia	Pichilingue Ecuador	Porto Viejo Ecuador	Kawanda Uganda	Sids Egypt	Delhi India	Pantnagar India	Pirsabak Pakistan	Khumaltar Nepal	Jumpur Nepal	Rikhi nova Nepal	Suwan Thailand	Means
1	Poza Rica 7437	3692	4904	4330	4804	2133	8018	3673	5206	3873	5007	5124	4667	1677	2518	4167	6627	4888	4512	5206	5976	2692	6612	1367	4452	2742	5133	1602	6252	1200	4277
2	Across 7437	3318	4753	4758	4739	1488	7352	3358	4791	3879	5120	4982	4088	1347	2218	4003	7449	4761	5146	4291	6388	2629	5349	1961	5170	2049	4176	2505	6621	1976	4256
3	Delhi 7439	3485	4561	4412	4697	1391	7158	3842	5009	3688	4383	4167	4878	1883	2342	3764	6376	3915	4358	5079	5036	2614	6700	1230	5214	2700	4653	2411	5958	2149	4182
4	Poza Rica 7439	3321	3808	3618	5042	1794	6955	3404	4894	2988	4343	4803	4588	1525	2230	3939	5248	3591	4321	4806	5242	2373	8429	1594	4488	2406	4109	2264	5354	1872	3996
5	San Andres 7440	3235	4222	3555	4255	1103	6579	2827	4618	2452	3690	4394	3315	1265	2250	3891	4842	3639	4091	3324	4691	2350	5675	1378	4614	2103	4961	2366	5394	1806	3826
6	Poza Rica 7441	3455	3830	4179	4779	1685	6348	3528	3991	3355	4127	4149	3452	1302	2009	3621	5927	3761	4642	4158	5067	2361	6399	1855	4218	3554	4197	2168	5153	1749	3782
7	Across 7441	2827	4546	4281	5155	1442	7136	3670	5806	3612	4457	5121	4433	1711	2303	3539	6197	4185	4652	4455	6156	2076	6755	1539	4696	2424	4197	2241	5461	2500	4090
8	Check 1 PDC1536 H.E.o_2	2977	4036	4034	4442	1455	6473	3376	3806	3258	3977	4321	3948	1552	2839	3700	5861	3912	4267	4036	4406	2224	6814	1167	4427	3188	4018	2255	5132	1760	3721
9	Check 2 (opaque-2)	3114	4351	2570	4115	1635	7364	4697	2355	3097	2907	2230	5767	1118	2924	3897	6376	4403	5285	5539	6527	3138	7337	1570	5592	1788	3561	1584	4149	3221	3877
10	Check 3 (normal)	4318	5184	2624	4621	1978	8185	4330	7533	3700	4727	4467	7618	923	3164	5421	6739	5855	5600	6570	5455	2212	8707	985	3609	2382	4270	2125	3509	4659	4535
	Means	3386	4427	3540	4694	1610	7157	3640	4891	3390	4326	4376	4713	1436	2478	4034	6164	4301	4717	4796	5495	2487	6703	1497	4648	2824	4318	2164	5355	2349	
	LSD (.05)	838	796	1133	414	665	852	873	1672	904	766	1624	986	602	728	773	1287	721	827	783	944	562	1221	848	316	847	1074	586	1330	795	
	C.V.	17.3	12.6	20.7	6.2	28.9	8.3	16.6	23.0	18.7	13.4	26.0	16.7	20.3	30.6	13.4	14.8	11.7	13.8	7.3	8.5	15.6	12.7	30.6	12.3	30.0	17.4	19.0	17.8	23.7	

1/ Check 3 and Check 3 did not have the same pedigree at all locations.

Table 3.4.1

INSECTICIDE TRIAL
PR 76B PT - 300

SEED INCREASE

San Andres 7530 (2)

	INSECTICIDE	COMMON NAME	FORMULATION	QUANTITY APPLIED PER PLANT (cc)	A.I. / HA (g)	MEAN PERCENT DAMAGED PLANTS: 6 days after Infestation	8 days after Insecticides Applied	14 days after Insecticides Applied	20 days after Insecticides Applied
1	S-3206	Synth-pyrethrin	0.5 G	0.3	46	42.3	1.3	39.3	27.6
2	S-5602	Syn.Pyrethrin (Fenvalerate)	0.5 G	0.3	48	45.3	1.0	37.0	22.0
3	THIODAN	Endosulfan	5 G	0.3	660	49.4	1.4	30.7	23.4
4	COUNTER	Terbufos	5 G	0.5	583	44.6	1.6	29.9	20.7
5	CYTROLANE	Mephosfolan	2 G	0.5	227	46.1	7.0	29.6	22.0
6	SEVIN	Carbaryl	5 G	0.3	730	44.7	25.0	41.1	36.1
7	FURADAN	Carbofuran	5 G	0.3	660	52.3	13.1	34.6	35.6
8	BIRLANE	Chlorfenvinphos	2 G	0.5	360	49.1	7.1	31.1	29.7
9	DIPTEREX	Trichlorfon	2.5 G	0.5	567.5	48.4	18.4	44.7	42.6
10	CHECK	Untreated	---	---	---	37.9	47.0	53.3	38.9
					Significance Level	n.s.	.001	.025	.05
					LSD .05		7.4	14.2	15.3

Planting Date - 17 Aug. 76
Infestation Dates - 31 Aug. - 16 larvae/plant
- 3 Sept.- 12 larvae/plant

Insecticide Applied - 9 Sept.

Reinfestation Dates - 18 Sept. - 13 larvae/plant
- 22 Sept. - 13.5 larvae/plant

INSECTICIDE TRIAL
PR 76B PT - 301

SEED INCREASE

Across 7523

	INSECTICIDE	COMMON NAME	FORMULATION	QUANTITY APPLIED PER PLANT (cc)	A.I. / HA (g)	MEAN PERCENT DAMAGED PLANTS: 6 days after Infestation	8 days after Insecticide Application	14 days after Insecticide application
1	S-3206	Synth.Pyrethin	0.5 G	0.3	46	72.0	0	0
2	S-5602	Syn.Pyrethring (Fenvalerate)	0.5 G	C.3	48	76.8	4.0	0.8
3	THIODAN	Endosulfan	5 G	0.3	660	73.0	2.8	0
4	COUNTER	Terbufos	5 G	0.5	583	73.1	0.4	1.9
5	CYTROLANE	Mephosfolan	2 G	0.5	227	80.8	2.0	2.8
6	SEVIN	Carbaryl	5 G	0.3	730	75.9	17.1	10.4
7	FURADAN	Carbofuran	5 G	0.3	660	75.8	13.5	7.1
8	BIRLANE	Chlorfenviphos	2 G	0.5	360	79.1	7.8	5.4
9	DIPTEREX	Trichlorfon	2.5 G	0.5	567.5	69.0	3.6	2.3
10	CHECK	Untreated	---	---	---	77.4	37.6	15.8
					Significance Level	n.s.	.005	.005
					LSD .05		6.4	4.2

Planting Date - 6 Sept. 76
Infestation Date - 22 Sept. 76 - 7.6 la.vae/plant
Insecticides Applied - 29 Sept. 78

Table 3.4.2 INSECTICIDE TRIALS

SEED INCREASE

PIRSABAK 7532

TL 768

Eto Blanco

INSECTICIDE	COMMON NAME	FORMULATION	QUANTITY APPLIED PER PLANT (cc)	A.I. per hectare (40,000 pl.)	MEAN PERCENT DAMAGED PLANTS: 6 days Post Infestation Pre-insect Application	8 days Post Insecticide Application	13 days Post Insecticide Application	21 days Post Insecticide Application	MEAN YIELD TONS/HA 1/
S-3206	Synth.pyrethrin	0.5 G	0.5	75g	90.1	0.6	7.4	11.9	4.0 bcd
S-5602	Syn.Pyrethrin (Fenvalerate)	0.5 G	0.5	80g	92.3	0.0	7.7	18.1	4.1 bcd
THIODAN	Endosulfan	5 G	0.3	660g	87.9	0.6	5.9	6.4	5.4 a
COUNTER	Terbufos	5 G	0.5	585g	91.0	0.0	6.3	12.3	5.1 ab
CYTROLANE	Mephosfolan	2 G	0.5	227g	92.3	0.0	51.9	61.1	3.5 cd
SEVIN	Carbaryl	5 G	0.3	730g	88.4	8.3	20.3	30.1	4.5 abc
FURADAN	Carbofuran	5 G	0.3	660g	90.3	0.6	4.3	23.1	4.5 abc
BIRLANE	Chlorfenvinphos	2 G	0.5	360	88.7	0.0	22.9	35.9	4.0 bcd
DIPTEREX	Trichlorfon	2.5 G	0.5	568	88.0	0.0	47.0	55.7	2.9 d
CHECK	Untreated	---	---	-0-	90.3	45.4	66.1	48.3	4.1 bcd
				Significance level	n.s.	.005	.005	.005	.01
				LSD (.05)		3.92	11.4	12.9	1.2

TL 76 B

SEED INCREASE

Across 7537
TUXPEÑO Opaque-2

S-3206	Synth.pyrethrin	0.5 G	0.5	75g	98.8	1.3	15.5	26.0	7.3
S-5602	Syn.Pyrethrin (Fenvalerate)	0.5 G	0.5	80g	99.0	2.5	34.8	35.6	5.8
THIODAN	Endosulfan	5 C	0.3	660g	98.0	2.0	36.8	36.0	6.5
COUNTER	Terbufos	5 G	0.5	585g	100.0	2.0	11.8	15.0	5.9
CYTROLANE	Mephosfolan	2 G	0.5	227g	100.0	1.0	27.8	49.3	5.8
SEVIN	Carbaryl	5 G	0.3	730g	99.0	30.5	53.0	47.0	5.7
FURADAN	Carbofuran	5 G	0.3	660g	99.0	5.8	10.0	17.8	8.9
BIRLANE	Chlorfenvinphos	2 G	0.5	360g	97.8	0.0	40.8	48.0	6.5
DIPTEREX	Trichlorfon	2.5 G	0.5	568	98.5	6.0	41.3	57.5	5.9
CHECK	Untreated	---	---	-0-	99.0	64.5	63.3	50.3	5.1
				Significance level	n.s.	.005	.005	.01	n.s.
				LSD (.05)		9.04	25.3	27.5	

1/ Means not having letter in common differ significantly at .05 level DMRT.

FIG.34A Sugar cane borer, Diatraea saccharalis, foliar damage in IPTT-22, Mezcla Tropical Blanca (250 full-sib families; 6 checks) after artificial infestation with 50 larvae per plant. Insect companion nursery, Poza Rica 76B.

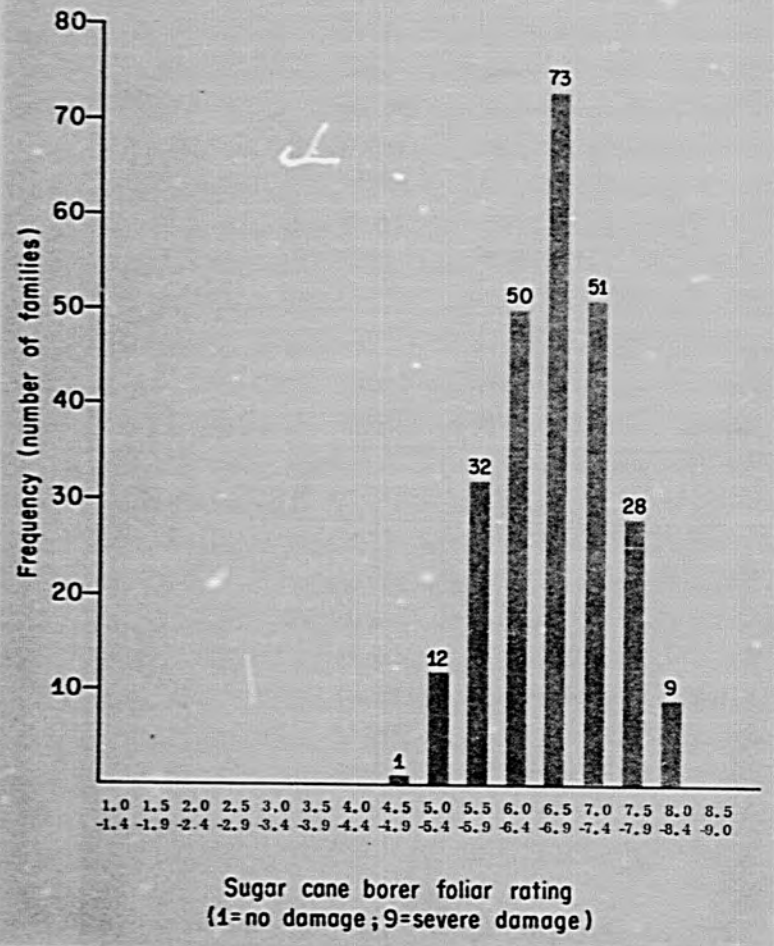


FIG. 3.4 B Borer damaged internodes in IPTT-22, Mezcla Tropical Blanca (250 full-sib families; 6 checks) after artificial infestation with 50 Diatraea saccharalis larvae per plant, plus moderate level of natural infestation by D. lineolata. Insect companion nursery, Poza Rica 76B.

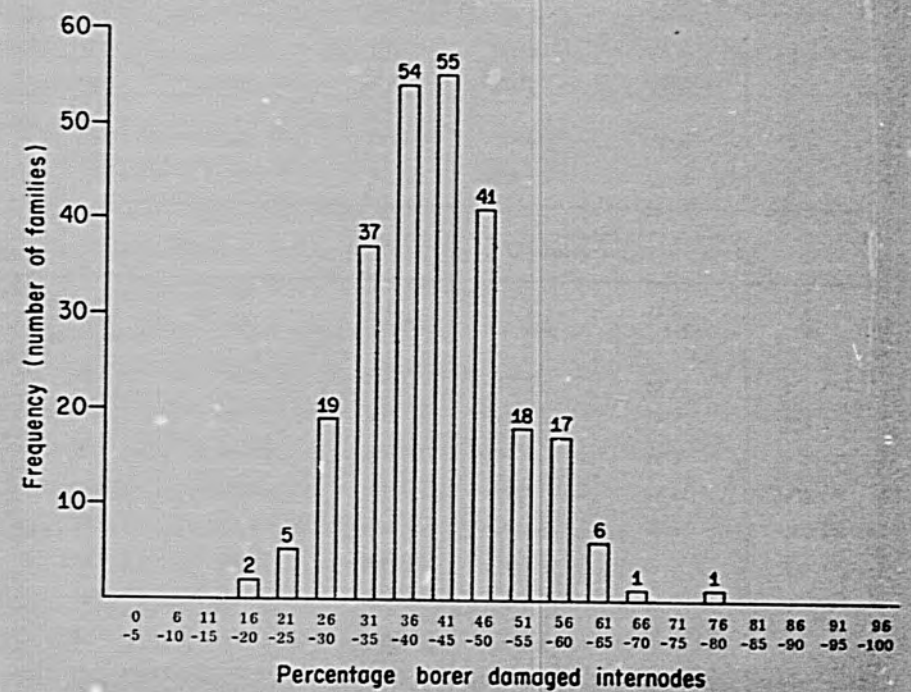
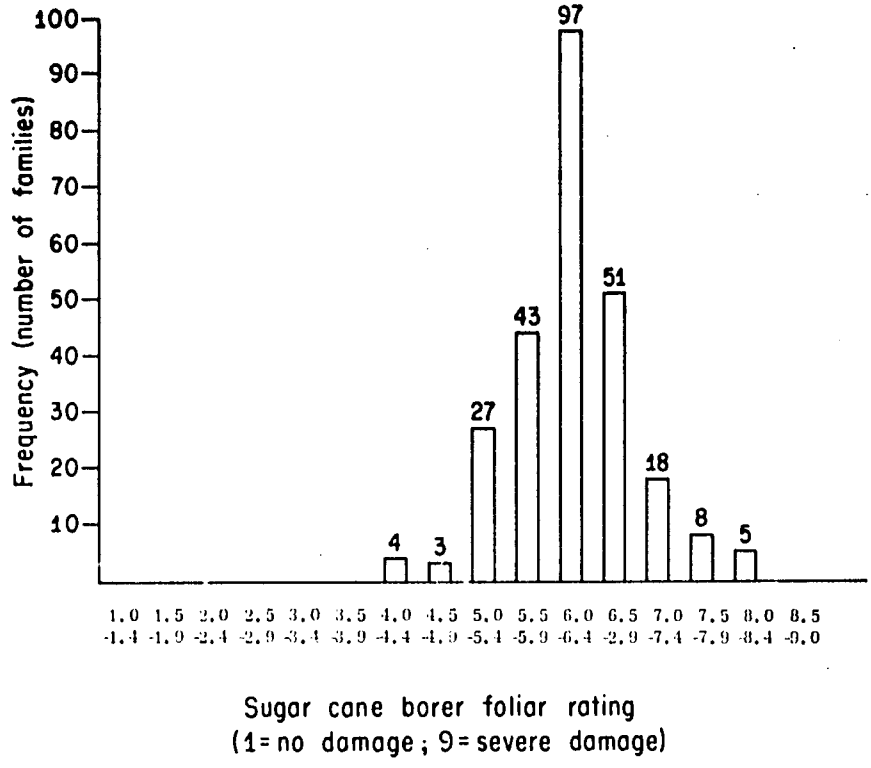


FIG.34C Sugar cane borer, Diatraea saccharalis, foliar damage in IPTT-38, PD(MS)6 H.E. Opaque-2 (250 full-sib families; 6 checks) after artificial infestation with 50 larvae per plant. Insect companion nursery, Poza Rica, 76B.



In identification and improvement of genetic resistance to insects in maize, insect larvae are used for infesting thousands of plants. A bazooka is used to provide more uniform infestation.

The germplasm bank filled 106 seed requests in 1976 and 1977, sending 6,291 samples to 37 different countries.

4.0 BACK-UP UNIT

CIMMYT's maize Back-up unit continues to evaluate and utilize maize materials (introductions) from around the world, to maintain a working germ plasm bank, and to create and improve gene pools of different maturities, grain colors and textures. New introductions and bank accessions are systematically evaluated and added to the appropriate gene pools for their improvement and to extend their genetic heterogeneity. Superior progenies of gene pools are identified and transferred to corresponding existing Advanced-unit populations to increase their usefulness for collaborators, or to form new Advanced populations.

4.1 MAIZE GERM PLASM BANK

At the end of 1977, the maize germ plasm bank held well over 12,000 accessions of maize; this represents the vast amount of variation found within this species in the Americas and parts of Asia. The bank conserves these materials for use by CIMMYT and other persons and organizations.

4.1.1 Regeneration of Materials

As the germ plasm bank seed is used, accessions must be regenerated when the amount falls below 500 gms. In the summer of 1976, 82 tropical and temperate accessions and 30 highland accessions were regenerated. In 1977, 183 tropical and 122 highland accessions were regenerated. This required a total of 90,000 hand pollinations, and plantings on over 6 ha of land. The number of plants used in the regeneration of an accession was limited to 270, as this number was felt to represent adequately the variation within the accession. Bulk-pollination was substituted for plant-to-plant crosses. This ensures better regeneration and conservation of land and labor allowing more accessions to be regenerated with the same facilities.

During 1976, regeneration of Andean materials was continued in cooperation with the "Programa Cooperativo de Investigaciones en Maíz" in Peru. This continued the arrangement begun in 1973, when 1,067 collections were shipped to Peru for regeneration because they could not be successfully regenerated in Mexico. A total of 441 accessions have now been regenerated with their cooperation.

4.1.2 Bank Observation Nurseries

The germ plasm bank contributes to maize improvement through provision of new sources of genetic variation. For efficient use of bank materials, multi-site observation nurseries are invaluable for identifying promising materials. In the summer of 1976, 278 accessions of early tropical origin (along with suitable checks) were grown in nurseries at Poza Rica, Tlaltizapan and Obregon to identify materials for incorporation into early tropical gene pools. In 1977, 456 tropical accessions of various maturities (plus checks) were grown at the same sites, while 258 highland accessions were grown at El Batan and at Toluca.

Data on each accession were taken at each site, for yield, maturity, disease reactions, and plant and ear height. At harvest, several accessions were chosen on the basis of their across-site performance. These were then introduced into appropriate gene pools or improved in a breeding nursery before incorporation.

4.1.3 Services Rendered

Accessions from the bank are requested by national program workers in many countries and by CIMMYT personnel. A quantity of seed sufficient for evaluation and increase is made available for each request. The germ plasm bank filled 106 seed requests in 1976 and 1977, sending 6,291 samples to 37 different countries (Table 4.1). These accessions have been used for studies in evolution, breeding, chemotaxonomy, identification of chromosome knobs and disease resistance.

4.2 INTRODUCTION NURSERIES

Superior maize materials from various national programs are evaluated at several locations within Mexico in one-row plots, 5 meters long. They are studied for all agronomic attributes, including maturity, height, yield potential and reaction to insects and diseases.

In 1976, evaluations were made on over 2,000 introductions from tropical lowland areas, on 150 introductions from temperate areas, and on 150 from the tropical highlands. These evaluations were similar to those made on materials from the germ plasm bank. In 1977 there were 107 such introductions from the tropical lowland areas, 353 from temperate areas, and 323 from the

tropical highlands. The superior materials were incorporated in the appropriate gene pools (Table 4.3). Characteristics such as earliness and insect and disease resistance are of special interest in new materials.

4.3 GENE POOLS

A gene pool is a mixture of diverse germ plasm undergoing continuous recombination; materials can be taken from and added to this mixture when necessary. CIMMYT works with gene pools for three broad ecological zones: tropical lowlands, subtropical-temperate, and tropical highlands (see Appendix). Within each of these zones, pools are characterized in terms of general maturity range (early, medium and late), grain colors (white and yellow), and grain textures (flint and dent). There are 12 gene pools for the tropical lowland zone, 8 for the subtropical-temperate zone (with the omission of the late maturity group), and 14 for tropical highland areas. This group also includes one early and one intermediate white floury type (Table 4.2). (See the Appendix for gene pool chart).

If the gene pools are to be maintained as a heterogeneous plant community to be gradually improved, two requirements must be met:

1) low selection intensity applied to the within-gene pool component of improvement, and
2) provision for systematic introgression of additional superior germ plasm into the pool.

The half-sib method of selection, as modified by CIMMYT, satisfies these needs. Approximately 500 half-sib families making up a gene pool are planted in a 2 female:1 male row pattern. All female rows and undesirable male plants are detasselled before pollen shed. In the summer season, when each pool is grown at more than one site, superior families are identified at each location by a team of scientists from various disciplines. Yield potential, height, maturity, lodging, disease and insect reaction, and uniformity are taken into account at appropriate stages of plant development. The best plants are identified at each location only in those families that have performed well at all locations. At harvest, the best ear is chosen from the selected plants for each pool at each site. The individual selected ears form the half-sib families, and their balanced mixture forms the seed for male rows in the next cycle's planting.

In addition, ears found to be greatly superior at only one site also are retained to provide superior recombinants for the future. They are planted as female rows only. Their seed is not included in the male composite. In winter, when pools are planted generally at only one site, relatively mild selection intensity is applied.

Introductions and the additions from the germ plasm bank are planted only as female rows. This avoids the possibility of unproven materials contaminating the pool and allows introductions to be compared with the pool, while they are being crossed to it. Their superior progenies are harvested. These progeny ears are again planted as female rows in the next cycle to obtain an indication of the compatibility of the introduction with the pool. Superior introductions are then identified and incorporated in the next cycle, using their remnant seed or seed of crosses with the pool.

The tropical lowland gene pools were planted at Poza Rica (latitude 21°N; altitude 60 m) during the summer and winter, and at Obregon (latitude 28°N; altitude 39 m) during the summer of 1976 and 1977. To upgrade the early tropical pools for yield, lodging resistance, and insect and disease resistance, these pools were crossed in the summer of 1975 with a mixture of families from Advanced populations having a matching grain type. During 1976, these pools went through two cycles of recombination with very mild selection. In the winter of 1977, more intense selection was begun for early maturity. Approximately 1,500 of the early-silking plants were identified in each pool. At harvest, the best and relatively drier ears were selected—the intent being to select genotypes with faster rates of grain filling and drying. The male rows were completely detasselled when 70 per cent of the female plants had silked; this was done to ensure that selected female plants did not receive pollen from late male plants. In addition, late female plants produced no grain and were automatically eliminated by this system. Thus, if insufficient ears were available from selected plants, more could be selected from other plants without fear of introducing late germ plasm into the pool.

Tropical gene pools of intermediate and late maturity had been through six cycles of improvement by the end of 1977 (with the exception of Pool 22 which completed seven cycles of improvement). In 1976, five plants from each family were inoculated with ear-rot pathogens in all of these pools. This was repeated, in winter 1977, in half of each family of pools 19, 20 and 25. Clean ears selected from inoculated plants, along with the ears selected from agronomically superior non-inoculated plants, were used to continue the next generation.

Also in winter 1977, half of each family of pools 21, 22, 23, 24 and 26 was infested at seedling stage with first instar larvae of the fall armyworm (*Spodoptera frugiperda*), while the other half was protected with insecticide. The less-damaged infested plants in agronomically superior families were hand pollinated among themselves. Seed from these crosses re-entered the pool in the next cycle, along with half-sib selections from the protected plants.

The existing subtropical-temperate gene pools (pools 27, 32, 33 and 34) were planted at Tlaltizapan (latitude 19°N; altitude 940 m) during summer and winter, and at Obregon during the summer season. They had completed seven cycles of improvement by the end of 1977. The group of subtropical-temperate pools was completed with the addition of pools 29, 30 and 31 in the summer of 1976,

and pool 28 in the winter of 1977. The materials making up these pools are listed in Table 4.4. These pools also were planted at Poza Rica during the summer of both years to broaden their adaptation.

The highland gene pools are grown once a year at El Batan (latitude 20°N; altitude 2,249 m) and Toluca (latitude 20°N; altitude 2,640 m). These pools (with the exception of pool 6 which was initiated in 1977) have now completed four cycles of improvement. They are needed for the highland areas of Mexico, Central America, South America, Africa and Asia. Although the popular grain types in other areas are hard flints and dents, most of the maize grown in the highlands of the Andean region has a floury texture, and is late and susceptible to earworms and ear rots. The floury pools 3 and 8 therefore, were artificially inoculated by ear-rot pathogens in 1976, and clean ears were selected from inoculated plants for the next cycle of recombination. In 1977, pools 3 and 8 and the Cacahuacintle composite were rearranged to form an earlier pool 3 and intermediate pool 8. To obtain floury versions of early and intermediate flint and dent gene pools, they were crossed with floury donors. The crosses were advanced to F_2 and large seeded floury segregates were selected. These seeds will be used in future backcrossing and selection programs.

In 1977, flint selections from the population Mezcla Amarilla x Lineas Illinois-Precoces were merged with pool 9, while dent selections were merged with pool 10.

At the request of maize breeders from Europe at their Eucarpia meetings at Krasnodar, Russia in 1977, materials are being assembled to form gene pools for North Europe, South Europe, and a United States gene pool. These gene pools will supply germ plasm to breeders of other temperate areas. Attempts will be made later to introgress into these materials some tropical germ plasm.

Plants are artificially inoculated to select for resistance to stalk rot.

TABLE 4.1 - Destination of seed shipments sent by CIMMYT's maize germplasm bank during 1976 and 1977.

Country	1976		1977	
	No. shipments	No. items	No. shipments	No. items
Argentina	1	19		
Bolivia			1	124
Brazil	5	2,091		
Bulgaria			1	5
Canada	1	18		
China (Taiwan)	1	5		
Colombia			1	89
Costa Rica			1	25
Czechoslovakia	1	4		
Ecuador	1	2		
Egypt			1	48
El Salvador	1	3	3	791
France	1	49		
Germany	1	18	2	31
Honduras	1	47	1	18
India			2	174
Italy	3	33	1	1
Malaysia			1	15
Mexico	2	22		
Netherlands	8	141	5	301
New Zealand	2	31		
Nicaragua	1	2	2	3
Nigeria			1	28
Papua	1	117	1	24
Peru			1	10
Poland	1	21	1	21
Rhodesia	1	38		
Romania	1	12		
South Africa	1	18		
Switzerland	1	374	1	370
Thailand			1	23
United Kingdom			1	7
USSR	7	351	3	187
U.S.A.	3	50		
Venezuela	13	311	11	163
Yugoslavia	1	1	1	3
Zambia	1	51		
	1	1		
Total	62	3,830	44	2,461

TABLE 4.2- The gene pools - stage of development and characteristics

Pool No.	Name	Stage of development	Days to 50% silking: BATAN (1977)	TOLUCA (1976)
	HIGHLAND:			
1	Early White Flint	C_3	85	116
2	Early White Dent	C_3	85	116
3	Early White Floury	C_3	92	121
4	Early Yellow Flint	C_3	85	119
5	Early Yellow Dent	C_3	83	107
6	Intermediate White Flint	C_0	110	-
7	Intermediate White Dent	C_3	94	123
8	Intermediate White Floury	C_3	94	114
9	Intermediate Yellow Flint	C_3	94	130
10	Intermediate Yellow Dent	C_3	88	131
11	Late White Flint	C_3	117	162
12	Late White Dent	C_3	111	160
13	Late Yellow Flint	C_3	101	135
14	Late Yellow Dent	C_3	106	142

			Summer 1977: Poza Rica	Obregon	Winter 1977: Poza Rica
	TROPICAL:				
15	Early White Flint	C_5	54	57	87
16	Early White Dent	C_5	56	58	87
17	Early Yellow Flint	C_5	56	60	84
18	Early Yellow Dent	C_5	53	58	88
19	Intermediate White Flint	C_6	58	64	-
20	Intermediate White Dent	C_6	59	64	-
21	Intermediate Yellow Flint	C_6	58	58	91
22	Intermediate Yellow Dent	C_7		60	96
23	Late White Flint	C_6	61	63	91
24	Late White Dent	C_6	61	64	93
25	Late Yellow Flint	C_6	65	65	-
26	Late Yellow Dent	C_6	61	63	93

			Summer 1977: Tlaltizapan	Obregon	Winter 1977: Tlaltizapan
	TEMPERATE:				
27	Early White Flint	C_7	54	56	77
28	Early White Dent	C_1	54	56	82
29	Early Yellow Flint	C_2	54	-	76
30	Early Yellow Dent	C_2	53	55	71
31	Intermediate White Flint	C_2	64	-	87
32	Intermediate White Dent	C_7	61	62*	86
33	Intermediate Yellow Flint	C_7	58	58*	83
34	Intermediate Yellow Dent	C_7	59	61*	83

* Obregon 1976 data.

TABLE 4.3-Materials added to the gene pools during 1976 and 1977.

Pool 1:	Chihuahua composite
Pool 3:	Compuesto Grano Grande; Cacahuacintle - Huanchinango and Xicotepec de Juárez; Precoz Harinoso rojo; Precoz harinoso azul; Group F.
Pool 4:	Alph 4; SSSB(R) C_6; Hungarian Composite; BSCB (R) C_6; Amarillo Bajío; Líneas Illinois; UNCAC 242; Pachia.
Pool 4:	Cundinamarca 431; Compuesto Grano Grande; Cacahuacintle - Huauchinango and Xicotepec de Juárez.
Pool 9:	Amarillos tropicales
Pool 10:	Planta Pequeña Mazorca Grande; Holandes 2; Sintético Pairumani; Blanco Colombiano; Kenya 683/tc; Synthetics AT-2,4,5, 6; Inbred 38; AT-633; 52/57-B; 174/56-B; 20/57-B.
Pool 12:	Compuesto Tardío Grano Blanco; Large ear materials from the U.S.A., Mexico, Ecuador y Hungaria.
Pool 14:	Large ear materials from the U.S.A., Mexico, Ecuador and Hungary.
Pool 15:	ES 38-ES Gpo. 1A-Nicaragua Syn.II; Compuesto Caribe; Guatemala 335; Guerrero 100, 176; Nicaragua 55; Sonora 55; Mata Hambre; Guajira 314; materials resistant to downy mildew.
Pool 16:	Honduras Gpo. 13A; Honduras 58,68,69,84,87; Guatemala Gpo. 13-2A; El Salvador 77,82,87,103; San Luis Potosi 100; Mata Hambre; Guajira 314; materials resistant to downy mildew.
Pool 17:	Mata Hambre; Guajira 314; Antigua 2, 4; Barbados 1,3,5; Cuba 40,75; Guadalupe 3,4,11; Guatemala 225; Honduras 97; Israel 1; St. Vincent 3; Uruguay 643, 684, 698, 711; Local Flints (80 and 90 days) from Malaysia; Indonesian Comp.; Pairumani Syn.; Corn Belt materials; materials resistant to downy mildew.
Pool 18:	Santa Croix 6; Guatemala 73; Jalisco 279; Oaxaca 244; Diacol V206; Nayarit 36; Amarillo Bajío; Mata Hambre; Guajira 314; Dominican Republic 203, 240, 243, 258, 271, 274, 275, 277; El Salvador 105; Guatemala 262; Israel 2; materials resistant to downy mildew.
Pool 19:	Compuesto Blanco Pfister; Sicarigua Mejorado; Guatemala Gpo.26-1A; Nayarit 22; Panama 138, 141; materials resistant to downy mildew; Compuesto Caribe; materials from Colombia; materials resistant to tar spot.
Pool 20:	Honduras Gpo. 13-A; San Luis Potosi Gpo. 10,14,54,56,58; Nigeria 1; Guatemala Gpo. 13-5A; Guatemala 786, 794; Nuevo Leon 8,12; Jalisco 274, 286; Nayarit 165; Sinaloa 21; Tabasco 2; Oaxaca 225; Katumani Comp.; Blanco Comun; Nicaragua Syn. 11, Zapalote Grande; materials resistant to downy mildew; materials from Colombia; materials resistant to tar spot.
Pool 21:	Materials resistant to downy mildew; Amarillo Salvador; Guatemala Gpo. 72; Tuxpeño FF; Haiti Gpo. 3; Guadalupe 16; Compuesto Caribe; Panama 114, 148, 149; Compuesto Ecuador, Mexico, Argentina & India
Pool 22:	U.S. Corn Belt materials, and materials resistant to downy mildew.
Pool 23:	Compuesto Caribe; materials resistant to downy mildew; materials from Colombia.
Pool 24:	Materials from Colombia; materials resistant to downy mildew; materials resistant to tar spot.
Pool 25:	Materials resistant to downy mildew; materials resistant to tar spot.
Pool 26:	Materials resistant to downy mildew; materials resistant to tar spot.
Pools 27-28:	Materials resistant to downy mildew; Mata Hambre; Guajira 314; Minita; Pujaguas.
Pools 29-30:	Materials resistant to downy mildew; Amarillo Bajío Precoz; Indonesian Comp.; Pairumani Syn.; Materials from Holland - Aurelio; Capella; Diana; Elina; Florina; Fronica; Fortha; Leopard; Pastora; Sandrina; Tamira; Rheintaler, (Ht_1A; Ht_1B to Pool 30 only).
Pool 31:	Materials resistant to downy mildew; White flint segregates from Comp. Ecuador, Argentina, India and Mexico.
Pool 32:	South Carolina 228; materials resistant to downy mildew.
Pool 33:	Same as Pool 31 except Yellow flint grains selected from comp. Ecuador, Argentina, India and Mexico.
Pool 34:	Materials resistant to downy mildew; Ht_1A; Ht_1B; South Carolina 229; Yellow dents from Amarillo; Pakistan.

TABLE 4.4- Composition of pools formed during 1976 and 1977**.

1. Highland Early White Flint (Pool 6):

   White flint segregates from Highland Intermediate White Dent (Pool 7); Highland Late White Flint (Pool 11); and Highland Late White Dent (Pool 12).

2. Temperate Early White Dent (Pool 28):

   Dent segregates from Pool 27 x Corn Belt, Hungary (materials making up pool 30); Dent segregates from Blanco Pakistan; Taveron; Tla. Syn. C-62.

3. Temperate Early Yellow Flint (Pool 29):

   Uruguay Composite; Amarillo Bajfo; MV.SC.202; MV.TC.281; MV.TC.290; MV.MSC.201; MV.MSC.262; MV.MSC.342; BE-KE 270; UNCAC 242; Cornell Precoz; Compuesto Indonesia.

4. Temperate Early Yellow Dent (Pool 30):

   Sabana Grande; Canda; Los Altos; El Viejo; Santa Ana; Maicillo; Tola Rivas; MV.MSC.342; MV.TC.281; MV.TC.290; MV.MSC.201; MV.SC.202; MV.MSC.201; MV.MSC.262; BE-KE 270; UNCAC 242; Cornell Precoz; Compuesto Uruguay; Amarillo Bajfo; Titicaca Precoz Amarillo; Chihuahua Gpo.E; Pool 1; Syn. 107; Syn. 137; MV.SC.291; MV.SC.370; MV.TC. 431; MV.DC.59; MV.DC.460; MV.DC.520; MV.SC.530; MV.SC.590; MV.SC.405; MV.SC.587; MV.TC.596; MV.TC.610; MV.SC.620; MV.TC.635; MV.SC.660; MV.SC.380; MV.SC.429; MV.SC.598; Mazorca Larga; MV.TC.540; MV.DC.350; KSC. 360; GK-TC 433; Low Ear Syn. (Early) Tenn; Eto (M) C_6 Iowa; Comp. Indonesia.

5. Temperate Intermediate White Flint (Pool 31):

   White flint segregates from Temp. Intermediate White Dent (Pool 32); Temp. Intermediate Yellow Flint (Pool 33); and Blanco Pakistan.

** For composition of existing pools, refer to "CIMMYT Report on Maize Improvement 1973".

5.0 CIMMYT'S COLLABORATIVE RESEARCH PROJECT IN MAIZE DISEASES

5.1 BACKGROUND

Selection for resistance to three major diseases of maize cannot be done effectively at CIMMYT's facilities in Mexico. Thus, in research on these diseases, CIMMYT collaborates with strong national programs in countries where the diseases occur widely and where effective screening for resistance can be done. The three diseases are: (1) downy mildew, caused by the fungus *Sclerospora* spp; (2) corn stunt, caused by *Spiroplasma* sp transmitted by the Cicadellid leafhopper, *Dalbulus maidis* DeL. & W.; and (3) corn streak, caused by a virus transmitted by the Jassid leafhopper, *Cicadulina* spp.

The collaborative breeding project began in 1974, when CIMMYT and six national maize programs made initial selections for resistance to the diseases. Selections for downy mildew were made in Thailand and the Philippines; for corn stunt, in El Salvador and Nicaragua; and for corn streak in Nigeria and Tanzania.

5.2 ORIGINAL MATERIAL FOR SCREENING

In Mexico, during 1974, three broad-based populations of maize were developed that could fit the requirements for grain type and maturity of several national programs. These populations were: (a) Tropical late white dent (TLWD), (b) Tropical intermediate white flint (TIWF); and (c) Tropical yellow flint-dent (TYFD). The research aim was to develop resistance in these three populations against the three major diseases. At the same time, all pools and advanced materials were crossed with downy mildew-resistant sources having appropriate kernel colors. In 1975, the three broad based populations, plus their crosses to known sources of resistance to corn stunt, corn streak and downy mildew, were sent to the six participating countries to be screened for resistance.

The plantings in Africa (Nigeria and Tanzania) were lost due to drought, thus delaying the streak-resistant selections for one year. Plants apparently resistant to downy mildew were selected in Thailand and the Philippines, following artificial inoculations with downy mildew conidia. Stunt-resistant plants were selected under natural incidence of the leafhopper vectors in El Salvador and Nicaragua. In these four locations, the selected plants were either selfed or sib-pollinated. After harvest, seed from selected ears was sent to Mexico for recombination.

5.3 DEVELOPMENT OF CYCLE 1 OF RECOMBINATION

In early 1976, seed from families and bulk-selections that had shown resistance in at least two locations was planted in Mexico in a half-sib recombination block. Families and bulk-selections were planted as female rows; male rows consisted of a balanced composite of all female entries (Tables 5.1, 5.2, 5.3).

Simultaneously, remnant seed of S_1's selected in Thailand was planted in that country and artificially inoculated with conidia of the downy mildew fungus. The resulting information was sent to Mexico so that downy mildew-susceptible S_1 families could be discarded.

5.3.1 EVALUATION OF HALF-SIB (C_1) FAMILIES

Seed from half-sib ears (C_1) selected from three broad-based populations were sent to the collaborating countries for the second cycle of evaluation and selection. A Zaire location replaced that in Nigeria.

In October 1976, ears selected from families showing resistance both in Thailand and the Philippines were included in the downy mildew specific nursery to be evaluated for a second cycle in those same countries (Table 5.4). A similar procedure was followed with the families showing resistance at the two stunt locations; seed from the selected ears were included in the stunt-specific nursery to be evaluated in El Salvador and Nicaragua (Table 5.4). Seed from ears of families showing resistance in at least one downy mildew and one stunt location were sent to all six disease nurseries. Tanzania and Zaire also planted all entries that were sent to the stunt and downy mildew locations.

As in the previous cycle, seedlings in Thailand and the Philippines were artificially inoculated with conidia of the downy mildew fungus. The selection in the stunt and streak locations was done under natural incidence of the insect vectors. In all locations, the healthy and agronomically desirable plants were self-pollinated. Table 5.5 lists the number of half-sib ears evaluated within each group, and the number of S_1's obtained.

5.3.2 EVALUATION OF S_1 FAMILIES C_1

After the harvest, in March 1977, some of the seed from ears selected in Thailand was sent to be planted in the Philippines, and vice versa. The same procedure was fol-

lowed with S_1 seed harvested in El Salvador and Nicaragua.

To obtain more precise information, and to confirm the results obtained under natural infection, the selections from the best entries (those showing resistance at both stunt locations) were artificially inoculated with the stunt agent in Mexico. Inoculation was by virulent leafhoppers which were allowed to feed 24 hours on seedlings in the greenhouse. These seedlings were later transplanted to the field.

Selected S_1 ears from half-sib families showing resistance for both downy mildew and stunt were included in the second cycle nurseries for screening at downy mildew and stunt locations.

5.4 DEVELOPMENT OF CYCLE 2 OF RECOMBINATION

Data from S_1 evaluations planted in April 1977 were obtained only from Thailand (downy mildew) and El Salvador (corn stunt). Materials could not be planted in the Philippines due to drought, and planting was delayed in Nicaragua and information was not available. Selection of S_1 families was made in Mexico using available information from Thailand, El Salvador and Mexico, and full-sib (FS) families developed by crossing disease-resistant, agronomically desirable families.

Following the breeding scheme described in Table 5.4, three sub-populations have now been developed for each base population, each with some gain in resistance against stunt, or downy mildew. Similarly, a long-term project will continue to accumulate genes for resistance against any combination of two or all three of these diseases simultaneously, as reports have been received from countries where downy mildew occurs with stunt, or downy mildew occurs with streak. Although there have been no reports of all three diseases occurring simultaneously, there are possibilities for such a condition to occur in the future.

The reaction of the S_1 families utilized in the regeneration of the base populations (C_2) shows that some gain in resistance has been achieved, when such families are compared with families that have not been selected against one specific disease.

When the level of resistance against certain disease and desirable agronomic characteristics is considered to be adequate, populations will be distributed to national programs. In turn, these countries can utilize the populations to develop open-pollinated varieties, or inbreds can be derived if a hybrid program is desired.

5.5 CONVERSION OF FIVE ADVANCED POPULATIONS TO DOWNY MILDEW RESISTANCE

In 1976, it was decided to improve five advance unit populations for downy mildew resistance. These populations included 3 whites Tuxpeno 1, Mezcla Tropical Blanca and (Mix. 1 x Col.Gpo.1) x ETO and 2 yellows, Amarillo Cristalino–1 and Amarillo Dentado.

When the half-sib recombination blocks were planted in Mexico, S_1 families generated in these five populations were artificially inoculated with downy mildew conidial evaluated for resistance in Thailand. Resistant S_1 families were selected in Mexico and backcrossed to the susceptible recurrent parent (Table 5.6).

In late 1976, these populations (BC_1) were planted in Tlaltizapan. Agronomically desirable plants were selected and advanced to F_2 by selfing. S_1 ears were sent to Thailand for artificial inoculation and evaluation of downy mildew reaction. Table 5.6 shows the number of S_1 families selected in each of these 5 populations.

Table 5.1. Performance of half sib families screened for resistance to stunt and/or downy mildew and number of ears selected for recombination. (Population TLWD).

Base population and crosses	Num.HS families screened (CO)	Num.locations where resistant	Num.resistant HS families	Num.ears selected and used in half sib recombination (C1)
TLDW	440	2	123	355
		3	23	179
		4	1	1
TLDWxDMR sources	249	2	29	78
		3	4	24
		4	0	0
TLWDxStunt sources	39	2	1	6
		3	5	98
		4	1	1
Total	728	—	187	742

Table 5.2. Performance of half sib families screened for resistance to stunt and/or downy mildew, and number of ears selected for recombination. (Population TIWF).

Base population and crosses	Num.HS families screened (CO)	Num.locations where resistant	Num.resistant HS families	Num.ears selected and used in half sib recombination (C1)
TIWF	400	2	25	55
		3	18	72
		4	3	17
TIWFxDMR sources	173	2	46	164
		3	6	28
		4	0	0
TIWFxStunt sources	92	2	20	62
		3	5	18
		4	0	0
T o t a l	665	—	123	416

Table 5.3. Performance of half sib families screened for resistance to stunt and/or downy mildew, and number of ears selected for recombination. (Population TYFD).

Base population	Num.HS families screened (CO)	Num.locations where resistant	Num.resistant HS families	Num.ears selected and used in half sib recombination (C1)
TYFD	400	2	23	100
		3	1	2
		4	0	0
TYFDxDMR sources	224	2	19	75
		3	0	0
		4	0	0
TYFDxStunt sources	20	2	16	122
		3	3	4
		4	0	0
T o t a l	644	—	62	303

Table 5.4. Development of downy mildew, streak and stunt resistant populations in CIMMYT's Collaborative Research Program.

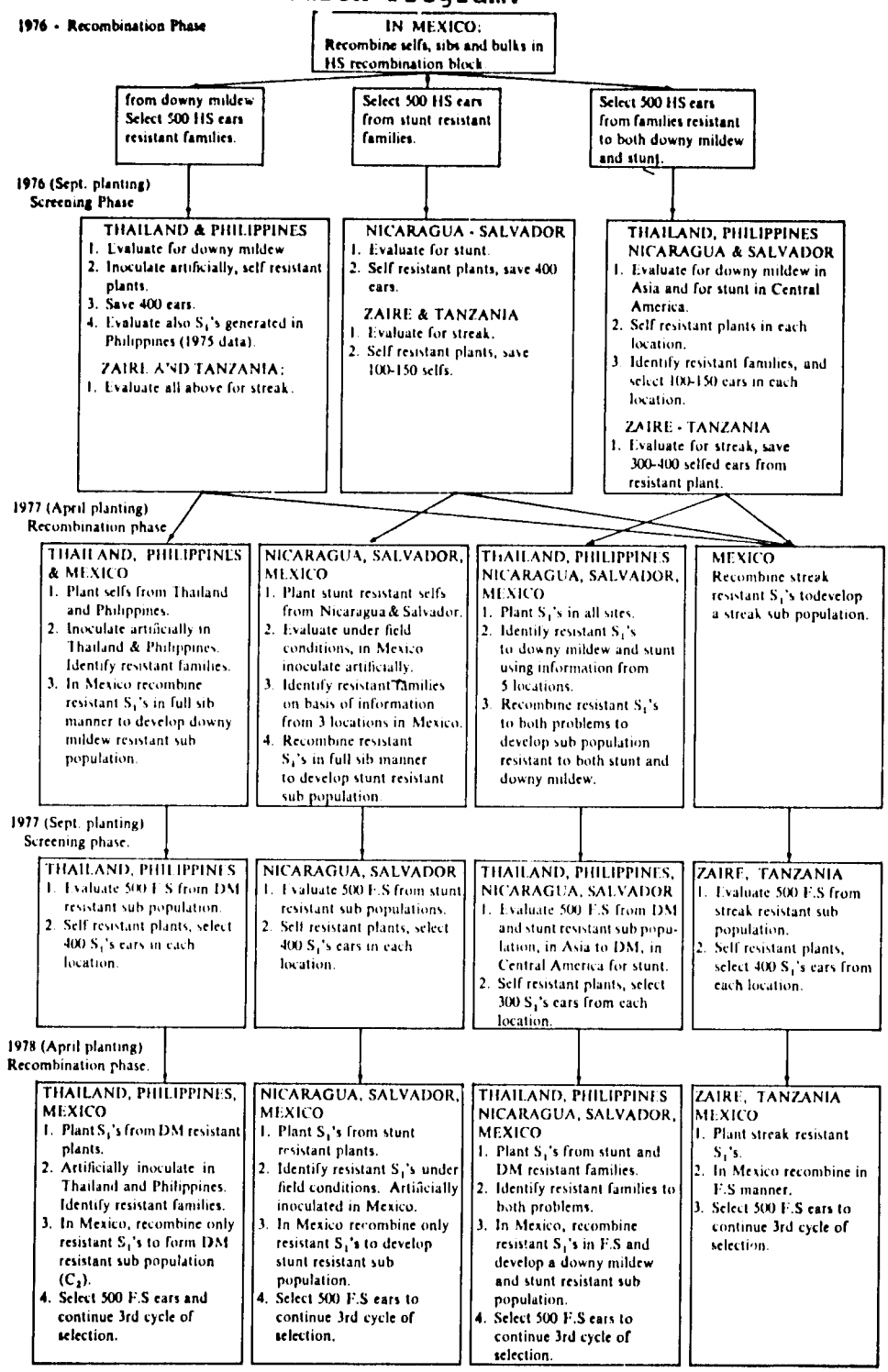


Table 5.5. Half sib (HS) families screened for stunt and/or downy mildew from three populations and number of ears selected. Cycle 1976.

Population Nº	Origin HS families	Num. HS families screened (C_1)	Num. of resistant HS families	Resistant at: Nic.	Salv.	Thail.	Phil.	Num. S_1 families Generated	Selected
1	TLWD (DMR+Stunt)	363	67	X	X	X	X	141	52
2	" (DMR specific)	202	56			X	X	372	328
3	" (Stunt specific)	825	185	X	X			416	160
4	TIWF (DMR+Stunt)	304	64	X	X	X	X	194	52
5	" (DMR specific)	165	86			X	X	351	291
6	" (Stunt specific)	346	166	X	X			424	143
7	TYFD (DMR+Stunt)	392	46	X	X	X	X	105	27
8	" (DMR specific)	418	25			X	X	482	413
9	" (Stunt specific)	793	236	X	X			385	121

Table 5.6. Advance Unit populations improved for downy mildew resistance.

Population Nº	Name	Number S_1 families: Evaluated in Thailand, Number	Evaluated in Thailand, Mean % DM	Selected for BC_1, Number	Selected for BC_1, Mean DM
21	Tuxpeño 1	29	56	6	27
22	Mezcla Tropical Blanca	27	61	7	25
25	(Mix.1 x Col.Gpo.1) ETO	28	66	6	30
27	Amarillo Cristalino-1	28	68	6	20
28	Amarillo Dentado	21	52	7	6

Plant height, along with grain yield and days to flower, is one of the primary criteria considered in making across site selections of superior progeny for recombination.

6.0 SPECIAL PROJECTS

In development of maize materials to be channeled into national programs, certain limitations in the usefulness of various materials have become apparent. Special Projects are a mechanism for investigating promising research areas and for exploring ideas that might be used in the program. Such research can be managed without interrupting or dislocation of the established, on-going system.

6.1 SELECTION FOR YIELD EFFICIENCY

The development of plant types that produce a greater proportion of their total dry weight in the form of grain, rather than leaves and stem, is a basic concept in the overall maize program. Different approaches to achieve these types are now being used; however, no single methodology or breeding procedure is considered to be ideal, nor are the sources of appropriate germ plasm thought to be sufficiently well identified so as not to require changes from time to time. As these projects proceed, changes are considered in both selection procedures and in materials under selection. Any appreciable modification in plant phenotype is assumed to imply an appropriate modification in the evaluation procedures used, and in the kinds and amounts of data taken, as well.

6.1.1 YIELD EFFICIENCY WITHIN TROPICAL GERM PLASM

6.1.1.1 Short Plants

Of the materials in the CIMMYT population improvement program, the population Tuxpeño 1 (Tuxpeño Planta Baja) has been subjected to the greatest number of cycles of selection for shorter plant height and it has shown the greatest reduction for plant height.

The ultimate degree to which plant height is subject to modification is not known, nor are the effects on other characters. To assess these changes as rapidly as possible, and to apply the resulting information to selection criteria, height reduction has been emphasized as the primary objective. A subpopulation of Tuxpeño 1 (Pop. 21) has been diverged from the regular selection procedure for this purpose.

Reduced plant height has led to increased grain yield when plant density has been increased. The concurrent increase in the number of plants that do not produce grain (barren plants) does, however, contribute to a loss in yield efficiency. There appear to be genetic differences in this response (see high density nursery, Advanced unit) which are best expressed under the stress of high plant density. Research elsewhere has shown that silk delay (the interval between pollen shedding and silk emergence) is positively related to the incidence of barrenness, thus, it would seem desirable to use silk delay as an additional selection criterion.

Full-sib families of the subpopulation were grown in 5-meter rows at a population density of 107,000 plants/ha. Approximately 50 per cent of the families (those with a plant height below the population mean and free from foliar diseases) were selected for intercrossing. Within the selected families, individual short plants (3 to 5 plants per family) with a good coincidence of flowering in the tassel and ear were crossed with similar individuals in other families. At maturity, ears from all plants were harvested, and yield and ear rots were evaluated visually. A number of families and their crosses were discarded to give a final selection of one-third of the families (with 3 ears per family) for the next cycle of improvement. Two such cycles of selection were made each year during 1976 and 1977 at Poza Rica.

No evaluations of cycles of selection were made in 1976 or 1977, as only modest progress was expected. An additional four or five generations of selection should provide differences that are great enough for an evaluation; such evaluation is projected for 1978.

Plant height is influenced considerably by the environment (Fig. 6.1). Thus, populations that have an acceptable plant height in Mexico may become tall and may lodge severely (see International Trial Results) at other sites around the world. Plant height is determined by the number and length of internodes. Leaf number (or node number) increases with increasing daylength (Fig. 6.2), the increase becoming especially pronounced at latitudes greater than 25 degrees. Regression analysis has shown that 20 per cent of the variation in mean internode length in a number of tropical maize cultivars can be explained by variation in mean daily maximum and minimum temperatures (Fig. 6.3 and 6.3A) during the period from tassel initiation to flowering. Maximum height expression in tropical maize can be expected, therefore, in environments with mean maximum temperatures of 32C and mean minimums of

16C, and at latitudes greater than 25 degrees. Research at such sites (e.g. Sids, Egypt, 30 deg.N) should enable better differentiation between lines for absolute height. When combined with research data from Mexico (Poza Rica), such data should allow the identification of genotypes whose height is less sensitive to the environment.

6.1.1.2 Reduced Foliage

Tropical maize has a lower grain number and grain yield per unit leaf area of plant and a higher density of leaf area above the ear when compared with temperate material grown in a disease-free environment in the tropics (Table 6.1). The light environment of the crop around flowering has been shown to influence grain number and yield per plant (Maize Improvement Report, 1975). It is not clear to what extent the light environment of specific leaves (particularly those near the ear) is involved in this response. Data from translocation patterns in temperate maize does indicate, however, that (at flowering) the leaf subtending the ear contributes a greater proportion of its photosynthate to the ear than do the leaves at other positions. Thus, it seems logical to select for reduced foliage density above the ear leaf to improve the illumination of the leaves close to the ear.

Considerable variation exists within CIMMYT material, in leaf orientation, leaf dimensions, and leaf area density above the ear. Thus, there is variation in illumination of the ear leaf and in the quantity of light reaching the ground at a given leaf area index (Table 6.2).

A subpopulation has been diverged from each of three populations (Tuxpeño 1–Pop.21, ETO Blanco–Pop. 32, and Antigua-Republica Dominicana–Pop. 35) for the purpose of selecting for reduced foliage density above the ear. (Again, as previously described, there is selection against barreness.) Two selection cycles were completed each year at Poza Rica during 1976 and 1977, family selections being based on measurements of leaf number, leaf length, leaf width and plant and ear height. Considerable variation among families in leaf area above the ear appears to exist (Table 6.3). As in the case of reduced plant height, no evaluations are planned until four or five selection cycles have been completed.

6.1.1.3 Reduced Tassel Size

Maize tassels have been shown to be considerably larger than is required for their function as pollen sources. Large tassels intercept and waste considerable incident radiation during the flowering and grain filling periods, and may compete with the developing ear for nutrients during the preflowering and flowering period.

As with selections for reduced foliage density above the ear, a subpopulation of each of the same populations

A feature of production training at CIMMYT is the layout of agronomic trials on private farmer's lands and organizing field days for farmers.

was diverged for selection for reduced tassel size. Selection procedures were similar, with the exception of ETO Blanco (Pop. 32), where selections for foliage and tassel reductions were made in the same subpopulation, rather than in separate subpopulations. Selection was for reduced tassel branch number, a character which varies considerably (Table 6.3). Two cycles were completed each year.

6.1.2 YIELD EFFICIENCY IN TROPICAL X TEMPERATE GERM PLASM

The problems of direct transfer of temperate region germ plasm to tropical areas and the logical alternatives for combinations between tropical and temperate germ plasms have been mentioned briefly in previous reports. As might be expected, results are usually of an intermediate type in terms of the response of recombinants to the normal disease and insect problems of tropical areas. An intermediate response in parameters of yield efficiency (Table 6.4) also is apparent. Considerable variation occurs in these parameters, and is apparently related to the different sources of temperate and tropical germ plasm used in the combination (Table 6.5).

If temperate-type plant architecture and dry-matter partitioning are to be usefully recombined with disease and insect resistance from tropical sources, it is expected that systematic recombinations will be required over a series of generations, concurrent with selection for survival under tropical conditions of the temperate plant phenotype. A large number of such materials are in various stages of mixing and mild selection. One, previously referred to as "Amarillo Bajío", has been assigned to the Advanced unit as Pop. 45.

As step-wise mixtures of these materials become reasonably homogeneous (when contrasted with those that are discarded), they are planted in more than one location for simultaneous selection under at least two environments. The two selections are then combined to constitute the families of the succeeding generation. Modified ear-to-row mass selection (Lonnquist) is used. As before, families are evaluated under two population densities (40,000 and 80,000 plants/ha). Where possible, families, and plants within families, are selected with good yield at the higher density.

Previous CIMMYT reports have described the relative grain yield efficiency of the tropical maize plant as compared with plants evolved in temperate climates. Such comparisons have relied on data from different environments, or from the simulated growth of the two types in a given environment. Figure 6.4 shows the contrasting patterns of dry matter distribution, when a tropical population (Tuxpeño 1) is compared with a temperate hybrid (Pioneer 3369A): Tlaltizapan, winter 1974. The lower total dry matter production by the temperate hybrid probably is due to its lower leaf area index (Figure 6.5) and its earlier maturity. In this comparison it is possible that the greater proportion of shoot dry matter partitioned to grain by the hybrid was due partly to hybrid vigour. However, in an earlier study, Goldsworthy found little difference between the harvest index of the tropical varietal cross Tuxpeño x ETO and the harvest indices of the parent populations.

6.2 ADAPTATION

Many attempts have been made to use "exotic" germ plasms: in temperate regions to incorporate insect and disease resistances from tropical corns; in tropical regions to incorporate the "efficient" plant type of temperate origin maizes. One complication results from the very different heat unit requirements of different genotypes, which are reflected in their relative maturities. The tendency is to select so-called "productive" varieties; however, those that are "productive" types in tropical areas require such a long growing period under temperate conditions that they are not useful and eventually must be abandoned. Photoperiod sensitivity provides another formidable obstacle. Length-of-growing-period is a major consideration in limiting "adaptation"—the longer the growing period required, the fewer locations where a given material may be satisfactorily grown. This is of special importance in incorporating tropical germ plasm into temperate areas. It would follow then, that earliness 'per se' is important in adaptation and that there is logic in choosing 'early maturity' tropical types for use in temperate areas.

The basic procedure for achieving wider adaptation in CIMMYT maize populations is the selection of the superior genotypes under a series of different environments, followed by their recombination successively through an indefinite number of such selection cycles. In all such materials, a critical part is the formation of the base populations so as to include (insofar as possible) all the appropriate germ plasm. In most cases, germ plasm is assembled from areas representing the extremes of the range of conditions for which the population is being developed. Then, after cycles of mixing, selection is done under different environmental conditions. An extreme example of this procedure has been applied with the population called "Estudio Reacción Largo del Día", which is being sent to a large number of sites around the world, in addition to the five CIMMYT locations in Mexico. In this case, under the conditions of higher latitudes and altitudes a limiting factor is the length of growing cycles required for the material. Pressure will be increased for earliness to expand the number of potential sites where selection can be done. (See 1974 Report.)

6.3 EARLY MATURITY

In 1975, a broad-based population (here referred to as Lote 81) was formed, composed of very early tropical genotypes intercrossed with intermediate and late maturity types (see 1975 report). Two cycles of selection each year were conducted in 1976 and 1977 at Poza Rica,

with the second planting cycles duplicated at the Obregon, Sonora station. Selections from both Poza Rica and Obregon were combined to constitute the subsequent generation for selection.

A reduction of about one day per cycle is being sought in days to flowering (a measure of maturity), while maintaining grain yield. To obtain this reduction, it may be necessary to change the relative durations of the developmental phases of the crop in favor of a shorter period to flowering, and a longer duration of grain filling. The relationships among grain yield and its components, days to silking, and grain moisture content, at a given harvest date were examined for healthy plants within the early flowering sector of Lote 81. The variation in grain yield per plant by flowering date and grain moisture percentage groups is shown in Table 6.6. The absence of a relationship between grain yield and flowering date for a given range of grain moisture content (29.0 to 31.9 per cent) suggests that it is possible to select early flowering types without reducing grain yield (Figure 6.6). Grain yield per plant for plants of the same flowering date, however, is positively related to grain moisture percentage at harvest (Figure 6.7 and 6.7A). This appears to reflect a dependence of grain yield on the effective grain filling period duration (EFPD). In a separate study, variation in grain yield among families from five distinct tropical materials (after effects of materials 'per se' were removed from the data) also was unrelated to flowering date, but positively correlated (r equal 0.33) with EFPD.

A different method of developing very early maturity tropical varieties consists of assembling the earliest maturity genotypes from wherever they are encountered in the lowland tropical latitudes of the world. Presently composited in this effort are thirty-three collections from Indonesia (Indonesia composite), one from Colombia (Guajira 314), two from Honduras (Mata Hambre), one from El Salvador, and six from Pakistan (Bannu early group). These are being composited in step-wise fashion by making all possible crosses among groups as they are grown together. The performance of these crosses is then compared at two locations prior to deciding which of the combinations are to be incorporated in the very early maturity population. Initially no attention is being paid to color or texture of grain.

Simultaneously, trial combinations are being made of these materials with early maturity temperate germ plasm. When planted at the Poza Rica station during the summer season, these early tropical types are ready for harvest 80 days after planting. Previously, there had been no extensive attempts to incorporate early maturity tropical germ plasm with the most productive temperate latitude types.

No attempt has been made to assess the yield of these short and early materials at their optimum planting densities. Preliminary evaluation (Table 6.7) indicates that grain yield per unit leaf area and harvest index of these materials are comparable with those of the tropical x temperate germ plasm, and are better than those of the late tropical material. Indeed, the grain yield per unit leaf area per planted day for early and late tropical materials is 1.68 and 1.18 g/m^2 (leaf)/day. Given the variation in performance among groups of early materials (Table 6.7), it should be possible to develop early maturing germ plasm with a high grain yield produced over a short cycle of growth.

6.4 PERFORMANCE UNDER DROUGHT

Periodic drought, caused by insufficient rainfall and accentuated by soils with a low water-holding capacity, is a major cause of yield loss in maize throughout the tropics.

Studies reported in the Maize Improvement Report for 1974 and 1975 indicated that while there was little measured change in relative performance among varietal genotypes over a wide range of water stress conditions, this was not so for individual genotypes (families) within the population Tuxpeño 1. The problem of whether this interaction represented true genetic differences among families grown in small single row plots was considered best answered by the performance of a synthetic created from these progenies in a yield trial conducted under similar condition as at the progeny trial.

Based on the performance of the full-sib families tested in winter 1975-76, a number of synthetic varieties were created from remnant seed in summer 1976. Although a total of 10 varieties were created, those discussed here are: (1) synthetics created from the 10 best yielding full-sib families under the treatments of no water stress (Selection T_1), medium stress (Selection T_2) and severe stress (Selection T_3); (2) multiple Selection 1 was the synthetic created from the 5 best full-sib families and multiple Selection 2 was the synthetic created from the 5 worst subfamilies, based on yield and yield stability across stress levels, leaf tissue death score, and relative leaf extension index; (3) population mean, a synthetic created from all of the progeny families; and (4) Poza Rica 7521, a synthetic (or experimental variety) developed in the regular international testing program at CIMMYT from the population Tuxpeño 1.

These combinations were selected to provide information as to the genetic diversity for drought tolerance within a population, the ability to improve a population for tolerance to drought, and the importance of various selection criteria in selecting for drought tolerance.

The yield trial was sown in November 1976, using the same block of land and experimental design used in the previous trial, except that the trial was replicated four times. Plots consisted of 4 rows, 5-meters long. The central two rows were used for observations and yield was determined from 14 plants located near the center of each plot.

Yield levels in the trial were lower than those predicted from the previous season's data, but the increasing

coefficient of variability with increasing water stress was again apparent. Correlations between predicted and actual synthetic performance, although non-significant, were highest for the severe stress treatment (coefficient of correlation being 0.47 for yield, 0.45 for leaf tissue death score, and 0.02 for relative leaf extension index.

Comparative performance of the materials is shown in Table 6.8. The similarity of performance of synthetics selected on the basis of yield alone (T_1, T_2, T_3) is contrasted with the superior performance of Multiple Selection 1 over other entries under severe water stress. This entry outyielded all other entries by 36 per cent and outyielded the entry selected for yield under irrigation by 64 per cent. The performance of Poza Rica 7521, the synthetic derived from the Advanced unit program, suggests that the system of international testing employed may enhance performance under intermediate levels of water stress. Interaction of entries x water stress level was non-significant, although there were significant differences among entries across all stress levels. Analysis of the extreme water treatments as randomized complete blocks, however, did reveal that the yield of Multiple Selection 1 under severe stress was significantly greater than that of Multiple Selection 2 and Selection T_1. There was no significant difference in yield under non-stress conditions.

This comparison in performances between Multiple Selection 1 and Multiple Selection 2 suggests that there are genetic differences for drought tolerance within a population and that such genotypes are not identified under non-stress conditions.

Flowering is generally considered the ontogenetic stage at which grain yield is most sensitive to water stress. It might, therefore, be expected that the higher-yielding varieties also might be those flowering earliest. This, however, was not indicated (Table 6.8). The higher-yielding varieties, however, did lose fewer lower leaves than did the more drought-susceptible varieties.

Some of the superior performance shown by Multiple Selection 1 as compared to other selections undoubtedly was due to the greater selection pressure used in forming this variety (6 per cent vs. 12 per cent for selections based on yield alone). The expected rates of gain over the population mean from this difference in selection intensity is 1.2:1. The ratio of realized gain of Multiple Selection 1 over Selection T_3 is 4.9:1 under conditions of severe stress and 1.5:1 across all stress levels. It is thought that the use of the leaf death score in selection improved the efficiency of selection for performance under stress, since this index is less sensitive than yield to the competitive effects of neighboring plots in the progeny trial. Linear correlations computed between yield at two levels of water stress and other characters (Table 6.8A) indicate that leaf tissue death and relative extension index are reasonable indicators of ability to perform under water stress. The relatively strong association of performance under drought with the anthesis-to-silking interval indicates the ubiquity of this index as a general measure of stress tolerance in maize.

The mechanisms accounting for the yield superiority of Multiple Selection 1 under severe stress were not identified: it may have had a larger root system; a larger root volume would enable a greater uptake of water and nitrogen, the latter resulting in less leaf tissue death. Analysis of yield components under conditions of severe stress demonstrated that the 500 kg/ha yield superiority of this synthetic, as compared to the others, reflects its superiority in all yield components. It is not known, however, if this superiority would persist under a stress produced rapidly on a soil of low water-holding capacity.

Some varietal trials conducted in farmers' fields in the State of Veracruz, Mexico by the Maize Training Program indicate that the characters selected for in Multiple Selection 1 may be useful for the various stresses, including drought, that are encountered in these trials.

The preliminary results from a single cycle of selection indicate that the technique outlined can be used to improve populations of tropical maize for their performance under drought, without sacrificing their ability to perform under well-watered conditions.

During the 1977A cycle, crosses were made in many possible combinations among approximately 50 families that had been identified as the best performers under drought (grown in 1975A cycle). From these crosses, 250 full-sib families were selected and grown under the same trial conditions in Tlaltizapan in the 1978A cycle. It is expected that this number of families will be evaluated annually during the A cycle in Tlaltizapan for several more years, using this location as the testing site in a recurrent selection program for performance under drought.

TABLE 6.1 Yield and parameters of yield efficiency in two tropical maize varieties and one temperate maize hybrid. (Tlaltizapan, winter 1977).

Material	Days to silking	Grain yield ($g.m^{-2}$)	Grain number per unit leaf area ($.m^{-2}$)	Grain yield per unit leaf area ($g.m^{-2}$)	L.A.D.A.E.* cm^2cm^{-1}
Tuxpeño Cycle 14	84	647	728	179	39.5
Tuxpeño Cycle 2	95	552	456	144	51.2
Pioneer 3369A	75	572	1051	286	26.9

* Leaf area density above car.
L.A.D.A.E. = leaf area above and including ear leaf/distance from ear to upper ligule.

TABLE 6.2 Variation in foliage parameters and in simulated light intensities for several materials grown at Tlaltizapan, winter 1977.

Material	Leaf area per plant (cm^2)	Mean leaf angle (degree)	Mean leaf length (cm)	Length/width	Leaf no above ear	LADAE*	Simulation at LAI=4[a] Ear leaf light intensity[b] ($nE.cm^{-2}sec^{-1}$)	% incident light reaching ground[c]
Pak.Precoz x Mata Hambre	2192	45.3	58	9.8	5.0	24.0	16.5	13.9
MVSC x Guajira 314	2821	43.8	55	8.6	5.6	20.9	16.3	13.8
Mazorca larga x Indonesia	4776	45.2	72	10.2	6.4	34.0	24.8	8.8
Amarillo Bajio x Ant. R.D.	5710	46.4	77	9.6	6.4	37.9	24.8	9.4
BSSS(R) C6 x Ant. R.D.	3919	43.8	70	10.1	6.6	28.8	18.7	9.6
Selección Precoz	5574	46.6	72	8.9	6.8	34.9	24.0	10.6
Antigua x Rep. Dom.	5097	42.5	72	9.5	6.8	35.5	17.7	9.0
Mezcla Amarilla	5895	48.5	73	9.7	6.8	33.4	25.0	10.8
Tuxpeño cycle 14	7192	49.5	78	10.1	7.4	39.5	23.7	9.8
Hungarian Composite	4086	43.1	68	10.6	6.2	26.5	23.2	10.3
Amarillo Bajio	5264	46.7	68	9.7	6.8	34.1	21.6	10.3
Pioneer 3369A	5140	47.7	63	7.5	6.8	26.9	22.4	12.4
Tuxpeño cycle 2	9897	52.9	94	10.4	7.0	51.2	33.5	10.2
Michoacan 21	4097	46.7	67	8.9	5.4	22.1	26.8	11.9
Mean	5119	46.5	71	9.5	6.4	32.1	22.8	10.8
SE	1877	2.7	9.4	0.8	0.7	8.1	4.6	1.6
CV (%)	36.7	5.7	13.3	8.7	10.4	25.1	20.1	15.2

* Leaf area density above ear (includes ear leaf).
a Simulation assumes 80 cm row width.
b Simulated for radiation conditions of an average day in January at Tlaltizapan. Values are for photosynthetically active radiation.
c For solar noon only.

TABLE 6.3 Family variation for morphological characters in 151 families in the population ETO Blanco (IPTT 32). Poza Rica, winter 1977.

	Leaf width* (cm)	Leaf length* (cm)	L.A.D.A.E. cm^{-2} cm^{-1}	Leaf no. above car	Tassel branch number
Mean	9.72	83.6	35.5	5.50	22.0
Range	3.35	31.3	22.2	2.00	19.3
Standard error	0.60	4.8	4.2	0.44	3.7
C.V. (%)	6.13	5.77	11.78	7.94	16.68

* Measurements made upon the leaf one above the leaf subtending the car.

TABLE 6.4 A comparison of yield and parameters of yield efficiency in maize.

Material		Silking (Days)	Grain Yield (gm^{-2})	Yield per days(Silking) ($gm^{-2}day^{-1}$)	Leaf Area Index	Grain Yield per leaf area (gm^{-2})	Harvest Index	Total Stem Sugars (gm^{-2})
Early Tropical	Mean	69.4	354	2.96	1.76	197	0.43	34.6
(8 Materials)	Range	7.5	184	1.44	0.56	46	0.05	17.5
Tropical x	Mean	78.3	771	5.88	3.96	194	0.45	56.6
Temperate	Range	2.5	246	1.82	0.83	43	0.04	12.0
(6 Materials)								
Temperate								
(Pioneer 3369A)		75	576	4.18	2.00	288	0.53	25.0
Tropical Late								
Tuxpeño - C_{14}		84	647	4.28	3.61	179	0.41	92.3
Tuxpeño - C_2		95	554	3.67	3.84	144	0.31	94.2

TABLE 6.5 Yield and parameters of yield efficiency in a number of maize population with tropical and temperate germplasm - (Tlaltizapan winter 1977).

Materials	Silking (Days)	Grain Yield (gm^{-2})	Grain Yield per day (Silking) ($gm^{-2}day^{-1}$)	Leaf Area Index	Grain Yield per Leaf Area (gm^{-2})	Harvest Index	Total Stem Sugar (gm^{-2})
Amarillo Bajio	81	705	5.10	3.57	197	0.45	55.4
BSS(R)C6 x Indonesia	79	543	4.28	3.51	155	0.40	51.2
Mazorca Larga x Indonesian	76	653	5.10	3.73	175	0.44	48.6
Amarillo Bajio x Antigua Rep. Dom.	77	1036	7.92	5.18	200	0.48	72.7
Mazorca Larga x Antigua Rep. Dom.	79	808	6.17	4.08	198	0.45	49.2
BSS(R)C6 x Mezcla Amarilla x Antigua Rep. Dom.	78	880	6.72	3.66	240	0.47	62.6
Mean	78.3	771	5.88	3.96	194	0.45	56.6
Range	2.5	246	1.82	0.83	43	0.04	12.0

TABLE 6.6 Distribution of plant grain yield by silking date and grain moisture content at harvest (maturity index) in the earlier flowering segment (mean flowering date of population, 84 days) of a tropical population.

Silking (Days)	GRAIN MOISTURE AT HARVEST (%)			
	20-25	25-30	30-35	35-40
78	84	102	112	107
79	93	100	111	-
80	84	102	117	119
81	90	106	114	127
82	87	100	118	-

TABLE 6.7 Yield and parameters of yield efficiency in a number of early tropical maize population (Tlaltizapan winter 1977).

Materials	Silking (Days)	Grain Yield (gm^{-2})	Grain Yield per day (Silking) ($gm^{-2}day^{-1}$)	Leaf Area Index	Grain Yield per Leaf Area (gm^{-2})	Harvest Index	Total Stem Sugar (gm^{-2})
Mata Hambre x Guajira 314	70	335	2.82	1.50	223	0.44	28.9
Indonesia x Mata Hambre	69	356	3.00	1.93	155	0.42	37.3
Pakistan Precoz x Mata Hambre	60	316	2.89	1.26	251	0.45	38.4
Pujaguas	75	222	1.77	1.36	163	0.39	20.7
Pujaguas x Mata Hambre	71	275	2.31	1.77	155	0.45	22.7
MVSC x Guajira 314	70	358	3.00	1.74	206	0.48	26.5
Pairumani x Indonesia	72	590	4.65	2.39	247	0.46	46.9
Compuesto Indonesia	68	383	3.28	2.13	180	0.37	55.7
Mean	69.4	354	2.96	1.76	197	0.43	34.6
Range	7.5	184	1.44	0.56	46	0.05	17.5

TABLE 6.8 PERFORMANCE OF A NUMBER OF VARIETIES SELECTED WITHIN TUXPEÑO- UNDER SIMULATED DROUGHT AT TLALTIZAPAN 1977 A

ENTRY	Relative Yield Irrigation	Relative Yield Medium Stress	Relative Yield Severe Stress	Drought Index (Irrigation Severe Stress)	Flowering Delay (Stress)	Relative Leaf Extension Rate	Tissue Death (Score 1-5)	Plant Height (Irrigation)	Days to Flower (Irrigation)
1. Synthetic variety selected for yield under Irrigation	1.01	0.90	0.95	0.78	6.3	0.31	4.0	182	87.3
2. Synthetic variety selected for yield under Irrigation and Stress	1.05	1.06	0.92	0.79	5.9	0.17	3.7	172	87.2
3. Synthetic variety selected for yield under Medium Stress	1.06	0.84	0.86	0.80	6.3	0.33	3.6	173	87.5
4. Synthetic variety selected for yield under Medium Stress and Irrigation	1.01	0.97	0.90	0.78	5.7	0.23	4.1	176	86.1
5. Synthetic variety selected for yield under Severe Stress	1.13	1.13	1.17	0.75	4.7	0.34	3.8	175	84.5
6. Synthetic variety selected for yield under Severe Stress and Irrigation	1.03	1.08	0.89	0.80	6.8	0.23	4.3	181	85.3
7. Synthetic variety selected for yield under Irrigation Medium and Severe Stress	1.08	1.04	1.05	0.77	6.7	0.22	4.1	181	85.9
8. Synthetic variety selected for 'drought tolerance'	1.09	1.31	1.60	0.65	5.2	0.19	3.1	178	86.1
9. Synthetic variety selected for 'drought susceptibility'	0.99	0.91	1.05	0.75	3.7	0.25	4.5	187	85.7
10. Original Population (Tuxpeño P.B. C_{14})	0.96	1.11	1.06	0.86	5.5	0.18	3.6	180	87.2
11. Poza Rica 7521	0.82	1.15	1.10	0.69	4.6	0.19	3.4	178	89.1
12. Tuxpeño C_2	0.77	0.51	0.46	0.86	10.6	0.27	3.8	239	98.5
Mean	1.00	1.00	1.00	0.77	6.02	0.24	3.7	184	87.5
SE	0.17	0.17	0.17	0.06	0.76	0.07	0.3	6	1.1
Absolute (Yield (Kg ha^{-1})	5460	2868	1433						

TABLE 6.8A Coefficients of linear correlation between grain yield and other characters for ten synthetics of maize (Var. Tuxpeño) when grown at three levels of water stress. Tlaltizapan, winter 1977.

	YIELD	
	No Water Stress	Severe Water Stress
Leaf tissue death score	-0.22	-0.39*
Relative extension index	0.17	-0.53**
Plant height under irrigation	0.35*	0.47**
Days to 50% silk	-0.25	-0.56**
Anthesis-to-silking interval	-.03	-0.73**

* p≤.05 ** p≤.01

Fig. 6.1 VARIATION IN PLANT HEIGHT (MEAN OF 12 VARIETIES) SOWN AT MONTHLY INTERVALS AT TWO SITES IN MEXICO

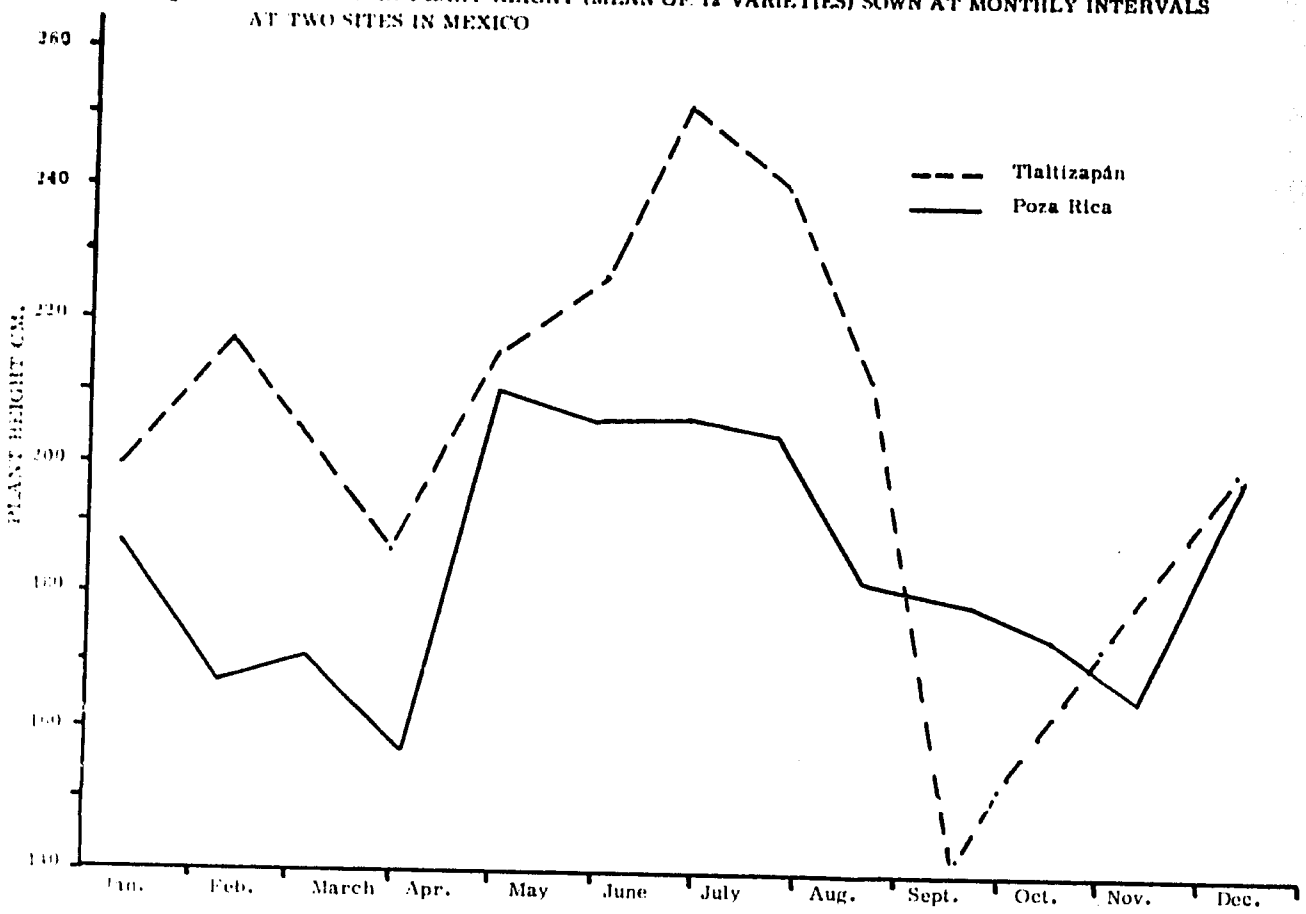


FIGURE 6.2. RELATIONSHIP BETWEEN LEAF NUMBER AND PHOTOPERIOD FOR THE MAIZE VARIETY TUXPEÑO. MAXIMUM DAYLENGTHS AT DIFFERENT LATITUDES ARE INDICATED ABOVE THE ABSCISSA.

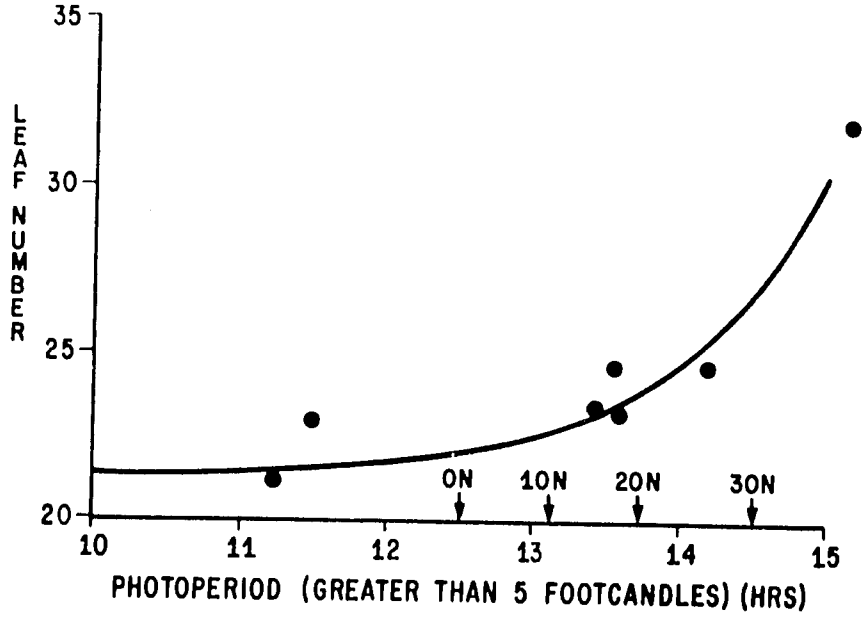


Fig. 6.3

PREDICTED RELATIONSHIP BETWEEN INTERNODE LENGTH AND DAILY MAXIMUM TEMPERATURE FOR LOWLAND TROPICAL MAIZE. (MIN. TEMP. = 20C)

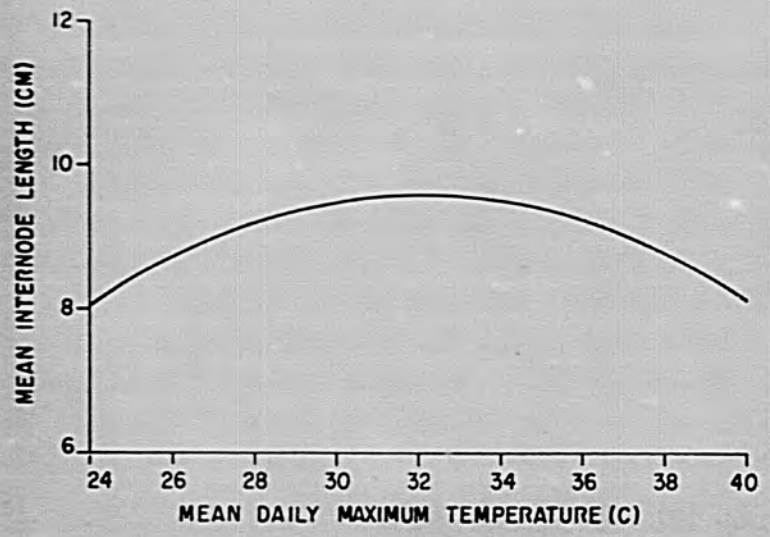


Fig. 6.3A

PREDICTED RELATIONSHIP BETWEEN INTERNODE LENGTH AND DAILY MINIMUM TEMPERATURE FOR LOWLAND TROPICAL MAIZE (MAX. TEMP. = 30C)

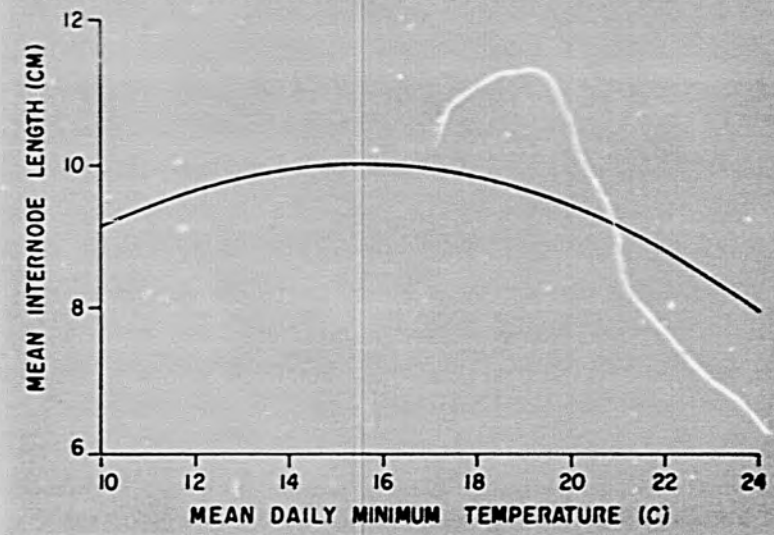


Fig.6.4

TOTAL CROP AND GRAIN DRY MATTER ACCUMULATION IN TUXPEÑO-1 (O) AND PIONEER 3369 (●) GROWN AT TLALTIZAPAN WINTER CYCLE 1974 AT 80,000 p/ha (SILKING DATE INDICATED)

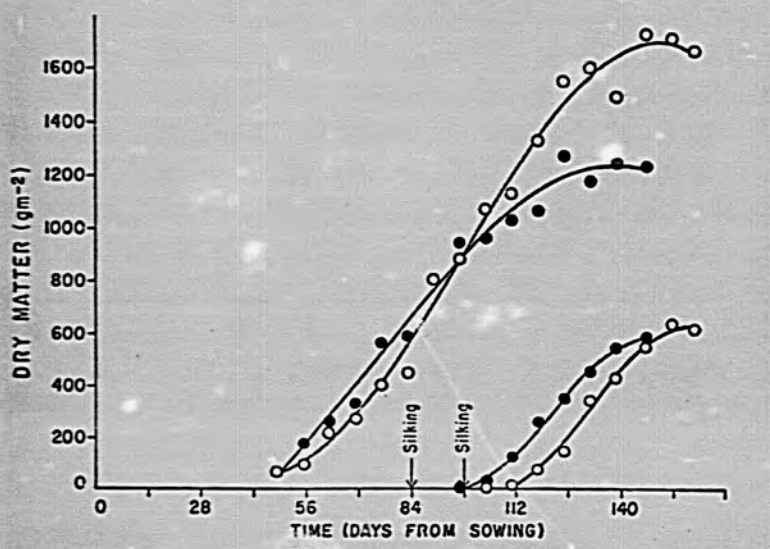


Fig. 6.5

LEAF AREA INDEX (LAI) ACCUMULATION IN TUXPEÑO-1 (O) AND PIONEER 3369 (●) GROWN AT TLALTIZAPAN - WINTER CYCLE 1974 AT 80,000 p/ha (SILKING DATE INDICATED)

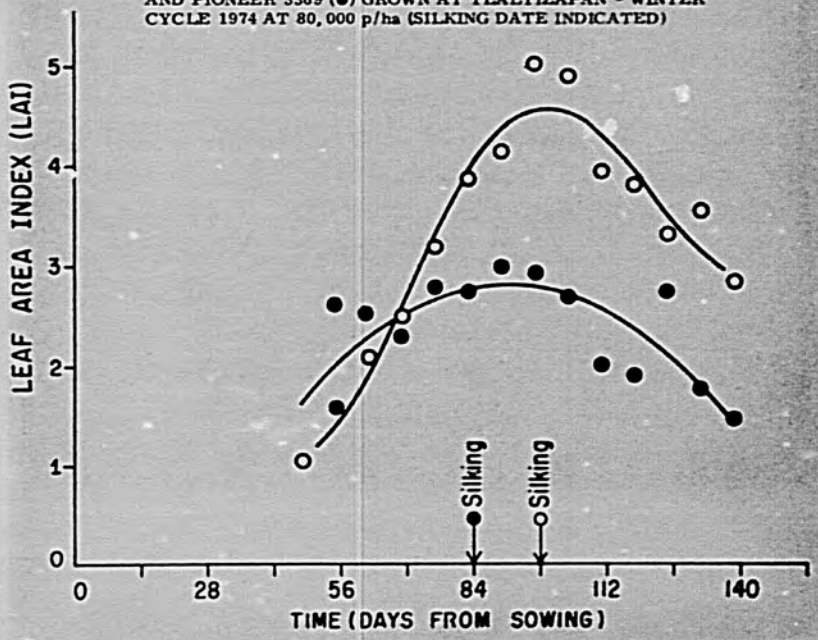


Fig.6.6

RELATIONSHIP BETWEEN DATE OF SILKING AND GRAIN YIELD/PLANT (n=123, r=004) FOR THE EARLIER FLOWERING SECTOR OF A POPULATION HARVESTED AT SIMILAR GRAIN MATURITY (30.8 ± 1.5% MOISTURE) (POPULATION-SELECCION PRECOZ - POZA RICA 77A)

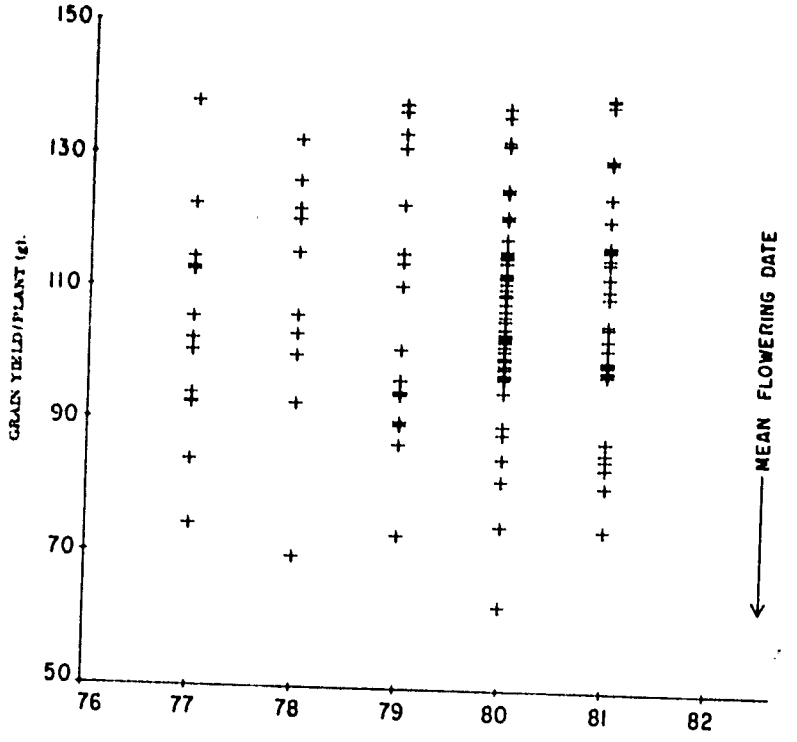


Fig. 6.7

RELATIONSHIP BETWEEN GRAIN MOISTURE CONTENT AND GRAIN YIELD/PLANT (n=40) FOR PLANTS FLOWERING ON DAY 78 (POPULATION-SELECTION PRECOZ-MEAN FLOWERING DATE 83 DAYS, POZA RICA 77A)

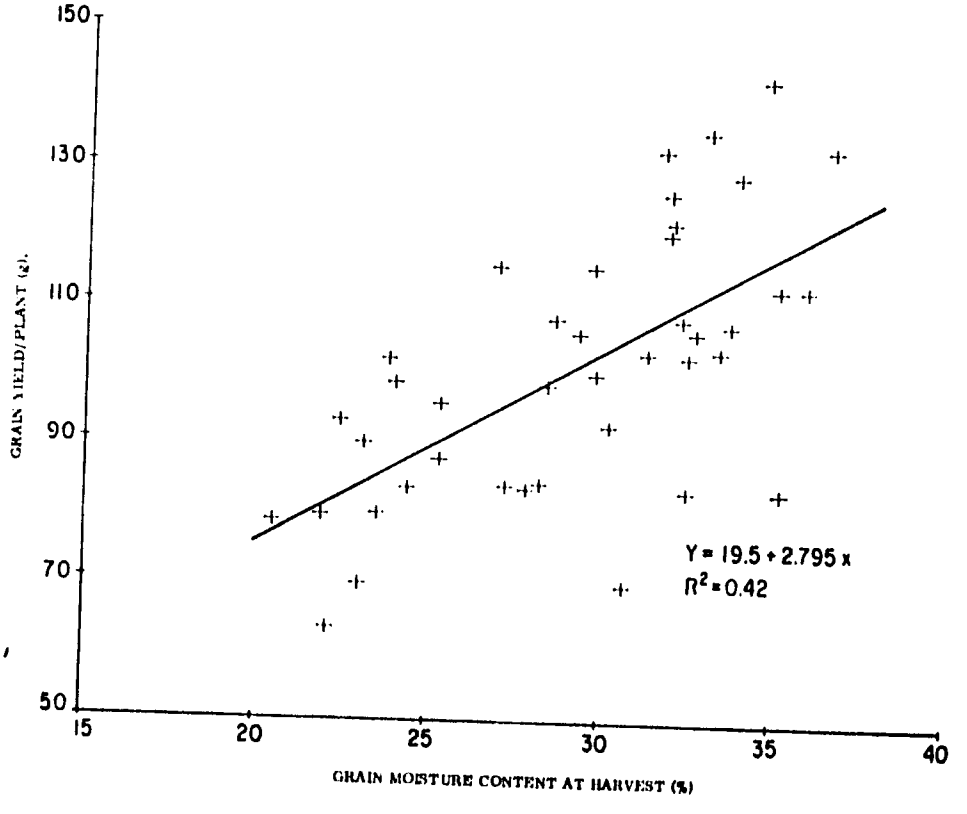
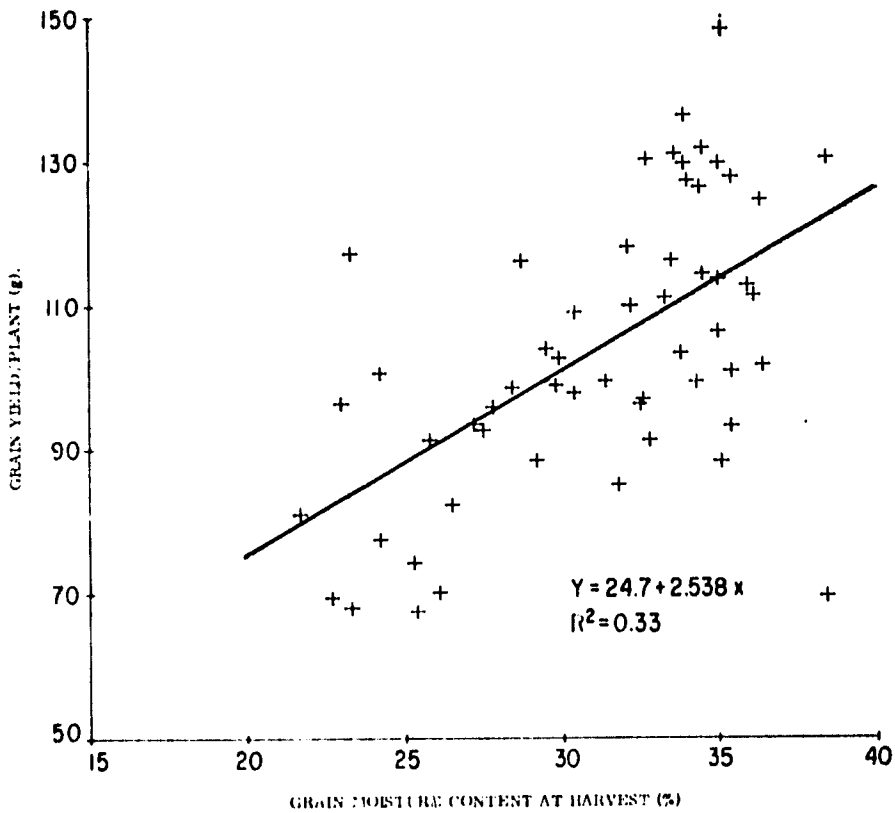


Fig. 6.7A

RELATIONSHIP BETWEEN GRAIN MOISTURE CONTENT AND GRAIN YIELD/PLANT (n=56) FOR PLANTS FLOWERING ON DAY 82 (POPULATION - SELECCION PRECOZ - MEAN FLOWERING DATE 83 DAYS, POZA RICA 77A)



A limited number of hybrids have been obtained through crosses between maize and related species. These hybrids could become the basis of improved maize of the future.

7.0 WIDE CROSSES

In 1976 and 1977, tripsacum and sorghum crosses with maize were continued to assess and utilize the potential of the alien germ plasm in maize improvement.

7.1 MAIZE x TRIPSACUM

Approximately 27,000 maize x tripsacum pollinations were made and 19 hybrids were identified (Table 7.1). Fourteen of these hybrids were of the classical type that possesses the full gametic complement of chromosomes from each parent; ten from maize and 18 or 36 from tripsacum, depending on the ploidy level of the tripsacum parent. These hybrids are more like tripsacum than maize. They are perennial, tiller profusely, and begin to flower in approximately two years from germination. So far none of these hybrids has produced pollen and all backcrosses have been unsuccessful.

Five of the 19 hybrids were not of the classical type, and possessed a variable number of chromosomes in cells of the same root tip. Chromosome loss was erratic and progressive. Most cells examined contained 20 maize and no tripsacum chromosomes; other cells examined contained 20 maize chromosomes and up to eight of tripsacum. In at least three hybrids, some cells contained a total of 20 chromosomes, of which up to four were tripsacum substitution chromosomes. At flowering, only approximately 2 per cent of the cells possessed one or more alien chromosomes. These five non-classical hybrids are more maize-like, and are annual. Most have flowered within three months of germination. Although they have produced no viable pollen, four plants have set seed after backcrossing to maize.

It seems that the classical hybrid is produced by a fusion of normal reduced gametes, while the non-classical hybrid results from the fusion of an unreduced or doubled egg cell with a normal male gamete, followed by chromosome elimination.

The identification of the non-classical hybrids, in addition to the classical type, opens up exciting practical possibilities for maize improvement. For example, the plant breeder could test a maize-like morphology for desirable characteristics immediately in the F_1 hybrid; and should the hybrid prove fertile, progeny could be obtained in less than one year. Thus selection and further breeding could be speeded greatly as compared with that of the classical hybrid.

7.2 MAIZE x SORGHUM

Over 18,000 maize x sorghum crosses were made, and nine hybrids were identified (Table 7.2). All hybrids were non-classical aneuploid mosaics, and (like the five similar hybrids of maize x tripsacum) they possessed a variable number of chromosomes in different cells of the same plant. Again, chromosome loss was erratic and progressive, but far more complete than with the maize x tripsacum hybrids. At flowering, no more than 1 per cent of the cells possessed only one or two alien chromosomes. In the vast majority of cells, only 20 maize chromosomes were retained.

All nine hybrids were more like maize than sorghum in appearance. None produced viable pollen. However, two were partially female fertile and a total of 33 backcross progeny were obtained with maize pollen.

7.3 FUTURE WORK

In maize x tripsacum and maize x sorghum crosses, only a few hybrids have been produced. This is due mainly to low seed set and seed breakdown. It is necessary to generate a greater number of wide genetic diversity for use in plant improvement, and for cytological and genetical analysis. The production of a sufficient quantity of hybrids requires identification of parental genotypes that yield such progeny more frequently, and would require improvement of techniques for their survival. With such improvements the importance of these hybrids could be determined.

To increase the number of effective crosses made between maize and tripsacum, a garden has been formed with replicate clones of each tripsacum genotype that has given hybrids with maize, so that more crosses may be made with those successful genotypes, and thus more hybrids produced. With sorghum, more crosses are made with those materials that have already given hybrids with maize. However, with both tripsacum and sorghum, new combinations are crossed each season to identify additional genotypes of possible superior crossability.

Also, research into tissue culture techniques is under way to develop techniques to prevent such breakdown and to stimulate plant development from a greater range of hybrid embryos than is possible at present.

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Also, research into tissue culture techniques is under way to develop techniques to prevent such breakdown and to stimulate plant development from a greater range of hybrid embryos than is possible at present.

Table 7.1. **List of Maize x Tripsacum hybrids produced.**

Hybrid pedigree ♀	♂	Type of pollination	Number of hybrids produced	Chromosome type	/	number
Recovered maize	T. dactyloides 7220-3	1	6	C	/	46
Recovered maize	T. dactyloides 7139-4	1	1	C	/	46
Amarillo Bajío	T. dactyloides 65-1234	2	1	C	/	46
Cuban Flint	T. dactyloides 65-1234	2	3	C	/	46
Pool 33	T. dactyloides 65-1234	2	2	C	/	46
Pool 33	T. dactyloides 66-221	2	1	C	/	28
Pool 33	T. dactyloides 65-1234	2	1	N	/	20-28
Recovered maize	T. latifolium 7150-1	2	1	N	/	20-24
Mezcla Amarilla	Tripsacum sp.	3	1	N	/	20-28
Pool 15	Tripsacum sp.	3	1	N	/	20-24
Pioneer 304	Tripsacum sp.	3	1	N	/	20-21

Key:

C = classical hybrid N = non-classical hybrid

Table 7.2. List of Maize x Sorghum hybrids produced.

Maize ♀	Sorghum ♂	Chromosome no.
Pioneer 304A	C561 K556 B-line	20-30
CIMMYT Syn CD (4x)	Asgrow Mexica H-674	20-26
CIMMYT Syn CD (4x)	Asgrow Mexica H-674	20-22
Pioneer 105	Martin B	20-24
CIMMYT Pool 15	Asgrow Mexica H-679	20-24
CIMMYT Pool 5	CIMMYT SF4-328	20-22
CIMMYT Tuxpeño	Asgrow Mexica H-679	20-26
CIMMYT Mezcla Amarilla	Asgrow Mexica H-679	20-24
Pioneer 304A	C561 K556 B-line	20-30

8.0 MAIZE TRAINING

In 1976, 55 young scientists from 24 countries took part in CIMMYT's In-Service Training Program; there were 59 trainees in 1977, representing 22 countries.

Despite their diverse backgrounds these scientists find a common ground for their training at CIMMYT: each has an intense interest in improving maize production in his home country; and each will have his learning experience shaped by "hands-on" work in the fields of local farmers in on-farm experiments at several locations in Mexico. CIMMYT's training "curriculum" stems from findings gleaned from these fields. Here the trainees are scheduled for about 6 out of every 10 days, working alongside their colleagues, the local farmers, and the CIMMYT training and professional staff. Although each in-service trainee may specialize in one of four training categories (Production Research, Maize Improvement, Protein Evaluation, and Experiment Station Management) the overriding concern is that each trainee will become immersed in production-level problems of the farmer.

8.1 FIVE TRAINING STAGES

The field work is organized in a sequence of five stages which ranges from research in experiment stations up to the testing of technological alternatives and fitting them in real production systems. This work is complemented by structured discussion and learning sessions.

Countries represented in these courses were:

	76	77
Belize	1	–
Bolivia	2	–
Colombia	–	–
Costa Rica	2	1
Ecuador	1	–
Dominica	–	1
Dominican Republic	2	3
Ecuador	–	3
Egypt	2	2
El Salvador	8	–
Ethiopia	1	1
Grenada	1	–
Haiti	2	2
Honduras	–	5
Kenya	1	–
Korea	1	–

	76	77
Malawi	1	–
Mexico	3	4
Nepal	–	4
Nicaragua	4	–
Pakistan	2	4
Panama	–	1
Papua	–	1
Peru	1	3
Philippines	–	2
Tanzania	6	12
Thailand	2	4
Tunisia	–	2
Venezuela	–	1
Yemen	1	1
Zaire	1	–
Zambia	1	1

In the first stage the trainee acquaints himself with the type of experiments which should be done in experiment stations. These are normally the development and selection of varieties, production of foundation seed, tests of new chemical products, tests and calibration of equipment and machinery, etc. The stages which follow take place outside the experiment station in the fields of local farmers who are representative of the socioeconomic and technological reality of the area.

In the second stage various experiments are planted to determine those factors which limit the production of maize in the area. Emphasis is given to experiments which permit identification of critical management factors, their priority and interactions; tests of new chemicals for control of weeds and insects not present on the experiment station; and the preliminary investigation of new management practices. The experimental results at this stage supply the information to determine the economically relevant factors which should be considered in the experiments programmed for the following stage.

In the third stage, the experiments are designed specifically to evaluate the level effects of those critical factors identified in stage two. The results of these experiments determine the best varieties, plant density optimum fertilizer levels, herbicide or insecticide rates, etc.

The information obtained in these three stages is also used to demonstrate to the trainees proper techniques of forming production alternatives with different levels of farmer risk. These alternatives are then evaluated in the fourth stage. The agronomic and economic evaluation of these experimental results assure that the variables which are tested in the fourth stage are those with the greatest probability of farmer acceptance and of increasing maize yield. This fourth stage, called the "Verification Stage", is highly important. It summarizes the results of the previous research into technological recommendations which are to be evaluated in a large number of locations.

The fifth stage is the most challenging one because it is where the technological alternatives produced through the system of production research are exposed to the realities of field-scale agriculture. Although supervised by production agronomists and breeders, the actual field work is carried out by the participating farmers. This stage is of major importance since it condenses into one operation the diffusion of technological alternatives and, in some cases, the supervision of seed increases.

The technical training offers the skills necessary to design maize production and improvement projects, conduct experiments, interpret the results, and develop general recommendations in the form of technological alternatives suitable for the average farmer of a region. These skills are complemented through classes in experimental design, soil fertility, applied genetics, entomology, maize pathology, weed control, economics, irrigation, maize physiology and morphology, maize growth, etc. In addition, the trainees have the opportunity to present technical seminars as a means to both increase their technical knowledge and to improve their ability to communicate their knowledge to others.

All classroom time is devoted entirely to increasing their effectiveness as field researchers. Most classes have a specific field component. The objective of every subject is to enable each trainee to integrate field observations with scientific knowledge so that he can formulate technological alternatives at the end of the course.

Although in-service trainees are proportionately the

Model of the strategy used by CIMMYT for maize

Stage/Function		Test Location	
1	Research Agronomy	Experimental Station	IN THE FIELD CASE STUDIES
2	Production Research	Farmers' Fields	
3	Production Research	Farmers' Fields	
4	Verification and Diffusion	Farmers' Fields	
5	Diffusion and Seed Increase	Farmers' Fields	

largest category of trainees, the other trainees contribute to this approach and also learn on the same firsthand basis. These categories include: predoctoral fellows, postdoctoral fellows, visiting senior scientists, and short-term visitors. There is also some in-country training with other national maize crop programs.

There are, of course, many ways to train maize specialists for countries with developing agriculture. The strategy followed by CIMMYT provides knowledge within a logical system which integrates all phases of production research. It is CIMMYT's hope that similar systems can be developed to meet the specific needs of each country.

training in production research

Trainee Task	Training Program Objectives	
Direct Responsibility	Screening new varieties based on relevant criteria at farmers level (yield, grain, end uses, etc.) Studies on planting dates. Testing new agricultural chemicals.	Testing agricultural machinery. Related laboratory studies.
Direct Responsibility	Identify critical management factors, their order of importance and significant interactions. Testing agricultural chemicals against pests and weeds detected as problem by farmers. Preliminary investigations of new management methods e.g. minimum tillage.	Preliminary evaluations of breeding objectives. Economic analysis to detect factors of production with a higher impact on benefits and higher probability of acceptance by farmers. Sample survey of farmers to determine the agro-economic circumstances relevant to maize production.
Direct Responsibility	Describe quantitatively the response to each critical management factor. Further investigation of significant interactions. Trials of promising varieties. Comparative trials of promising pesticide rates. Evaluation of breeding materials under different input levels.	Formulation of technological alternatives with different benefit levels and related risk. Demonstration to extension agents on formulation of technological alternatives and how to carry out stage IV. Partial budget analysis of agronomic data and range of relevant economic factors to be considered in future trials.
Observers and Direct Responsibility	Verification trials of technological production packages. Assessing farmers reaction to new inputs and breeding materials. Observation of new factors limiting production.	Economic analysis of possible modification of technological alternatives due to changes in relative prices.
Supervision	Verification of experimental results in production size plot (1 hectare or more). Experience with production size plot on farmers' fields. Assessing farmers' reaction to technological alternatives.	Increase of open pollinated variety seed for potential release in the area. Supervision and maintenance of varietal purity. Large scale economic study of the technological alternatives used.

FEED BACK

9.0 MAIZE COOPERATIVE PROJECTS OUTSIDE MEXICO

Regional Programs

Regional maize programs link CIMMYT and collaborators in several maize growing parts of the world. Regional groupings usually consist of neighboring countries where maize is a major crop, grown under similar climatic conditions, with similar diseases and insects, and therefore benefitting from continuous exchange of technology and germ plasm within the region.

In 1977 these regions were: Central America and Caribbean, with headquarters in Mexico; South and Southeast Asia, headquartered in India; and the Andean, with headquarters in Colombia.

CIMMYT maize scientists share activities such as helping with periodic workshops, circulation of nurseries and exchange of trial data, visits of local scientists to other countries, training of maize workers, and consultation by staff stationed in the region or travelling from Mexico.

A total of six CIMMYT staff members are posted to these regions; they receive logistical support from other international centers or strong national programs.

National Programs

National programs participating with CIMMYT in cooperative arrangements in 1977 were: Pakistan, Egypt, Zaire, Nepal, Tanzania and Guatemala.

These programs seek to improve maize research in local experiment stations, test experimental varieties on local farmers' fields, multiply seed for improved varieties, and provide training for local scientists. CIMMYT's assigned staff share in these responsibilities, including testing of germ plasm and feeding information on these materials to the complete network of maize scientists.

In future publications of the CIMMYT maize program, the work of these programs will be reported in greater detail.

Zaire was one of the 68 countries requesting variety trials in 1977. The best yielders from these trials have been widely tested on farmers' fields.

10.0 RELATED MAIZE IMPROVEMENT INFORMATION

Bulletins

CIMMYT Annual Report 1966-67, 1967-68, 1972, 1974, 1975.

CIMMYT Review 1976, 1977.

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

From agronomic data to farmer recommendations: An economics training manual. R.K.Perrin, at.al.1977(IB 27).

CIMMYT Today

Quality protein maize. A. Wolff, 1975 (CT 1).

Translations and reprints

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

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

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

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

Developing agricultural research personnel, E.W. Sprague, 1975.

Current status of plant resources and utilization, E.W. Sprague, K.W. Finlay, 1976.

Varietal traits limiting the grain yield of tropical maize, I, II, III, IV, J. Yamaguchi 1974.

Impediments to technical progress on small versus large farms. R.K. Perrin, D. Winkelmann, 1976.

Labor use patterns in the production of maize in southern Zaire. M.Mwamufiya and J.B. Fitch, 1976.

Maize marketing and distribution in southern Zaire. M. Mwamufiya and J.B. Fitch, 1976.

Progress toward novel cereal grains. L.S.Bates, et.al., 1974.

Varietal triats limiting the grain yield of tropical maize I, II, III, IV. J. Yamaguchi, 1974.

General

Adoption of hybrid seeds and fertilizers among Colombian corn growers. J.H. Colmenares, 1975.

The adoption of new maize technology in Plan Puebla, Mexico. D.L. Winkelmann, 1976.

Diffusion of hybrid corn technology: The case of El Salvador. J. J. Cutié T., 1975.

The diffusion of hybrid maize in Western Kenya. J. Gerhart. 1975.

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

International research in agriculture, 1976. Published by the Consultative Group on International Agriculture.

Proceedings-world wide maize improvement in the 70's and the role for CIMMYT, 1974.

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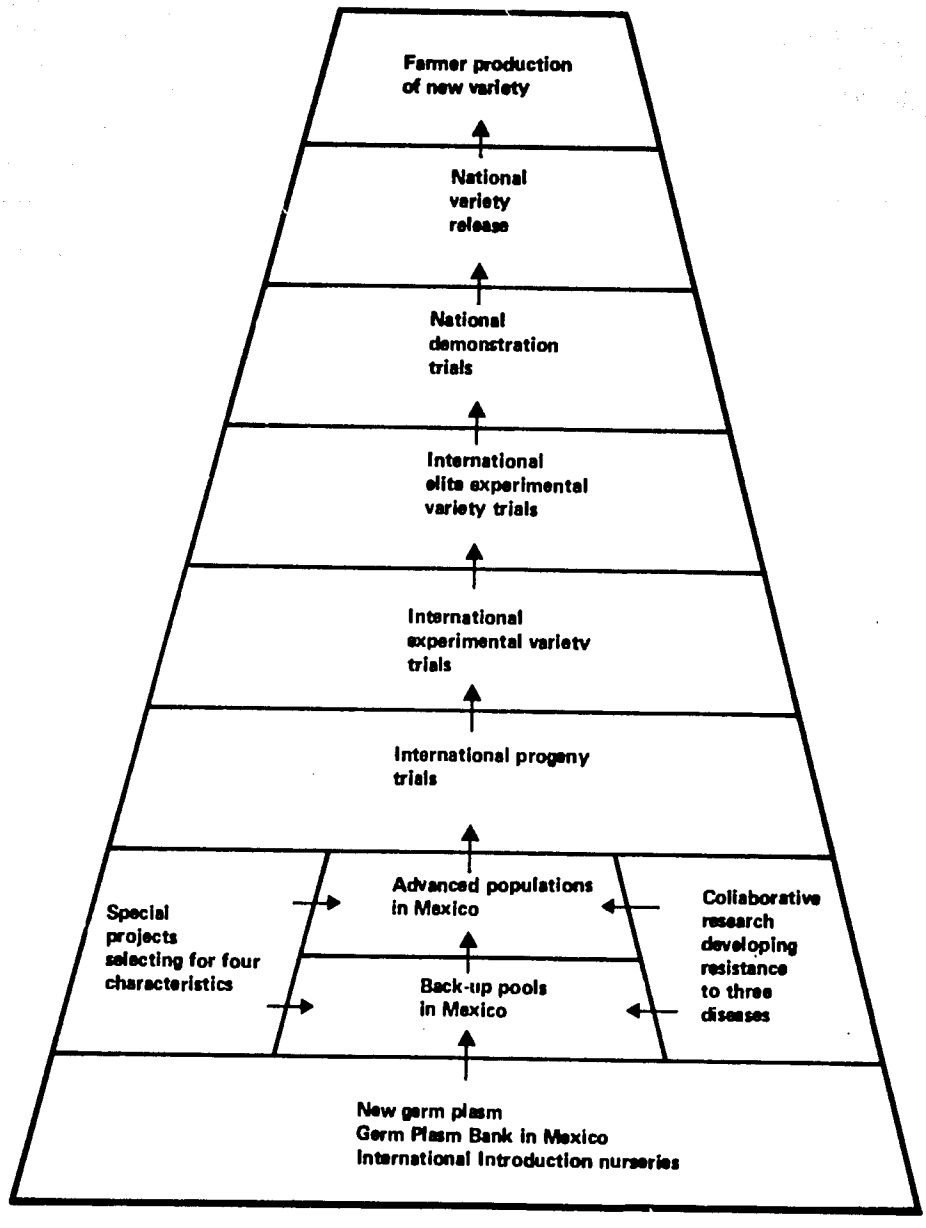
High Quality Protein Maize (27.50 U.S. dollars plus postage).

Maize Quality Protein Abstracts. Bibliography 1960-1974; Vol. I, 1975; Vol. 2, 1976; Vol. 3, 1977.

APPENDIX

THE MAIZE PYRAMID



National variety release
Based on local farmer demonstrations, and worldwide data, each national program decides whether to release a new variety.

National demonstration
National programs alone decide whether an elite experimental variety with appropriate production technology justifies wider demonstration on farmers' fields. CIMMYT supplies basic seed for increase by governments.

Elite experimental variety trials
Remnant seed of the elite varieties is increased in Mexico to generate the quantity required for testing the following year. For the first time, some trials are held on private farmers' fields.

International experimental variety trials
In Mexico during the off-season CIMMYT intercrosses the 10 best families from each test site using reserve seed and the random mating method, to produce an experimental variety which will be tested by collaborators at 20-40 sites, worldwide, during the following year. Data from these 20-40 sites determine the selection of elite experimental varieties for the following year.

International progeny trials
The 250 progenies from each population are sent to collaborators at five sites, worldwide, to be grown in 250 5-meter rows, with six local checks, forming a 16 x 16 simple lattice with two replications. Ten best progeny are identified by the collaborator at each site, to form one experimental variety for the following year.

From collaborators' data CIMMYT identifies the 10 best families giving superior performance across all test sites, and uses these to develop an "across-site" variety. CIMMYT also identifies 100 families on the basis of across-site performance to reconstitute the advanced population for the next generation.

Advanced populations in Mexico
Here materials continue to be grouped by agro-climates, but unlike the pools, the advanced populations have completed several generations of selection for better plant type, better disease and insect resistance, better yield. These populations are grown in Mexico, and 250 superior families (progeny) are developed from each population for international testing every second year.

Special projects
Special projects deal with specific characteristics like shorter maturity, wider adaptation, more efficient tropical plants (those putting a larger amount of dry matter into grain) and drought tolerance.

Collaborative research
Collaborative research develops resistance to three diseases: downy mildew in Asia, streak virus in Africa, corn stunt in Latin America.

Back-up pools in Mexico
Here germ plasm is classified into 34 pools (genetic groups) according to three climatic regions (tropical lowlands, tropical highlands, temperate zone), four grain types (flint or dent, white or yellow), and three lengths of growing season (early, intermediate, full season). There are 12 pools for the lowland tropics, 14 pools for the highland tropics, and 8 pools for the temperate zone. The pools are grown every year in Mexico and seed from superior families is moved into the appropriate advanced populations.

New germ plasm
Each year new germ plasm is tested and some is selected for addition to the back-up pools. Selections may come from the germ plasm bank (13,000 accessions of varieties, lines, wild types) which are continuously being classified; or from introduction nurseries (new materials received from national programs).

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.

TWO POPULATION GROUPS

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

POPULATIONS: GROUP 1

IPTT No.	Population Name
22	Mezcla Tropical Blanco
23	Blanco Cristalino 1
24	Antigua Gpo.2 x Veracruz 181
27	Amarillo Cristalino 1
31	Braquíticos
32	ETO Blanco
33	Amarillo Subtropical
35	Antigua x Rep. Dominicana
39	Yellow H.E.o_2
42	ETO x Illinois
43	La Posta
47	AED x Tuxpeño
52	Blanco Dentado Precoz de Altura
53	Blanco Harinoso Precoz de Altura
54	Amarillo Cristalino Precoz de Alt.
55	Amarillo Dentado Precoz de Alt.
58	Blanco Harinoso Intermedio de Alt.
60	Amarillo Dentado Intermedio de Alt.

POPULATIONS: GROUP 2

IPTT No.	Population Name
21	Tuxpeño 1
25	(Mix.1 x Col.Gpo.1) ETO
26	Mezcla Amarilla
28	Amarillo Dentado
29	Tuxpeño Caribe
34	Blanco Subtropical
36	Cogollero
37	Tuxpeño o_2
38	PD(MS)6 H.E.o_2
40	White H.E.o_2
41	Templado Amarillo o_2
48	Comp. de Hungría

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

Se dio término a la impresión de este libro el 1 de agosto
de 1980 en los talleres de Ediciones Las Américas
Tiro 1,000 ejemplares Impreso en México