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Maize production systems

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* Left during 1975

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Climatic and edaphological data for locations where CIAT's Maize Program has done research work in 1975

(Most research projects were carried out in cooperation with ICA)

Locations*	Altitude (meters above sea level)	Mean temperature (°C)	Rainfall (mm/year)	Organic matter (%)	pH	P (Bray II) (ppm)	K (meq/100 g)	Soil texture
CIAT, Palmira (Valle)	1,000	24	1,000	6.8	6.9	46.3	0.44	Clay
Carimagua (Meta)	200	27	2,031	4.3	4.7	1.6	0.08	Clay loam
Turipaná (Córdoba)	13	28	1,200	3.1	6.8	13.0	0.68	Clay
Tulio Ospina** (Antioquia)	1,438	21.5	1,443.30					

* Names of Colombian departamentos (political division similar to a state) are given in parentheses.

** ICA was in charge of the experimental trials at this station; CIAT acted merely as a consulting institution.

Maize production systems

HIGHLIGHTS OF 1975

Activities of the CIAT Maize Program have shifted from a Palmira-based, research-oriented program to one of collaborative services with the Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT) in Mexico. This program will principally support national programs in the Andean Zone and in tropical Brazil. An excellent spirit of cooperation exists among maize scientists of these countries and the two international centers involved.

During 1975, materials from CIAT's breeding program were tested in on-farm trials and recombined into basic genetic sources (populations), which may be useful to national programs and conveniently combined into existing CIMMYT materials. In breeding, emphasis has been placed on developing short materials that resist lodging, a major cause of yield reductions in the region.

International trials consisting of 30 CIMMYT experimental varieties and six local checks were planted in cooperation with the Instituto Colombiano Agropecuario (ICA) at several locations in Colombia.

Thirteen on-farm trials were conducted near Montería. Average yields of almost 5 tons|ha indicate that reasonable yields are possible for this traditional maize area. Establishing and maintaining a favorable plant density appears to be a major factor in the improvement of maize yields in this and similar areas.

The CIMMYT|CIAT collaborative services program has assembled and distributed national program materials to be tested in highland and lowland regional trials at 18 locations in six tropical countries.

PLANT IMPROVEMENT

Reduced plant height

Maize breeding work has concentrated on genotypes with reduced height and a stable plant type. The tendency of traditionally tall maize types to lodge is apparent in Table 1.

The program focused on full-sib family selection in materials homozygous for the brachytic-2 gene. As illustrated in the 1974 Annual Report, there are many variants of the "original" brachytic, with its thick stalk, wide leaves and very compact internodes. Such a plant type is not acceptable for intercropping with climbing beans or yams, as climbing and vegetative development are inhibited by a maize plant with compact internodes. Thus plants were sib-pollinated within rows that were reasonably uniform as to the plant types described in Table 2.

It was hypothesized that Type II would possess optimal support characteristics for association with climbing beans and yams and that Type III would not only have a better distribution of dry matter but would also be more responsive to higher densities in monoculture. This hypothesis was tested in collaborative studies with the Bean Program. Modified types II and III were compared with the new ICA brachytic hybrid H-210 (comparable to Type I) and the popular normal hybrid H-207. The value of a maize genotype as support was determined by the production of climbing beans. Preliminary results showed no significant differences among different maize types as supports for climbing beans (Table 3). These insignificant differences in the fall-off point for bean yields as maize densities increase will be studied in greater detail, using methods that will reduce the confounding of maize and bean densities and that will have more appropriate planting dates and systems for these associations. Under optimal conditions at Palmira, the ICA normal and brachytic hybrids outyielded CIAT's open-pollinated brachytics. Maize yields were high, averaging more than 6 tons/ha.

Table 1. **Results of 13 on-farm tests conducted near Montería (1975A).**

Plant type and variety	Origin	Grain	Average lodging (%)	Average yield (kg/ha)	No. of trials
Normal					
La Posta C_2	CIMMYT	Normal white dent	27	6,861	1
YHE	CIMMYT	Hard yellow opaque	34	5,036	2
WHE	CIMMYT	Hard white opaque	40	5,737	2
Comp. K	CIMMYT	Hard yellow opaque	39	5,295	2
ICA VE-21	ICA	Hard yellow opaque	33	5,273	2
ICA V-106	ICA	Normal yellow flint	53	3,948	6
ICA H-207	ICA	Normal yellow flint	46	4,969	5
ICA H-208	ICA	Soft yellow opaque	10	5,311	1
ICA H-154	ICA	Normal white flint	50	5,525	5
Brachytic					
Br I (Bl)	CIAT	Normal white flint	6	4,440	4
Br II (Bl)	CIAT	Normal white flint	8	5,029	2
Br III (Bl)	CIAT	Normal white flint	3	5,284	2
Br II (Am)	CIAT	Normal yellow flint	12	2,783	2
Br III (Am)	CIAT	Normal yellow flint	10	3,140	2
		Average (all materials over all locations)	26	4,902	

A second collaborative maize-bean experiment studied the importance of variety by system interaction in the selection of maize plant types adapted for both monoculture and intercropping (Table 4). Bean densities were significantly higher than in the previous experiment and in fact reduced the maize yields, which nonetheless were high in all systems. There were no significant differences among maize families in each of the three systems in the first maize trial. Correlations for maize yield and rank order were variable among the systems tested. Correlations for rank order ($r = 0.72^{**}$) and yield ($r = 0.66^{**}$) between the two maize-bean systems were highly significant, suggesting that maize selections made under one associated cropping system would be very successful in the other system as well. Similar studies of variety by system interaction are being conducted by the CIAT Bean Program to establish reasonable and inexpensive screening and

Table 2. **Characteristics of three different types of brachytic maize.**

	Height (m)	Stalk	Leaves	Internode compaction
Brachytic I	1.2	Thick	Wide, large	Extreme
Brachytic II	1.5.-2.0	Thick	Wide, large	Reduced
Brachytic III	1.5-2.0	Thin	Narrow, reduced	None

Table 3. **Yield of a climbing bean (P-259A) associated with four maize varieties, planted at four densities (CIAT, Palmira, 1975A).**

Maize variety	Bean yield (kg|ha)				
	Maize and bean density*				
	30	50	70	90	Average
ICA H-210 (brach.)	476.2d**	440.8de	334.2defg	204.4gh	363.9x
Brach. II Bl.	466.0d	459.4d	334.4defg	202.0gh	365.4x
Brach. III Bl.	491.0d	451.2de	241.0efgh	238.8efgh	355.5x
ICA H-207 (normal)	411.0def	281.6defgh	218.0fgh	177.8h	272.1x
Bean monoculture	1,754.8c	1,954.0bc	2,290.4a	2,083.8b	2,020.8y
Average	719.8m	717.4m	683.6m	581.4m	675.4

* Thousands of plants|ha of maize and beans

** Mean values in the same column, followed by the same letter, do not differ significantly at the 5 percent level.

Table 4. **Yield (kg|ha) and rank order of 15 maize genotypes planted alone and in association with bush and climbing beans (CIAT, Palmira, 1975A).***

Maize variety or family	System A		System B		System C	Maize rank by system			Av maize yield
	Maize	Bush bean**	Maize	Climbing bean***	Maize monoculture	A	B	C	
1188	3,853	455	3,403	424	4,643	13	14	11	3,966
1577	3,629	519	3,584	411	4,668	14	13	10	3,960
1768	4,207	422	4,581	450	5,437	9	5	1	4,742
1389	4,470	405	4,441	445	4,015	4	8	14	4,309
1464	4,106	479	3,308	402	4,167	11	15	13	3,860
1443	4,228	372	4,437	361	4,961	8	9	6	4,542
1101	4,630	325	4,924	372	4,934	3	3	7	4,829
1030	4,248	483	4,393	344	4,815	7	10	8	4,485
1599	4,880	337	5,076	383	5,003	1	2	4	4,986
1586	3,064	435	3,923	413	4,717	15	11	9	3,901
1449	4,181	323	4,603	520	3,855	10	4	15	4,213
4004	3,926	437	3,849	528	4,503	12	12	12	4,093
ICA H-207	4,866	372	4,470	341	4,992	2	7	5	4,776
ICA H-210	4,310	362	4,533	335	5,334	6	6	3	4,725
Tuxpeño Caribe-2	4,445	310	5,331	449	5,367	5	1	2	5,048
Average	4,203	402	4,324	412	4,761				4,429

* Yield correlations: $r_{AB} = 0.66^{**}$; $r_{AC} = 0.23$, $r_{BC} = 0.46$. Rank correlations: $r_{AB} = 0.72^{**}$, $r_{AC} = 0.45$, $r_{BC} = 0.56^{*}$

** Variety ICA Pijao, 300,000 plants|ha; yield in monoculture, 942 kg|ha

*** Variety P-259A, 300,000 plants|ha; yield in monoculture, 2,532 kg|ha

Table 5. **Yields (kg|ha) of maize selections in brachytic and planta baja populations (CIAT, Palmira, 1974B, 1975A).***

	Average yield		
	1974B		1975A
Population	All families	Selected families	All families
White brachytic	3,092	4,276	7,580
Yellow brachytic	2,582	3,518	8,229
White planta baja	3,676	5,477	8,479
Yellow planta baja	4,714	5,008	7,378

* Average of two replications

selection methods for crops grown in association, using as prototypes the bean-maize systems, which are extremely important in Latin America.

Two cycles of full-sib selection and crossing of selected families have produced open-pollinated populations of white and yellow modified brachytics that are 1.5 to 2.0 meters tall, resistant to lodging and with yields near those of normal hybrids (Tables 1 and 5). Since preliminary results indicated little or no variety by system interaction, current plans are to combine types II and III during the present selection and crossing cycle. A high density replication (66,000 plants/ha) has been planted to eliminate genotypes that respond poorly to increased plant populations.

Shorter plant height is also the principal criterion in half-sib selections of white and yellow "plantas bajas."* An attempt has been made to improve the adaptation of these materials, originally from CIMMYT, to Andean Zone growing conditions. A better flint grain texture is also being selected to improve its acceptability to the local or small farm sector. As in the brachytic selections, a replication of plantas bajas has been planted at 66,000 plants/ha to evaluate density response.

* The term planta baja refers to the reduced plant height attributed to many genes, each with a small effect; in contrast, the reduced height of brachytic materials is attributable to a single gene with a large effect.

Materials for poorly drained areas

In 1974 a CIMMYT material (La Posta C_2) was found to be highly tolerant to high pH and poor drainage at CIAT. ICA and CIAT plant breeders collaborated in the selection of the best ears from the best families. The resulting composite was divided for planting at several locations, including the same poorly drained CIAT lot and a farm near Montería, where it yielded almost 6.9 tons (Table 1). La Posta has been mass selected for still another cycle to study its response to conditions of excess soil moisture; it should also be compared to other materials in several poorly drained locations.

Protein quality

As CIMMYT is emphasizing the conversion of high-yielding normals to hard endosperm opaque-2, CIAT's role in breeding for protein quality has been limited to testing promising CIMMYT populations and recombining opaque-2 with brachytic-2.

Recent cycles of white and yellow, hard endosperm opaques have performed much better than earlier counterparts. This can be seen in Table 1, where yields of all opaques tested near Montería averaged more than 5 tons|ha. The 1974 average for these materials was only 2.4 tons. Yields of 2.6 and 3.7 tons have been obtained with Composite K and ICA VE-21, respectively, in a farm trial in Cundinamarca. It is apparent that shorter opaque materials would be desirable to reduce the high rate of lodging. Therefore, CIAT has limited further breeding of opaque materials to recombining hard endosperm opaque-2 with brachytic-2 into a high-yielding, open-pollinated yellow variety. These materials are nearly ready for initial farm testing.

Six opaque varieties, including five with a hard endosperm, have been multiplied for rat and swine feeding trials under way in CIAT's Swine Program. One of these varieties (ICA's experimental variety VE-21), an ICA|CIAT selection from CIMMYT's Vera Cruz x Antigua x Venezuela opaque population, has been increased for more extensive farmer testing.

Resistance to Diatraea

The stalk borer **Diatraea** spp. is found throughout tropical Latin America. Principal damage is yield reduction and lodging, which makes the maize crop more difficult to harvest and of little value as a support for other crops. Chemicals for controlling this insect effectively are expensive, and their distribution from one area to another is uncertain. Therefore, genetic resistance must be sought.

CIMMYT and Cornell University have collaborated for several years in developing and testing an Insect and Disease Resistant Nuersery (IDRN), which includes artificial infestation and selection for resistance to **Diatraea** in Mexico. From 287 maize families (1974A cycle) that were sent to CIAT, 32 were selected, representing a range in plant maturity and combinations of damage to leaves and stalks. ICA H-207 was included as the local check variety. Plants were artificially infested at 55 and 60 days, with four larvae two to three days old. Damage, evaluated at harvest by splitting the stalks, was heavy; and there was a highly significant negative correlation between damage and grain yield (r= -0.5681**). Stalk damage ratings at CIMMYT and either stalk damage or grain yield at CIAT were not significantly correlated. The results do not necessarily mean that materials selected for resistance to **Diatraea** in Mexico are not resistant in Colombia. They do suggest that materials selected for borer resistance should be screened under natural or preferably artificial infestation in a number of localities with different combinations of insects, plant genotypes and environments. Results from this trial, which should be repeated in another season, suggest that CIAT would be a good location for such testing.

VARIETAL TESTING

International trials

Yields in 11 CIMMYT progeny and experimental variety trials (Table 6), planted in 1974B and 1975A, were excellent. These experimental yields are for two replications of single 5-meter rows. Open-pollinated experimental varieties are produced by CIMMYT from reserve seed of families selected for yield (Table 6), reduced height, and resistance to lodging and ear rot. A replicated trial of 30 CIMMYT experimental varieties and six local checks produced average yields of 5 tons|ha. A hard endosperm, yellow opaque population gave the highest average yield (6.6 tons). This same experimental variety trial has been planted at three other locations in Colombia in cooperation with ICA and is planned for another two locations in order to study varietal stability from near sea level to 1,400 meters on diverse soils, from the

Table 6 **Yield (kg|ha) from international CIMMYT trials (two replications) planted at CIAT (Palmira 1974B, 1975A).**

Trial	Varieties	Yield of families: Trial (Av)	Yield of families: Selected (Av)	Yield of checks: Best	Yield of checks: (Av
La Posta C_2	256	3,152	4,610	3,744	2,536
Cogollero	256	3,122	5,148	3,619	2,942
IDRN	256	4,196	5,842	5,188	3,435
Blanco Subtropical	256	3,489	5,044	3,297	2,610
Amarillo Subtropical	256	3,329	5,138	3,387	2,330
Braquiticos	256	8,514	10,925	7,859	6,203
Tuxpeño Caribe 2	256	8,534	10,799	6,086	4,641
(Mix I x Col. Gp. I) ETO	256	7,105	9,201	6,277	5,058
Blanco Cristalino	256	7,400	8,956	5,603	4,339
Mez. Trop. Blanco	256	9,312	11,339	6,327	5,486
Experimental varieties*	36	5,004	6,602	6,550	3,884

* Four replications

fertile soils of the Valle del Cauca to the highly infertile soils of the Llanos Orientales. Additional progeny and experimental variety trials were planted in 1975B.

Key activities of the CIMMYT|CIAT collaborative services program are regional trials of national program materials. Trials for eight highland and ten lowland locations are being sent to the six collaborating countries.

On-farm trials

A number of farm trials were conducted at Montería in collaboration with the weed control and small farm groups. The principal objectives of these trials were (1) to evaluate CIAT brachytic materials and local varieties and hybrids in monoculture and associated with yams, (2) to determine optimal plant densities for the maize varieties, and (3) to evaluate several weed control alternatives for maize production on small farms.

Interesting conclusions may be drawn from the 13 trials; the most important is that reasonable maize yields are possible for this area (Table 1). In spite of delayed rainfall and subsequent flooding in some zones, 1975A was an excellent season for maize. All ICA, CIAT and CIMMYT materials produced several times the traditional average yields (approximately 1.2 tons|ha) reported for the Andean Zone. Furthermore, all hard endosperm opaque varieties were equal or nearly equal to normal hybrids and varieties at comparable plant densities.

Plant density was the principal limiting factor in varietal performance across all locations. A typical example of density effects on maize yields for the ICA hybrid H-207 is illustrated in Figure 1. Results were similar for all locations and for all 14 materials tested. The importance of adequate population density may apply to a large part of the Andean Zone. Estimates are that 70 percent increases in yields of unimproved Bolivian native varieties could be obtained if higher plant densities could be implemented.

Over all locations and varieties, 68 percent of the seed planted produced

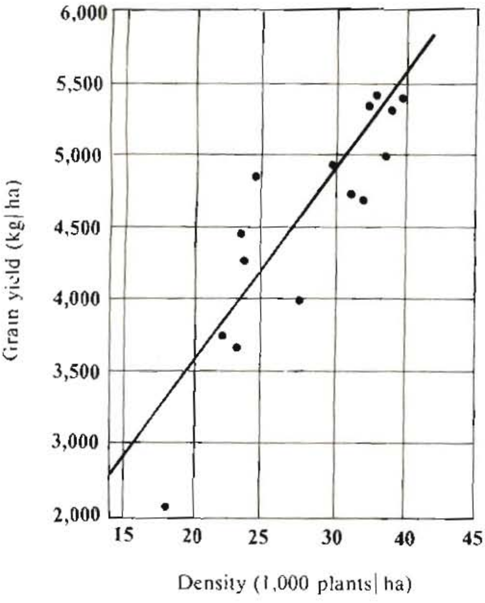

Figure 1. **On-farm yield of maize hybrid ICA H-207 as a function of plant density, Montería, Colombia (1975A) (r = 0.852).**

plants for harvest. Obtaining and maintaining high-quality planting seed from harvested opaque maizes stored under traditional farming conditions is a potentially serious limitation to a more extensive distribution of such materials, and must be examined.

La Posta C_2, selected from a 1974B CIMMYT progeny trial for its performance under adverse conditions of high pH and poorly drained soils, yielded extremely well under similar conditions in a field near Montería. An additional cycle of selection has been completed at CIAT. The acceptability of a soft, white, dent grain type is limited but can be improved by recombination with more desirable types.

Lodging data (Table 1) indicate that brachytic varieties should have distinct advantages over normal plant types as support for yams. Among the three selected brachytic plant types, no differences were observed in the relative growth and climbing ability of the yams. Variations in yields of yams supported on normal and brachytic maizes should show the importance of the lodging observed.

A number of the on-farm maize trials included weed control treatments, particularly the use of preemergence herbicides. Previous studies have shown that farmers have a labor shortage during the maize-growing seasons; an effective herbicide treatment plan could alleviate this situation.

Atrazine or linuron, alone or in combination, or atrazine and alachlor gave slightly higher yields than the farmers' usual system of two or three hand weedings. Since rainfall was light during the first 30 to 50 days of these trials, weeds were not as abundant or competitive as they would normally be.

The labor-saving potential of herbicides was also tested in nontillage systems on three farms. The nonselective, nonresidual compounds paraquat and glyphosate were applied alone or in combination with preemergence herbicides to the weeds present at planting time. These treatments were compared with the farmers' traditional land preparation methods. Results were promising for both products; when used in combination with a preemergence herbicide, they gave better control than when used alone.

These farm trials have demonstrated that at adequate plant densities, yields of a number of normal, brachytic and opaque varieties are high enough to justify inputs such as fertilizers, insecticides and herbicides.

REGIONAL ACTIVITIES

CIMMYT and CIAT acted as hosts of the 1975 meeting of Andean Zone maize researchers in Mexico. Participants explored ways in which the collaborative services of the two centers could best support national program efforts to increase maize production. CIMMYT provided an in-depth look at its materials, population development scheme and farm testing methodology. National program leaders presented current maize production data for their respective countries, as well as short- and long-term objectives for improving production. Natiònal program activities for reaching these goals were presented, followed by discussions of how CIMMYT and CIAT, through their collaborative services program, could best support national program activities in research, varietal development and testing, and the training of scientists and production agronomists. A number of the participants made a brief visit to Palmira on their return in order to see CIAT programs and services.

As a result of the Mexico meetings, guidelines were established for the regional program, which will encompass the five Andean countries and tropical Brazil. The key areas of support include:

1. A more liberal and rapid exchange of genetic materials at all stages of development among national programs and between national programs and CIMMYT.

2. The formation of national maize training programs at the production agronomist level, encouraging professionals from several countries to participate in the course presentation. Such a course has been planned by the Bolivian national program for the 1975B season in the state of Santa Cruz.

3. The facilitation of field-level interaction among scientists from different countries to broaden the exchange of ideas and germplasm on a regional basis.

4. The establishment of uniform variety trials of national program materials for both the highland and lowland tropical areas. The agronomic practices for these trials were developed at the conference in Mexico, and the materials have been distributed for planting during the next season.