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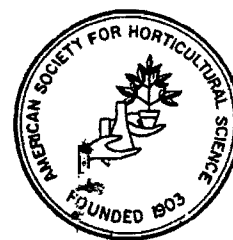
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# BREEDING AND AGRONOMIC PERFORMANCE OF CORN CULTIVARS AND HYBRIDS DURING THE PAST FIVE YEARS IN PUERTO RICO

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## ABSTRACT

Corn research activities conducted at the Tropical Agriculture Research Station (TARS), USDA-ARS, Mayaguez, Puerto Rico during the past five years are reported. The breeding programme utilizing recurrent selection has been successful in improving local and temperate zone populations. Progress has been made in transferring desirable genes to the local sweetcorn cultivar Suresweet. Numerous corn introductions from Central America and other tropical countries have been evaluated and high yielding selections identified for further studies. Based on numerous field studies, yields of over 8,000 kg ha<sup>-1</sup> can be expected utilizing superior commercial hybrids under intensive management with the application of up to 120 kg N ha<sup>-1</sup> at a population density of over 40,000 plants ha<sup>-1</sup>.

## RESUMEN

Este es un informe de investigación del maíz, llevado a cabo durante los últimos cinco años, en la Estación de Investigación de Agricultura Tropical (TARS), USDA-ARS en Mayaguez, Puerto Rico. El programa de mejoramiento, de selección recíproca-contigua, ha sido exitosa en cuanto se refiere al mejoramiento de poblaciones criolla y de la zona templada. Se hicieron avances en el transferimiento de genes, beneficiosos para la variedad criolla de choclo, Suresweet. Numerosas introducciones de maíz de América Central y de otros países tropicales han sido evaluadas y selecciones de alto rendimiento fueron identificadas para llevar a cabo estudios mas amplios. Basados en estudios de campo es posible obtener rendimientos mayores de 8000 kg/ha, utilizando híbridos comerciales superiores, llevados a cabo bajo un manejo intensivo, con aplicaciones de hasta unos 120/kg/N/ha y con una población de mas de 40,000 plantas/ha.

Keywords: Breeding, *Zea mays*, Puerto Rico

Exceeded only by wheat and rice, corn (*Zea mays* L), the third most important cereal grain in the world, plays an important role in feeding millions of people throughout the world (Sotomayor-Rios and Weibel, 1983). According to USDA (1984), production in the United States during 1983/84 was 106,781,000 tonnes of a world total of 344,058,000. During the same period mean corn yield ranged from 0.09 to 1.89 tonnes ha<sup>-1</sup> in Central America and was 5.12 tonnes ha<sup>-1</sup> in the U.S. Excellent yields in the United States and other developed countries are attributed to the use of advanced technology at the farm level, plus the ability of superior hybrids. Puerto Rico has a limited production of cereal grains. Nevertheless over 500,000 tonnes year<sup>-1</sup> are imported for livestock feed (Vicente-Chandler, 1984). According to data obtained by the authors, Puerto Rico could reduce the heavy importation of cereals if 50,000 ha of land were devoted to intensively cultivated corn and/or sorghum. In southern Puerto Rico over 3,000 ha of fertile flat land are being intensively utilized for commercial vegetable production during October through March, remaining idle during the rest of the year. Corn as well as sorghum are rotational crops providing an additional income to farmers outside the winter vegetable season and also improving the physical properties of the soil.

The objective of this paper is to summarize research findings on corn breeding and management conducted at the Tropical Agriculture Research Station (TARS), USDA-ARS, Mayaguez, Puerto Rico during the past five years. Most of the studies reported were conducted on a typical tropical Oxisol and should be applicable to other sites with similar soils in the Caribbean and elsewhere in the tropics.

## Materials and methods

The experiments reported in this article were conducted at the following locations: (1) Isabela Experiment Farm of the Tropical Agriculture Research

Station (TARS), USDA, ARS, Mayaguez, Puerto Rico. (2) The Agriculture Research and Development Center of the Agricultural Experiment Station, University of Puerto Rico at Lajas, Puerto Rico. (3) A private farm at Sabana Grande, Puerto Rico.

The Isabela farm is located in northwestern Puerto Rico, 128m above sea level at 18° latitude N and 67° longitude W. Mean monthly temperatures range from 21.6 to 26.2° C. Mean annual rainfall is 1658 mm. The soil is a Tropeptic Haplorthox, clayey, kaolinitic, isohyperthermic. It is highly weathered, leached with clays of low activity, and has a moderately high percentage base saturation throughout the profile. Crops on this soil do not consistently respond to added K, but have a moderate response to P and a good response to N and Zn.

The Lajas farm is located in southwestern Puerto Rico, 33m above sea level at 18° latitude N and 67° longitude W. Temperatures range from 22.6 to 31.4° C. Mean annual rainfall is 1194mm. The soil is a Vertisol clay (Udic Chromustert, very fine, montmorillonitic, isohyperthermic) with an organic matter content of 2.5 per cent. Soil pH is 6.3.

The Sabana Grande farm is located in southwestern Puerto Rico 33m above sea level at 18° latitude and 67° longitude. Temperatures range from 18.9 to 31.4°C. Mean annual rainfall is 1194mm. The soil is a Fraternidad clay (Udic Chromustert, very fine, montmorillonitic, isohyperthermic) with an organic matter content 2.3 per cent. Soil pH is 6.4.

Standard practices were utilized in the management of the different experiments conducted. These practices were described previously by Quiles-Belén (1983), Torres-Cardona and Sotomayor-Ríos (1983) and Torres-Cardona *et al* (1985). The corn germplasm consisted of populations and cultivars of a broad genetic background. For instance, outstanding corn populations from the International Maize and Wheat Improvement Center (CIMMYT), Mexico and the Central American Cooperative Improvement Program

(PCCMCA), were utilized as a source material for genetic and agronomic studies.

**Improvement through breeding:** a reciprocal recurrent selection scheme (Hallauer, 1972) has been utilized in the improvement of local corn cultivars "Diente de Caballo" (DC), "Mayorbela" (M), and temperate zone populations OHS9 and OHS10. Two improvement cycles have been completed. The pedigree method is being utilized in the improvement of the sweetcorn, Suresweet, developed at TARS, Mayaguez, a cultivar which is highly resistant to *Heliothis zea*, the corn earworm. The kernel pericarp of Suresweet is being improved by transferring the gene brittle-1 from Hawaiian Super-sweet No. 9, a high sucrose cultivar developed by Brewbaker (1977). Five cycles of selection have been completed using bite tests. The test is conducted 22 days after pollination at a late sweet corn stage, when kernel toughness is greater than at prime sweet corn stage, to ensure identification of the most tender ears. In this procedure the top half of each ear, is removed and subdivided for two testers while the bottom half is left to mature for seed production.

**Management studies:** (a). Twenty seven corn cultivars from the PCCMCA programme were evaluated at two planting dates (October, 1982 and March, 1983) at Isabela, Puerto Rico for yield and a series of agronomic traits.

(b). Thirty six corn cultivars and hybrids from PCCMCA were evaluated during 1983 at Isabela, Puerto Rico for yield and a series of agronomic traits.

(c). Twenty corn populations from CIMMYT, Mexico were evaluated at two planting dates during 1982-83 for grain yield and a series of agronomic traits.

(d). The effect of N levels (20, 40, 60, 120, 180 and 240 kg ha<sup>-1</sup>) and population densities (20,000, 40,000 and 80,000 plants ha<sup>-1</sup>) on commercial hybrids Pioneer 304 C, Pioneer 5800 and DeKalb XL 670 were studied at Sabana Grande and Isabela during 1983.

(e). Five commercial hybrids, DeKalb XL 560, Pioneer 304 C, DeKalb EXA 815, DeKalb XL 670 and DeKalb EXA 816, were evaluated at two planting dates (September and May) during 1984 for yield and a series of agronomic traits.

## Results and discussion

**Corn breeding:** preliminary results from the reciprocal recurrent selection improvement programme indicate that after two cycles of breeding and recombination, OHS9 and OHS10 yields were superior to those of M and DC. The most promising combinations obtained were those with OHS10, M and DC, with yields over 5,000 kg ha<sup>-1</sup>, which were comparable to check variety Pioneer Hybrid 304 C (Table 1). In the sweet corn breeding programme F5 families of the cross Suresweet x Hawaiian Super-sweet No. 9 are very promising and an early release of this material will be made this year.

Table 1 Yield comparison of corn cultivars Diente de Caballo (DC), Mayorbela (M), OHS9 and OHS10 their crosses and S<sub>1</sub> bulks after two reciprocal recurrent selection cycles, 1982 - 85, Puerto Rico.

Genotypes	Reciprocal recurrent selection cycle		
	1	2	X
	kg ha <sup>-1</sup>		
DM x M	5191	5598	5395
DC x OHS9	4759	4779	4768
DC x OHS10	4915	5709	5312
M x DC	4886	5412	5149
M x OHS9	4080	3900	3990
M x OHS10	5011	5103	5057
OHS9 x DC	4234	4810	4522
OHS9 x M	4270	4677	4474
OHS9 x OHS10	4011	4836	4424
OHS10 x DC	4618	5709	5164
OHS10 x M	5360	5641	5501
OHS10	2896	4177	3502
DC	2991	3652	3322
M	2808	3812	3310
OHS9	3619	3963	3791
OHS10 x OHS9	4257	4339	4298
DS S <sub>1</sub>	2806	3165	2986
M S <sub>1</sub>	3739	3348	3544
OHS9 S <sub>1</sub>	2076	3107	2592
OHS10 S <sub>1</sub>	1933	2918	2426
Pioneer X304 C (check)	5629	6089	5859

**Management studies:** Significant differences between cultivars and planting dates were obtained for grain yield and most traits (study (a), Materials and methods). Cultivar Tico V-6, from Costa Rica produced the highest grain yields across planting dates (6,407 kg ha<sup>-1</sup>), significantly superior to the remaining cultivars (Table 2) (Torres-Cardona and Sotomayor-Rios, 1983). Correlation coefficients between grain yield and leaf area index, plant height, ear length and ear diameter were highly significant, ranging from 0.86 to 0.95 (Table 3).

Significant differences between genotypes for grain yield and most traits were obtained (study (b), Materials and methods). Cultivars ICTA HB-33,

CENTA H-3 and CENTA HE-20, all from the PCCMCA programme, were the top yielders with 5,982, 5,749 and 5,524 kg ha<sup>-1</sup>, respectively, significantly higher than the remaining cultivars (Fig. 1).

Significant differences were observed for most traits including grain yield (study (c) Materials and methods). The best two populations were Across 7728 and Cuyuta 7929 with grain yields of 5,814 and 5,808 kg ha<sup>-1</sup>, respectively. These means were not significantly different from that of Pioneer Hybrid 304 C, the check variety (6,029 kg ha<sup>-1</sup>) (Fig. 2).

Table 2. Grain yield, leaf area index, plant height, ear length and ear diameter of 27 corn cultivars across planting dates at Isabela, Puerto Rico, 1982-83.<sup>1</sup>

Cultivars	Grain yield (kg/ha)	Leaf area index	Plant height (cm)	Ear length (cm)	Ear diameter (cm)
TICO V-6	6407a	3.74 a	247 b	19.0 a	5.4 a
PNIA HB-1	6212 b	3.45 cd	246 bc	19.1 a	5.4 a
H-5	6134 bc	3.67 b	249 a	18.7 b	5.4 a
TICO V-7	6013 cd	3.74 a	247 ab	18.8 b	5.5 a
Hibrido SIATSA H-1	5873 de	3.73 a	247 ab	19.2 a	5.4 a
HE-16	5825 e	3.42 d	243 def	18.2 c	5.5 a
HB-33	5724 e	3.64 b	247 ab	18.2 c	5.4 a
HE-102	5720 e	3.48 c	247 c	18.6 b	5.4 a
HG-82	5218 f	3.23 e	242 efgh	15.7 f	4.7 efg
Tocumen 7428	5045 g	3.22 e	243 def	16.7 d	4.9 bcde
La Máquina 7843	4987 gh	3.12 f	242 efgh	14.8 ijk	4.9 bcde
Alajuela - 2	4916 gh	3.06 g	2435 cd	15.6 f	5.0 bc
EX-811	4828 hi	2.98 h	243 def	15.2 g	4.7 fg
UNP -1	4740 i	3.02 gh	243 def	15.6 f	4.8 cdefg
HA-44	4692 i	3.08 fg	241 fghi	16.5 e	4.8 cdefg
B-555	4490 j	2.71 j	240 ijkl	14.9 ijk	4.8 cdefg
EX-815	4341 j	2.72 j	238 lmno	15.0 hi	4.8 cdefg
Los Diamantes 8043	4315 k	2.92 i	241 fghi	14.7 jkl	4.8 cdefg
Sintético Hondueño	4257 kl	2.42 m	239 klmn	14.2 n	5.0 bc
ICTA T-101	4220 kl	3.04 ghi	243 def	14.9 ijk	4.9 bcde
ICTA B-1	4099 lm	2.77 j	239 klmn	14.7 jkl	4.7 fg
HB-67	4027 mn	2.41 m	237 no	14.7 jkl	4.8 cdefg
H-3 4022 mn	4022 mn	2.64 k	239 klmn	15.1 gh	4.7 fg
TICO V-1	3985 mn	2.46 m	240 ijkl	14.7 jkl	4.7 fg
Tocumen 80 A	3928 n	2.44 m	240 ijkl	14.9 ijk	4.7 fg
H-9	3622 o	2.57 l	237 no	14.5 lm	4.9 bcde
Alajuela -1	3516 o	2.42 m	237 no	14.5 lm	4.9 bcde
$\bar{x}$	4858	3.04	242	16.2	5.00
C.V. (%)	3.15	1.95	7.2	1.23	3.19

<sup>1</sup> Means followed by a letter in common do not differ significantly ( $P=0.05$ ) according to Duncan's multiple range test.

Table 3. Correlation coefficients between grain yield and leaf area index, plant height, ear length and ear diameter of 27 corn cultivars across planting dates at Isabela, Puerto Rico, 1982-83.

	Leaf area index	Plant height	Ear length	Ear diameter
Grain yield	0.95**	0.91**	0.93**	0.86**

\*\* Significantly different from zero at  $P=0.01$

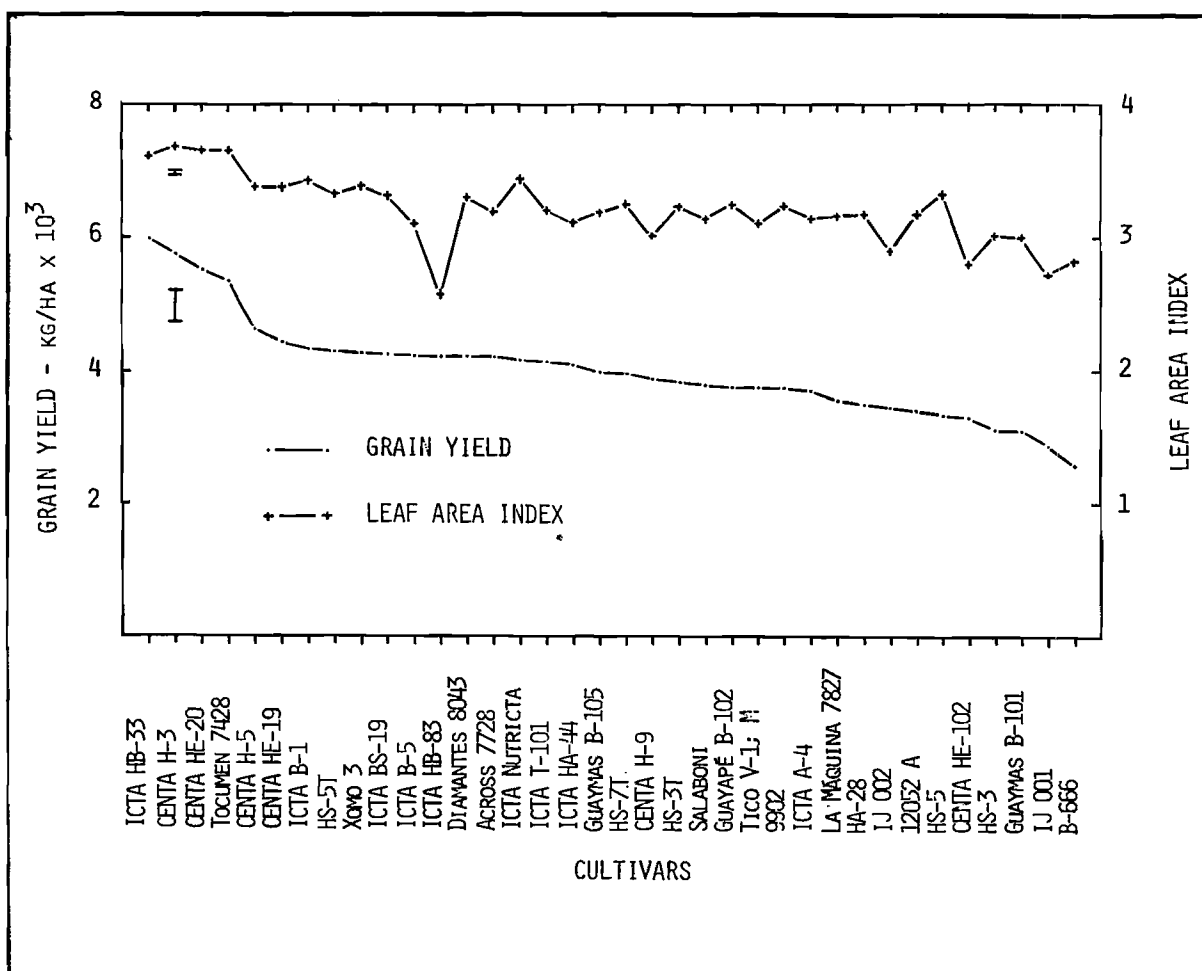


Figure 1 Grain yield and leaf area index of 36 corn cultivars at Isabela, Puerto Rico, 1983.

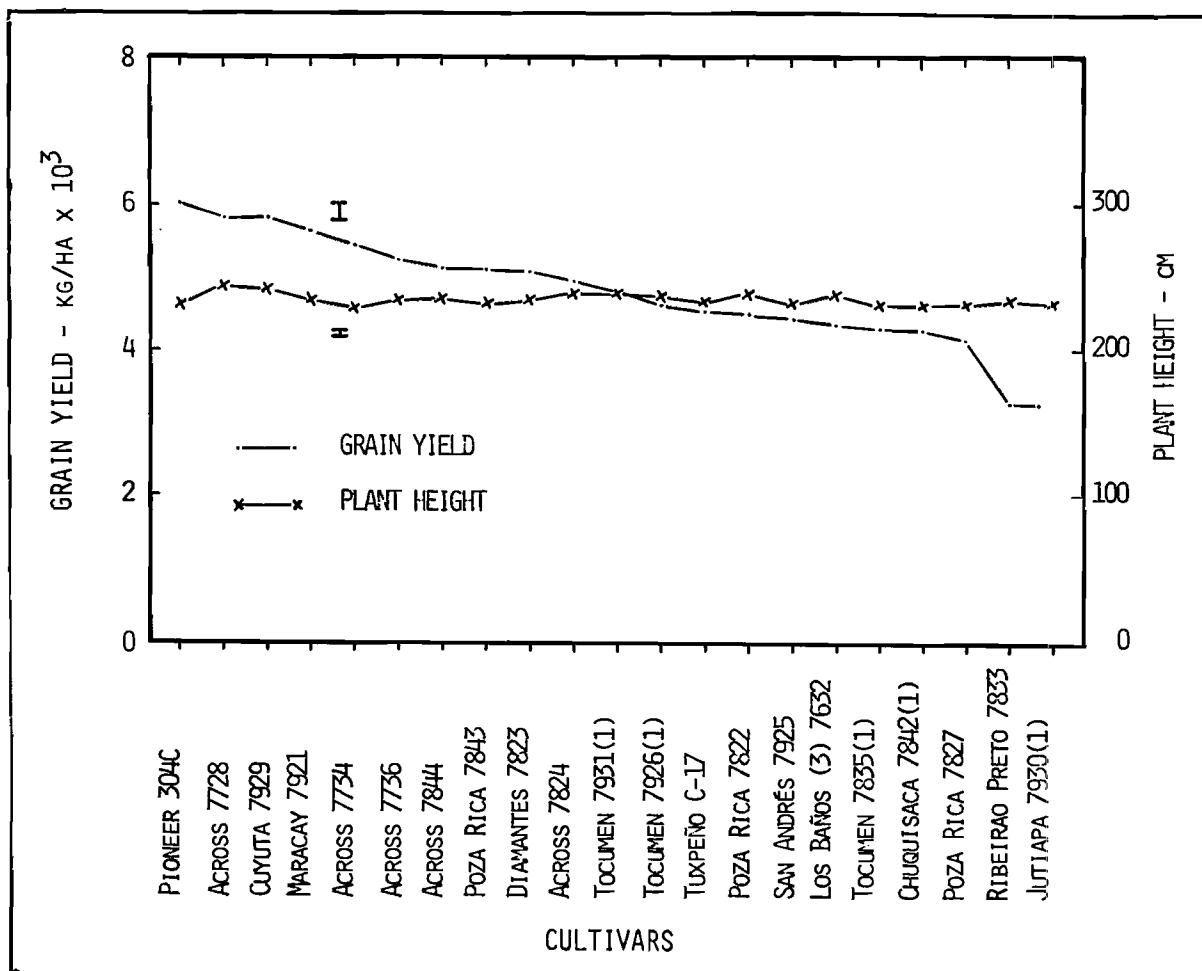


Figure 2 Grain yield and plant height of 21 corn cultivars across planting dates at Isabela, Puerto Rico, 1982 - 83.

Significant differences from grain yield and most traits were obtained for locations, N levels, hybrids, population densities and their interaction (study (d) Materials and methods). Average maximum yields of 8,890 kg ha<sup>-1</sup> (Pioneer Hybrid 304 C) resulted from

the application of 120 kg N ha<sup>-1</sup> at a population density of 40,000 plants ha<sup>-1</sup> (Isabela), although 88 per cent of such yields were obtained with the application of the initial 60 kg N ha<sup>-1</sup> (Table 4) (Quiles-Belén, 1983).

Table 4. N Level and population density effect on grain yield of three corn hybrids at two locations in Puerto Rico, 1983.<sup>1</sup>

Hybrids and Polution Densities (plants/ha)										
N Level	Dekalb XL 670			Pioneer X304 C			Pioneer 5800			$\bar{x}$
	20000	40000	80000	20000	40000	80000	20000	40000	80000	
kg/ha										
Isabela										
0	2505 a	4745 c	4153 b	3286 a	5580 c	5003 bc	3245 b	4951 b	4507 c	4219 d
60	2945 a	7243 ab	4658 b	3762 a	7836 ab	5619 ab	4366 a	6398 ab	5181 ab	5334 b
120	3459 a	8218 a	6135 a	4051 a	8890 a	6253 a	3844 ab	7195 a	5568 ab	5957 a
180	2943 a	6188 bc	6338 a	3967 a	8019 ab	4948 c	3616 ab	6139 ab	5802 a	5329 b
240	3142 a	6168 bc	4437 b	3262 a	7283 bc	4535 bc	4046 ab	6671 ab	5050 abc	5066 c
$\bar{x}$	2999	6512	4434	3666	7522	5472	3823	6271	5222	
Sabana Grande										
0	4045 a	6128 d	5028 d	3974 c	6425 a	5999 b	4239 ab	5298 d	4824 d	5107 c
60	5087 a	7151 ab	6413 a	5329 a	8040 a	6528 ab	4854 a	6019 cd	6453 ab	6208 ab
120	4714 a	8820 a	6205 abcd	4683 abc	7910 a	7415 a	4673 ab	6862 ab	6707 a	6443 a
180	4412 a	7388 ab	6313 ab	4455 abc	7869 a	6284 ab	3965 a	7231 a	5959 abc	5986 b
240	4365 a	7166 ab	6284 abc	4916 ab	7696 a	6854 ab	5403 b	6153 ac	6022 abc	5995 b
$\bar{x}$	4525	7331	6049	4671	7588	6616	4447	6313	5993	

<sup>1</sup> Means followed by a letter in common do not differ significantly ( $P=0.05$ ) according to Duncan's multiple range test.

During 1983/84 and at the Agricultural Research and Development Center at Lajas, Puerto Rico, the effect of N levels (0, 40, 80, 120, and 160 kg ha<sup>-1</sup>) and planting dates (September 1983 and May 1984) were studied on two commercial hybrids (Pioneer X304 C and Dekalb XL 670). Significant differences were obtained among N levels for all the agronomic traits studied. The mean maximum grain yield (7,114 kg ha<sup>-1</sup>) was obtained with the application of 120 kg N ha<sup>-1</sup> (Table 5) (Torres-Cardona *et al.*, 1985). These results are comparable to those obtained by Quiles-

Belén (1983) at Sabana Grande, Puerto Rico.

Combined analysis of variance showed significant differences among planting dates, hybrids and their interactions for grain yield and most traits studied (study (e) Materials and methods). The highest yielder was Dekalb XL 560 (7,713 kg ha<sup>-1</sup>) which significantly exceeded the remaining hybrids (Table 6). Based on cost estimates obtained by the authors and assuming a grain yield of about 7.5 tonnes ha<sup>-1</sup>, the net profit for growing field corn in Puerto Rico would be \$397 ha<sup>-1</sup>.

Table 5. N level effect on grain yield of two corn hybrids at two planting dates in Lajas, Puerto Rico, 1983-84.

N Level	September, 1983		May, 1984		$\bar{x}$
	Pioneer	DeKalb	Pioneer	DeKalb	
	X304C	XL 670	X304C	XL 670	
— kg/ha					
0	2422	3238	2373	2943	2744
40	6012	5467	56585	5314	5620
80	6983	6205	6565	6501	6564
120	7210	7168	7087	6904	7114
160	7105	6989	6889	6989	6993
$\bar{x}$	5946	5813	5720	5730	

Table 6. Grain yield, plant height and leaf area index of five corn hybrids across planting dates at Lajas, Puerto Rico, 1983-84<sup>1</sup>.

Hybrids	Grain yield kg/ha <sup>-1</sup>	Plant height m	Leaf area index
Dekalb XL 560	7713 a	2.5 d	4.8 a
Pioneer X304 C	6860 b	2.7 b	4.7 a
Dekalb EXA 815	6776 b	2.7 c	4.7 a
Dekalb 670	6764 b	2.6 c	4.7 a
Dekalb EXA 816	3793 c	2.9 a	4.2 c
$\bar{x}$	6381	2.7	4.6

<sup>1</sup> Means followed by a letter in common do not differ significantly ( $P=0.05$ ) according to Duncan's multiple range test.

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