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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 $ha^{-1}$ can be expected utilizing superior commercial hybrids under intensive management with the application of up to 120 kg N $ha^{-1}$ at a population density of over 40,000 plants $ha^{-1}$.**

**RESUMEN**

**Este es un informe de investigación del maiz, llevado a cabo durante los últimos cinco anos, en la Estación de Investigacion de Agricultura Tropical (TARS), USDA-ARS en Mayaguez, Puerto Rico. El programa de mejoramiento, de selección reciproca-contigua, ha sido exitosa en cuanto se refiere al mejoramiento de poblaciones criolla y de la zona templada. Se hicierón avanzes en el transferimiento de genes, beneficiosos para la variedad criolla de choclo, Suresweet. Numerosas introducciones de maiz de America Central y de otros paises 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 $ha^{-1}$ in Central America and was 5.12 tonnes $ha^{-1}$ 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 $year^{-1}$ 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 $ha^{-1}$) and population densities (20,000, 40,000 and 80,000 plants $ha^{-1}$) 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 $ha^{-1}$, 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 Supersweet 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 $S_1$ bulks after two reciprocal recurrent selection cycles, 1982 – 85, Puerto Rico.

| Genotypes | Reciprocal recurrent selection cycle 1 | 2 | X |
|---|---|---|---|
| | kg $ha^{-1}$ | | |
| 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 $S_1$ | 2806 | 3165 | 2986 |
| M $S_1$ | 3739 | 3348 | 3544 |
| OHS9 $S_1$ | 2076 | 3107 | 2592 |
| OHS10 $S_1$ | 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$^{-1}$), 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$^{-1}$, 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$^{-1}$, respectively. These means were not significantly different from that of Pioneer Hybrid 304 C, the check variety (6,029 kg ha$^{-1}$) (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.[1]

| Cultivars | Grain yield | Leaf area index | Plant height | Ear length | Ear diameter |
|---|---|---|---|---|---|
| | (kg/ha) | | (cm) | (cm) | (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 |

[1] Means followed by a letter in common do not differ significantly (P=.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

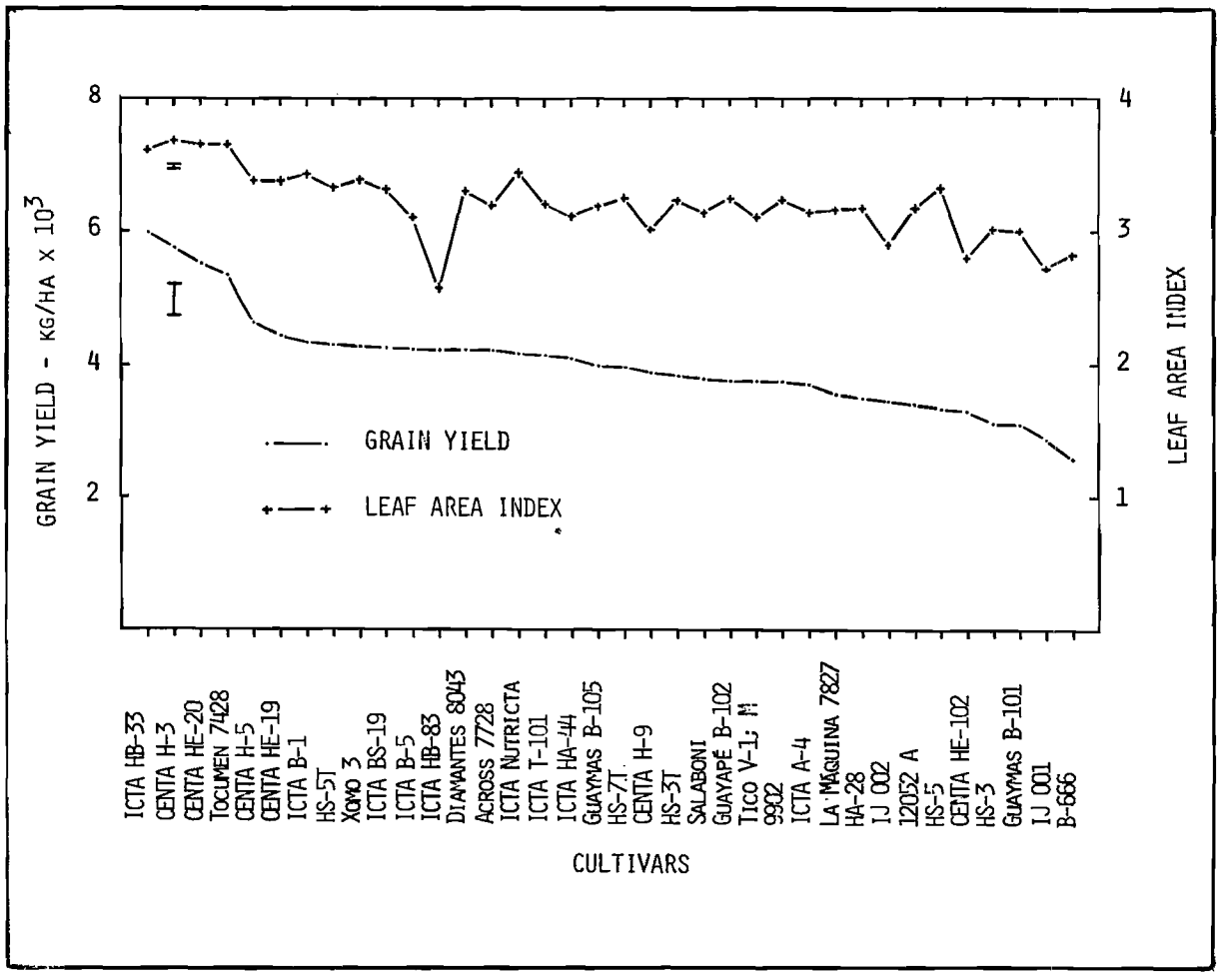


Figure 1 Grain yield and leaf area index of 36 corn cultivars at Isabela, Puerto Rico, 1983.

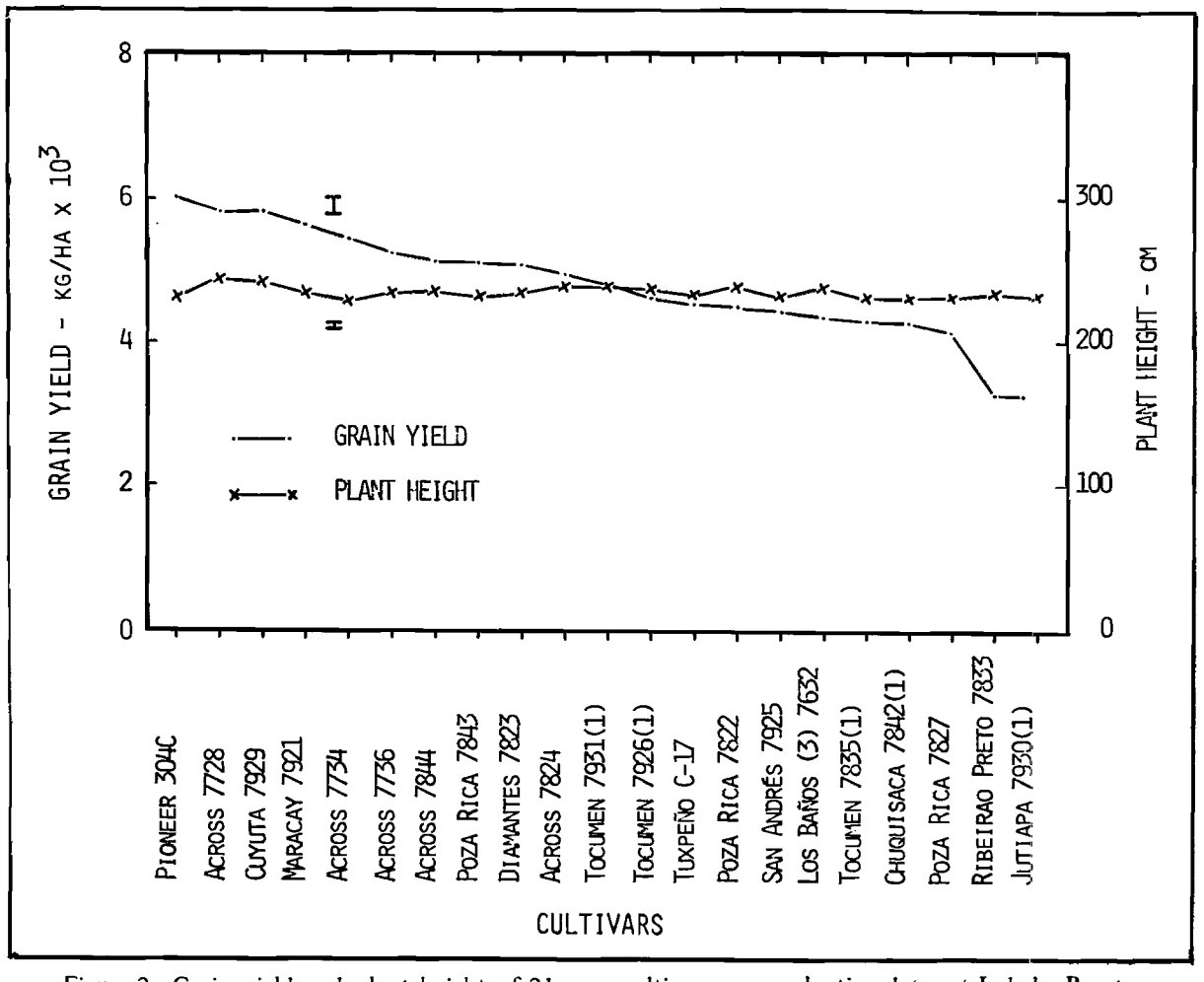


Figure 2 Grain yield and plant height of 21 corn cultivars across planting dates at Isabela, Puerto Rico, 1982 – 83.

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$^{-1}$ (Pioneer Hybrid 304 C) resulted from the application of 120 kg N ha$^{-1}$ at a population density of 40,000 plants ha$^{-1}$ (Isabela), although 88 per cent of such yields were obtained with the application of the initial 60 kg N ha$^{-1}$ (Table 4) (Quiles-Belén, 1983).

Table 4. N Level and polulation density effect on grain yield of three corn hybrids at two locations in Puerto Rico, 1983.[1]

| | Hybrids and Polulation Densities (plants/ha) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dekalb XL 670 | | | Pioneer X304 C | | | Pioneer 5800 | | | |
| N Level | 20000 | 40000 | 80000 | 20000 | 40000 | 80000 | 20000 | 40000 | 80000 | x̄ |
| | 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 |
| 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 |
| x̄ | 4525 | 7331 | 6049 | 4671 | 7588 | 6616 | 4447 | 6313 | 5993 | |

[1] Means followed by a letter in common do not differ significantly (P=.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$^{-1}$) 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$^{-1}$) was obtained with the application of 120 kg N ha$^{-1}$ (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$^{-1}$) 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$^{-1}$, the net profit for growing field corn in Puerto Rico would be $397 ha$^{-1}$.

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

| | September, 1983 | | May, 1984 | | |
|---|---|---|---|---|---|
| N Level | Pioneer X304C | DeKalb XL 670 | Pioneer X304C | DeKalb XL 670 | x̄ |
| | 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 |
| x̄ | 5946 | 5813 | 5720 | 5730 | |

Table 6. Grain yield, plant height and leaf area index of fivecorn hybrids across planting dates at Lajas, Puerto Rico, 1983-84 [1].

| Hybrids | Grain yield | Plant height | Leaf area index |
|---|---|---|---|
| | kg/ha$^{-1}$ | m | |
| 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 |
| x̄ | 6381 | 2.7 | 4.6 |

[1] Means followed by a letter in common do not differ significantly (P=.05) according to Duncan's multiple range test.

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