

# THE JOURNAL OF AGRICULTURE OF THE UNIVERSITY OF PUERTO RICO

Issued quarterly by the Agricultural Experiment Station of the University of Puerto Rico, for the publication of articles by members of its personnel, or others, dealing with any of the more technical aspects of scientific agriculture in Puerto Rico or the Caribbean Area

Vol. LXIII

JULY 1979

No. 3

## Influence of Cultivars, N Levels and Time of N Application on Plant Characters, Leaf Composition, and Yield of Corn Grown on an Oxisol<sup>1, 2</sup>

*J. Badillo-Feliciano, M. A. Lugo-López and T. W. Scott<sup>3</sup>*

### ABSTRACT

An experiment was conducted during the summer of 1975 (June 5 to September 24) on a clayey Oxisol in northwestern Puerto Rico to test the performance of 7 cultivars of corn at 2 different levels of N (67 and 134 kg/ha) at 3 different times of application (all at planting, 1/4 at planting + 3/4 one month after planting, and all one month after planting).

There were no significant differences in yields between the 2 levels of N, but there was a significant 5% increase in yield with all N applied postplant in comparison with all preplant. There were also significant differences between grain yield of cultivars. The best grain yields were obtained with Pioneer X-306B with more than 8,000 kg/ha at both N levels and times of application. An almost neglected local cultivar, Diente de Caballo, had a high mean yield of 7,387 kg/ha, which was significantly higher than those of the other 5 cultivars. Funk's G-795W and Opaque-2 type Sp 622 were the lowest yielders with about 5,400 and 4,800 kg/ha, respectively. Standard local cultivars (Mayorbela, and two other Opaque-2—Tuxpeño × La Posta and Composite K, hard endosperm) were intermediate in yield with over 6,000 kg/ha. Pioneer X-306B, Diente de Caballo, Tuxpeño × La Posta and Composite K, hard endosperm, produced over 6,000 kg/ha of stover, while Sp 622 produced only about 3,900 kg/ha. Plants of Pioneer X-306B and Diente de Caballo were the tallest, while those of Sp 622 were the lowest. Plants of Funk's G-795W had the smallest mean stem diameter. Mean leaf N at silking was higher for all cultivars in the high N level (134 kg/ha) than in the low N level (67 kg/ha), except in Mayorbela. There were no significant interactions between cultivars, N levels and time of N applications.

### INTRODUCTION

Intensive research on corn fertilization in the extensive, acid and relatively infertile Oxisols and Ultisols of the humid tropics has been

<sup>1</sup> Manuscript submitted to Editorial Board July 30, 1976.

<sup>2</sup> Joint contribution from the Department of Agronomy, Cornell University, Ithaca, N.Y., and the Agricultural Experiment Station, University of Puerto Rico, Mayagüez Campus, Río Piedras, P.R. This study was part of the investigations supported by the USAID under research contract ta-c-1104 entitled "Soil Fertility in the Humid Tropics."

<sup>3</sup> Associate Agronomist and Professor-Soil Scientist, Agricultural Experiment Station, University of Puerto Rico, Mayagüez Campus, Río Piedras, P.R., and Professor of Soil Science, Cornell University, Ithaca, N.Y., respectively.

under way for the past 6 years. Fox et al.<sup>4</sup> reported the results of 15 N-fertilization experiments conducted during 1970-72 with Pioneer X-306, a hybrid corn developed for tropical environments. They reported maximum grain yields of about 6.3 metric tons/ha with 67 kg/ha of postplant applied N. Further work by Talleyrand and Lugo-López<sup>5</sup>, on a sandy Oxisol at Manatí and a clayey Ultisol at Corozal, indicated that high corn yields (5 to 7 metric tons/ha) could be obtained using hybrids Pioneer X-306B and Funk's G-795W with 180 kg/ha of postplant N. Talleyrand et al.<sup>6</sup> obtained maximum yields of Funk's G-795W at Corozal (8,400 kg/ha) and at Manatí (5,400 kg/ha) applying between 60 and 120 kg/ha of N. Talleyrand and Lugo-López<sup>7</sup> working with Opaque-2 corn types on an Ultisol at Corozal under the same high level of postplant N and obtained from 5.1 to 6.3 metric tons/ha.

In general, the above-mentioned high corn yields, similar to those of the temperature zone, are possible in the tropics if high yielding cultivars are used under careful fertility management, if pests are effectively controlled, and supplemental irrigation is supplied at critical periods. Between 60 and 120 kg/ha of N are necessary for near maximum yields.

This paper reports on a more comprehensive field experiment where several corn cultivars were tested, including two native ones, at two levels of N applied at three different times.

#### MATERIALS AND METHODS

An experiment was conducted at the Isabela Agricultural Experiment Substation in northwestern Puerto Rico, with a maritime, humid, tropical climate. Mean annual rainfall is about 1,658 mm. Evaporation from a Class-A pan is approximately 6 mm/day in summer and 4 mm/day in winter. The mean annual maximum temperature is 29.4° C and the mean minimum temperature is 18.9° C. Average solar radiation ranges from 300 langleydays/day in winter to 600 in summer. The elevation is 122 m above sea level.

The soil is Coto, a Tropeptic Haplorthox, clayey, kaolinitic, isohyperthermic with pH about 5.8; CEC (NH<sub>4</sub>OA<sub>c</sub>) 13 meq/100 g of dry soil and 25% base saturation. It is high in Mn and low in available P.

<sup>4</sup> Fox, R. H., Talleyrand, H., and Bouldin, D. R., Nitrogen fertilization of corn and sorghum grown in Oxisols and Ultisols in Puerto Rico, *Agron. J.* 66: 534-40, 1974.

<sup>5</sup> Talleyrand, H. and Lugo-López, M. A., Performance of high-yielding corn hybrids Pioneer X-306B and Funk's G-795W at high levels of fertilization in the acid and relatively infertile soils (Ultisols and Oxisols) of Puerto Rico, *J. Agri. Univ. P. R.* 60(1): 132-4, 1976.

<sup>6</sup> Talleyrand, H., Fox, R. H., and Lugo-López, M. A., Nitrogen fertilization of a high yielding white-kernel corn in Oxisols and Ultisols in Puerto Rico, *J. Agri. Univ. P. R.* 60(3): 336-43, 1976.

<sup>7</sup> Talleyrand, H. and Lugo-López, M. A., Preliminary evaluation of two new high-quality protein Opaque-2 corn varieties in an acid and relatively infertile soil (Ultisol) of Puerto Rico, *J. Agri. Univ. P. R.* 60(1): 135-7, 1976.

The experiment followed a partially balanced randomized block design with 42 treatments and 4 replications. The variables were as follows:

Seven cultivars: Hybrids Pioneer X-306B and Funk's G-975W; Opaque-2 types, Tuxpeño × La Posta, Sp 622, and Composite K, hard endosperm; local cultivars Mayorbela and Diente de Caballo; 2 N levels: 67 and 134 kg/ha N as ammonium sulfate; 3 times of N application: 1/4 preplant + 3/4 1 mo after planting; all preplant; and all 1 mo after planting.

The treatments consisted of all possible combinations of those three variables.

Experimental plots consisted of four rows 75 cm apart and 3 m long with 1 m alleys at the ends. Seed was planted some 23 cm apart within the rows on June 5, 1975.

Prior to planting, all plots received a blanket application of 224 kg/ha of  $P_2O_5$  as triple superphosphate, 168 kg/ha of  $K_2O$ , as potassium chloride, 56 kg/ha of Mg as magnesium sulfate, 2.24 kg/ha of B as borax, and 10.5 kg/ha of Zn as zinc sulfate. The blanket application was plowed under and disced during land preparation.

Lasso (Alachlor)<sup>8</sup>, 43% active ingredient, was applied as preemergent herbicide at the rate of 2.4 L/ha. Weeds were removed mechanically when the corn was 3 weeks old. Lannate 90S at the rate of 1.12 kg/ha was sprayed every 2 weeks until silking to control the earworm (*Heliothis zea*); thereafter, it was applied every other day for one week. The lesser corn borer (*Elasmopalpus lignosellus*) and the fall armyworm (*Spodoptera frugiperda*) were controlled with Sevin 50 WP at the rate of 2.24 kg/ha. Dithane M-45 (2.5 kg/ha) was applied when necessary to control diseases.

Supplemental sprinkle irrigation was used as needed.

Husks were sampled at the silking stage to assess tissue nutrient status. Levels of N, P, K, Ca, Mg and Mn in the leaves were determined at silking time.

Plant height, height to ear, and stalk diameter 5 cm from the soil surface were recorded at harvest. The two inner rows of each plot were harvested on September 24, 1975, when 112 days old. Stover samples were obtained at harvest and analyzed for N content.

## RESULTS AND DISCUSSION

### CULTIVAR PERFORMANCE

Pooling all results, disregarding N levels and times of N application, the performance of the different cultivars can be assessed. Table 1 shows

<sup>8</sup> Trade names in this publication are used only to provide specific information. Mention of a trade name does not constitute a warranty of equipment or materials by the Agricultural Experiment Station of the University of Puerto Rico, nor is this mention a statement of preference over other equipment or materials.

significant differences in grain yield among cultivars. Hybrid Pioneer X-306B with 8,237 kg/ha outyielded all other cultivars at the 5% probability level. It outyielded the local cultivars Diente de Caballo and Mayorbela by 850 and 1,683 kg/ha, respectively. Diente de Caballo, an almost neglected local cultivar, had a surprisingly high mean yield of 7,387 kg/ha which was significantly higher than mean yields from the other five cultivars. There were no significant mean differences among cultivars Tuxpeño × La Posta, Mayorbela, and Composite K, hard endosperm. These three cultivars had significantly higher yields than Funk's G-795W and Sp 622. The latter was the lowest yielder among the Opaque-2 types. Funk's G-795W grain yield was similar to that reported by Talleyrand and Lugo-López<sup>5</sup> on a sandy Oxisol at Manatí (5.4 metric tons/ha with 60 kg/ha of postplant N).

TABLE 1.—Yields and plant characters of seven corn cultivars grown on a clayey Oxisol (pooling N levels and times of application)

Cultivars	Grain yield	Stover yield	Grain/stover ratio	Plant height	Height at ear	Stalk diameter
Pioneer X-306B	8237 a <sup>1</sup>	6812 ad	1.21	290.44 a	147.65 ab	2.538 ab
Diente de Caballo	7387 b	6465 ae	1.14	290.34 a	154.00 a	2.525 ab
Tuxpeño × La Posta	6693 c	6990 ad	0.96	269.75 b	125.27 d	2.624 a
Mayorbela	6554 c	5779 be	1.13	262.98 bc	139.95 bc	2.438 b
Composite K, hard endosperm	6386 c	7122 ad	0.90	273.67 b	138.43 bc	2.527 ab
Funk's G-795W	5432 d	5236 b	1.04	252.64 c	99.42 e	2.306 c
Sp622	4828 e	3925 c	1.23	230.79 d	81.72 f	2.373 b

<sup>1</sup> Mean values with one or more letters in common do not differ significantly at the 5% level.

There were no significant mean differences in stover yield between Composite K, hard endosperm; Tuxpeño × La Posta; Pioneer X-306B; and Diente de Caballo. Cultivars Mayorbela and Funk's G-795W outyielded Sp 622, the lowest stover yielder, at the 5% probability level. The low grain and stover yields of Sp 622 could be, at least in part, attributed to damage done by *Elasmopalpus lignosellus* and *Heliothis zea* and also *Cercospora*. Table 2 shows that Opaque-2 types Tuxpeño × La Posta and Composite K, hard endosperm, had the lowest grain-stover ratio; Sp 622, the highest, 1.23.

Plants of Pioneer X-306B and Diente de Caballo were the tallest, 290 cm. They were significantly higher than the other cultivars. Plants of Tuxpeño × La Posta, Mayorbela and Composite K, hard endosperm, reached almost the same height. Sp 622 had the shortest plants, 231 cm, significantly different from all other cultivars.

Ears of Diente de Caballo were borne at a higher point than those of other cultivars except for Pioneer X-306B. Ears of Mayorbela and Composite K, hard endosperm, were borne at about the same height. In the case of Sp 622, the lowest plants, the ears were borne also at the lowest point. The mean differences between Sp 622 and each other cultivar were significant.

Stalk diameter ranged from 2.62 cm in Tuxpeño × La Posta to 2.31 cm in Funk's G-795W. The mean differences between stalks of Funk's G-795W and those of the other cultivars were significant. Tuxpeño × La Posta had significantly thicker stems than those of Mayorbela, Funk's G-795W, and Sp 622.

At harvest time, stover N content ranged from 0.72 to 0.84%, except in

TABLE 2.—Nutrient levels in corn leaves at silking stage

Cultivar	Applied N Kg/ha	Level of indicated element					
		N %	P %	K %	Ca %	Mg %	Mn P/m
Pioneer X-306B	67	3.027	.343	2.067	.620	.283	98.3
	134	3.133	.363	2.407	.580	.253	107.0
Tuxpeño X La Posta	67	2.987	.350	2.257	.657	.353	92.3
	134	3.167	.340	2.427	.683	.360	99.0
Funk's G-795W	67	3.227	.407	2.440	.420	.277	90.3
	134	3.367	.403	2.383	.360	.243	75.7
Composite K, hard endo- sperm	67	3.007	.333	2.323	.583	.293	90.3
	134	3.187	.353	2.423	.587	.307	108.3
Sp 622	67	3.360	.423	2.717	.500	.223	67.7
	134	3.527	.443	2.803	.457	.230	84.3
Mayorbela	67	2.853	.337	2.077	.563	.270	70.7
	134	2.760	.353	2.377	.573	.263	87.7
Diente de Caballo	67	3.060	.333	2.327	.617	.303	83.7
	134	3.173	.346	2.370	.630	.297	103.7

the case of Mayorbela, which had 0.95%. This higher N uptake suggests that cultivar Mayorbela, in spite of the low N at silking (table 2), can later avail itself of more additional soil N than other cultivars.

There were no significant interactions among cultivars, N levels, and times of N application.

#### TIME OF N APPLICATION

The highest grain yield was obtained when all the N was applied 1 mo after planting (fig. 1). It did not differ significantly from that obtained from the plots that received 1/4 of the fertilizer N at planting and 3/4 1 mo after planting. Mean yields from the total N 1 mo postplant applications were, however, significantly higher than those from the total N preplant application; a difference of 293 kg/ha or about 5%. There were

no significant differences between the all N preplant and the split N application. The ineffectiveness of N applied before planting was perhaps due to leaching by the heavy rains immediately after application of fertilizer and planting. These results agree with results obtained in various Oxisols and Ultisols by Fox et al.<sup>4</sup> A fieldwise average total N removed by the stover was around 0.80%.

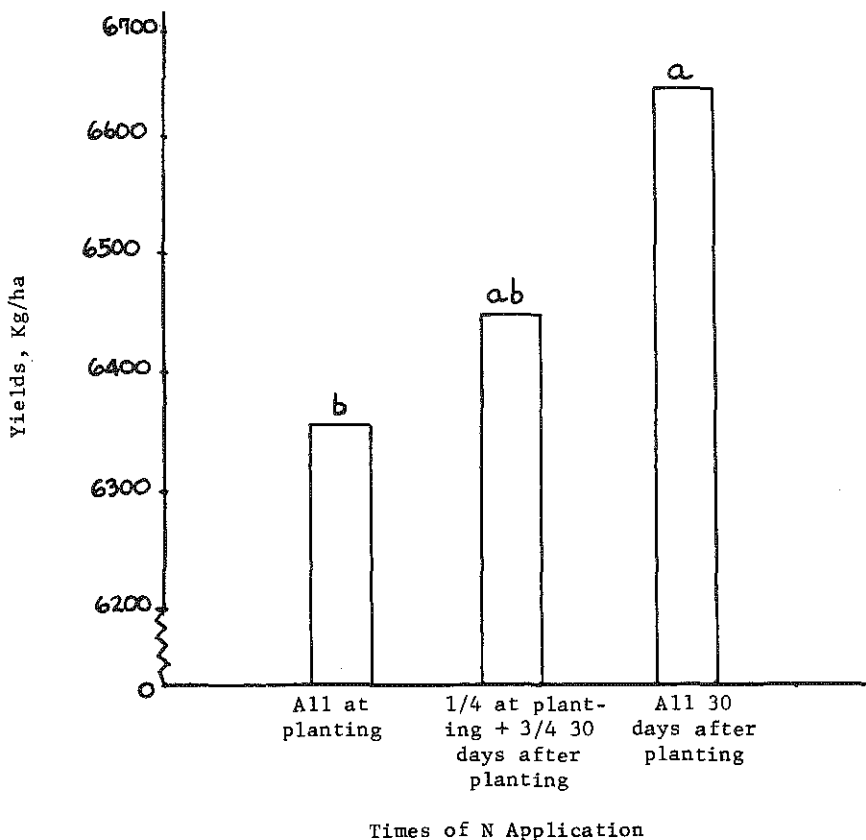


FIG. 1.—Effect of time of N application on corn yield on an oxisol.

N recovery could not be estimated because of the lack of a 0 N level. However, previous research has shown that average N recovery by corn, where there was a N response, was markedly superior for the postplant applications, especially at the near optimum N rate of 67 kg/ha, which had almost twice as much N recovery from the sidedress postplant applications as from the preplant application.<sup>4</sup>

#### RESPONSE TO N LEVELS

Grain response to N fertilizer levels ranged from 6,483 kg/ha in the low

N level to 6,522 kg/ha in the high N level, a nonsignificant difference. Also, mean differences in stover yields (314 kg/ha more in the high N plots) were nonsignificant. No differences in plant height, height to ear, and plant diameter could be attributed to N level differentials. It seems that in Coto soil the yield potential of the various cultivars can be attained by applying 67 kg/ha of fertilizer N. Total N removed by the stover ranged from 0.77 in the low N level to 0.83% in the high N level. Mean differences were not significant. Although the N supplying power of this soil cannot be assessed from these results, previous research indicates that it is probably low.<sup>4</sup> It is not possible to draw response curves because there are only two points of reference and a 0 N level was omitted because of previous evidence that in Oxisols, at least 67 kg/ha of N was required to approach near maximum yields.<sup>4</sup> It is expected that in Oxisols not cropped for several years, where little or no N fertilizer has been added, that corn will show a marked response to N fertilizer.

#### LEAF NUTRIENT STATUS

In general, leaf N content in all cultivars at silking time was higher at the 134 kg/ha N level than at the 67 kg/ha N level (table 2), except in Mayorbela, the local standard variety, which had the lowest leaf N values: 2.8% as compared to over 3% in all other cases, and even 3.5% in Sp 622, at the high N fertilizer level. The demand for N of this cultivar until silking seems to be low. The uptake of other nutrients, such as Ca, K, P and Mg, was not affected by the two N levels or by the time of N applications. The Mn percentage was higher in the high N levels for all cultivars except Funk's G-795W, where leaf Mn does not appear to relate to applied N levels. Coto clay is high in Mn, and perhaps the use of high levels of ammonium sulfate, which tends to acidify the surface soil, increases Mn availability.

No effect attributable to time of N application was measured.

#### RESUMEN

Un experimento de campo se realizó durante el verano (5 de junio a 24 de septiembre) de 1975 en un Oxisol arcilloso (Coto) en el noroeste de Puerto Rico para probar el comportamiento de siete cultivares de maíz a dos niveles de nitrógeno (67 y 134 kg./ha.), en tres aplicaciones (todo al sembrar; 1/4 al sembrar y 3/4 partes 1 mes después; y todo 1 mes después de sembrar).

No hubo diferencias significativas en rendimiento debidas a los niveles de nitrógeno, pero se obtuvo un incremento significativo de casi 5% en el rendimiento de grano cuando todo el nitrógeno se aplicó 1 mes después de la siembra en contraste con el obtenido cuando se aplicó todo al sembrar. Hubo, además, diferencias significativas entre los cultivares, independientemente del nivel de nitrógeno usado y de cuándo se

aplicó. El híbrido Pioneer X-306B produjo los mejores rendimientos: más de 8,000 kg./ha. Diente de Caballo, un cultivar nativo que apenas se siembra ya produjo rendimientos altos (7,387 kg./ha.), los que fueron significativamente mayores que los de las otras cinco variedades.

Los rendimientos más bajos fueron los de Funk's G-795W y el tipo Opaque-2 Sp 622 con 5,400 y 4,800 kg./ha., respectivamente. El cultivar nativo, Mayorbela, y los otros tipos Opaque-2 (Tuxpeño × La Posta y Composite K, hard endosperm) fueron intermedios, con rendimientos entre casi 6,000 y más de 7,000 kg./ha.

Pioneer X-306B, Diente de Caballo, Tuxpeño × La Posta y Composite K, hard endosperm, produjeron más de 6,000 kg./ha. de rastrojo. Sp 622 produjo como 3,900 kg./ha. Las plantas de Pioneer X-306B y de Diente de Caballo fueron las más altas mientras que las de Sp 622 fueron las más pequeñas. Las plantas de Funk's G-795W fueron las más delgadas. El contenido medio en nitrógeno de la hoja, cuando las plantas comenzaron a espigar, fue más elevado en las plantas de parcelas que recibieron la dosis más alta de nitrógeno (134 kg./ha.) que las que recibieron menos (67 kg./ha.), excepto los de Mayorbela. No hubo interacciones significativas entre cultivares, niveles de nitrógeno y épocas de aplicación de nitrógeno.