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Response of five corn genotypes to daylength in Puerto Rico

A. Sotomayor-Rios, S. Torres-Cardona, P. Hepperly

USDA, ARS, Tropical Agriculture Research Station
Mayaguez, Puerto Rico 00709

P. Maderal

Agronomy and Soils Department, University of Puerto Rico,
Mayaguez Campus, Mayaguez, Puerto Rico.

Response of corn (Zea mays L.) to daylength has not been investigated in Puerto Rico. Five genotypes, two temperate (Ohio S9 and Ohio S10), two local (Mayorbela and Diente de Caballo), and hybrid X304C (PBH304C) were evaluated every 90 days during a 2-year period at Mayaguez and Isabela, Puerto Rico. Planting dates were March 21, June 21, September 21 and December 21. Daylight hours (DL) for the first 60-day growth periods corresponding to the four planting dates were: 746, 771, 687 and 669 hours, respectively. Significant effects of location (L), planting date (PD) and genotype (G) and significant interactions (L x PD and PD x G) were observed for grain yield (GY) and most traits studied. The genotype overall response was higher at Mayaguez compared to the Isabela location. Genotypes showed a quadratic response to PD. Genotypes responded to increases in daylength up to the June planting (771 light hours). The highest GYs, 5971 and 5469 kg/ha, were obtained by PBH304C at Mayaguez and Isabela, respectively. Diente de Callo showed the strongest response to PD and the best yields were obtained by planting before the initiation of long days.

Keywords: Corn; *Zea mays*; Daylength

Introduction

Although corn is not grown commercially in Puerto Rico, it is an important component for animal feed with imports over $50 million yearly (Vicente-Chandler, 1984). Research on corn breeding and management at Mayaguez indicate that Puerto Rico could reduce imports of cereals if at least 50,000 hectares of mechanizable land were utilized to cultivate corn and/or sorghum intensively (Quiles-Belen, et al, 1985; Quiles, 1983 and Sotomayor-Rios, 1979). At present, corn and sorghum are grown in Puerto Rico as rotation crops with sweet potatoes and vegetables in the southern part of the island.

Limited research has been done in the tropics to study the response of corn to daylength (Domenech et al, 1977; Mangual-Crespo, 1977; Quiles, 1983; SotoMayor-Rios, 1979; Sotomayor Rios et al, 1980, Spain, 1982; Torres-Cardona et al, 1984; Vicente-chandler, 1984), although numerous studies have been conducted on management and cultivar response to soil and climatic conditions (Badillo-Feliciano et al. 1979; Brown et al. 1970; Fox et al. 1970; Quiles. 1983; Sotomayor-Rios, 1980 and 1983; Spain et al. 1982; Talleyrand et al. 1976; Torres-Cardona et al. 1984; Vazquez, 1961; Webster et al. 1977). However, reports indicate that agronomic performance of the crop may be affected by photoperiod (Allison et al. 1979; Keun et al. 1982; Kiniry et al. 1983a & b; Rood et al. 1980; Russel et al. 1983).

This study was carried out to evaluate the effects of daylength on the agronomic performance of four selections (from a reciprocal recurrent selection program) and a commercial hybrid, Pioneer X304C, at two locations in Puerto Rico.

Materials and methods

The experiment was conducted at the experimental farms of the USDA, ARS, Tropical Agriculture Research Station (TARS) in Isabela and Mayaguez, Puerto Rico. The soil at the Isabela location is an Oxisol (Tropeptic Haplorthox), whereas at Mayaguez it is an Ultisol (Dystropeptic Tropudult).

General characteristics of the experimental sites were as follows:

	Isabela	Mayaguez
Location	Northwestern PR	Western PR
Latitude	18°30'N	18°7'N
Longitude	67°W	67°W
Temperature range (°C)	18.8-29.4	22.2-26.1
Elevation (m)	128 m	10 m
Annual rainfall (mm)	1,675	2,158
Soil - name	Coto clay	Consumo clay
- type	(Oxisol)	(Ultisol)
Organic matter content	2.5%	3.2%
Exchange capacity (meq./100 g soil)	23	23
pH	5.0	4.8
P (ppm)	53	3
K (ppm)	140	194
NO_3 (ppm)	10	8

The planting dates at both locations were March 21, June 21, September 21 and December 21, 1985. Total light hours for the first 60-day growth period were: 746, 771, 687 and 669 for the four planting dates, respectively. The genotypes used were Mayorbela, Diente de Caballo, Ohio S9 and Ohio S10 from the third reciprocal recurrent selection cycle program at TARS, and the commercial hybrid Pioneer Brand Hybrid 304C (PBH304C). The experimental design was a complete randomized block replicated four times. Each plot consisted of 4 rows, 6 m long and 0.75 m apart; plants were collected from the two inner rows, 7.5 m^2 in area.

Two weeks after planting, 560 kg/ha of a complete 15-5-10 fertilizer was applied to all plots. An additional application of N was applied as $(NH_4)_2$ SO_4 at the rate of 60 kg/ha, four weeks after planting. Weeds were controlled with propazine pre-emergent herbicide, at a rate of 2.5 kg ai/ha, and by hand-weeding. For the control of soil-borne insects and nematodes, carbofuran was applied at planting at a rate of 30 kg ai/ha. Methomyl was applied at a rate of 0.5 kg ai/ha to control foliar insects.. Supplemental overhead irrigation was applied to all plots as needed.

Prior to harvest, plant height (soil surface to tip of the tassel), ear height (soil surface to topmost ear-bearing node), leaf area (by a portable area meter, model LI-3000, Lambda Instruments Corporation), root and stem lodging, days to midbloom, and severity of southern rust (*Puccinia polysora*) southern leaf blight (*Helminthosporium maydis*) and corn bushy stunt (Spiroplasma) were measured. Harvested ears were dried to a uniform moisture content; ear length and ear diameter were measured on 10 ears/plot at random. Test weight (TW) was measured and grain yield (GY) was adjusted to 15.5% moisture. All data were subjected to analysis of variance (ANOV) and regression, and significant differences identified with Duñcan's multiple range test.

Results and discussion

Table 1 shows the combined ANOV for 14 traits of corn during four planting dates at two locations in Puerto Rico. Significant effects of location, planting date, genotype, location-x-planting date and planting date-x-genotype interactions were observed for most traits. Grain yield responded significantly to increases in total accumulative light hours.

Table 1 Combined analysis of variance for 14 traits of corn during four plating dates at two locations in Puerto Rico

Traits	C.V. (%)	Source [1)]						
		L	PD	LxPD	G	LxG	PDxG	LxPDxG
Days to midbloom	1.3	**	**	**	**		* [3)]	
Ear height	9.2		**		**		*	
Plant height	9.0		**	*	**			
Ear length	6.0		**	**	*			
Ear diameter	4.9	**	**	**	**			
Leaf area	73.0		**	**				
Root lodging	41.0	**	**	**	**	**	**	**
Stem lodging	112.0	**	**	**	**			
Grain yield	21.0	**	**	**	**	*	**	
Test weight	3.2	**	**	**	**	*		
Northern leaf blight	49.6	**	**	**	**			*
Southern leaf blight	77.1	*	**	**	**		**	
Corn bushy stunt	73.6	**	**	**	**		**	
Southern rust	42.0	**	**	**	**		*	

L = location, PD = planting date, F = genotype,
CV = coefficient of variance
* = significant at the 0.05 probability level
** = significant at the 0.01 probability level

Table 2 compares means between locations for 14 traits of five genotypes across four planting dates. The overall agronomic performance of genotypes (grain yield, ear length, ear diameter and leaf area) were higher at Mayaguez than at Isabela. Genotypes took two additional days to reach midbloom at Mayaguez (61 days) as compared to Isabela (59 days). While the severity of northern leaf blight was significantly higher at Mayaguez than at Isabela, the southern leaf blight, southern rust and corn bushy stunt diseases were higher at Isabela than at Mayaguez.

Tables 3a & b compare means among planting dates and locations for 14 traits of five corn genotypes. Days to midbloom were significantly different for planting dates at both locations, except for the June and September plantings at the Isabela location. Days to midbloom ranged from 54 to 66 (Isabela) and 58 to 64 (Mayaguez). The effect of daylength on midbloom on corn has been studied in the tropics. In general, the reports indicate that plants take longer to reach midbloom when planted during short days (less than 12 hours) as compared to plantings made during long days (over 12 hours) (Allison and Daynard, 1979; Kiniry et al. 1983a & b; Rood et al. 1980; Russel et al. 1983).

Table 2 Comparison of means between locations for 14 traits of five corn genotypes across four planting dates

Traits	Locations	
	Isabela	Mayaguez
Days to midbloom (days)	59b	61a
Ear height (cm)	107a	112a
Plant height (cm)	237a	247a
Ear length (cm)	16.2a	16.5a
Ear diameter (cm)	4.1b	4.2a
Leaf area (cm^2)	6805a	6953a
Root lodging (%)	24a	17b
Stem lodging (%)	5a	2b
Grain yield (kg/ha)	3069b	3631a
Test weight (kg/ha)	77a	73b
Northern leaf blight	0.7b	1.4a
Southern leaf blight	0.9a	0.7b
Corn bushy stunt	18a	4b
Southern rust	1.4a	0.8b

Horizontal means followed by the same letter do not differ significantly at the 0.05 probability level.

Ear height of genotypes was similar at both locations, but differed significantly among planting dates. The best plant, ear height and ear length increases were observed in the March and June plantings at both locations. Ear length was significantly higher when genotypes were planted in March (Mayaguez) and June (Isabela). At both locations, ear diameter and leaf area were higher during the March planting.

The leaf area results are in agreement with those obtained by Allison and Daynard (1979). Root lodging of genotypes was significantly higher during the September planting at both locations. Stem lodging was significantly higher in the June (Mayaguez and Isabela) and September (Mayaguez) plantings, corresponding to the rainy season at both locations. Grain yield was significantly higher when genotypes were planted in March at both locations, in agreement with Keun Jong et al. (1982), who found that corn yields in the tropics increase as daylength increases.

The northern leaf blight incidence was significantly higher when genotypes were planted in December at Mayaguez, and for the March and June plantings at Isabela. A higher southern leaf blight incidence was observed when genotypes were planted during September (Mayaguez) and June and September (Isabela), corresponding to periods of higher rainfall and humidity. There was no incidence of corn bushy stunt when genotypes were planted prior to the initiation of the long day period (over 12 hours) at either location, while for southern rust severity, the opposite was observed.

Table 3a Effect of planting date at Isabela on 14 traits of corn (Means of five genotypes)

Traits	Date of planting			
	Mar.	Jun.	Sep.	Dec.
Days to midbloom (days)	54 c	59 b	58 b	66 a
Ear height (cm)	136 a	116 b	84 c	91 c
Plant height (cm)	277 a	240 b	203 c	228 b
Ear length (cm)	16.3 b	16.9 a	16.0 bc	15.8 c
Ear diameter (cm)	4.3 a	4.0 b	4.1 b	4.1 a
Leaf area (cm2)	7,693 a	----	6,797 b	5,925 c
Root lodging (%)	4.9 b	4.9 b	85.0 a	3.1 b
Stem lodging (%)	4.5 b	12.2 a	2.1 b	2.6 b
Grain yield (kg/ha)	3,766 a	2,440 c	2,971 b	3,101 b
Test weight (kg/ha)	79 a	75 c	79 a	77 b
Northern leaf blight	1.4 a	1.1 a	0.2 b	0.2 b
Southern leaf blight	0.3 b	1.4 a	1.6 b	0.1 b
Corn bushy stunt	0.0 d	41.2 a	21.6 b	8.5 c
Southern rust	1.9 a	1.8 a	1.3 b	0.5 c

Figures within rows, followed by the same letter, do not differ significantly at the 0.05 probability level.

Table 3b Effect of planting date at Mayaguez on 14 traits of corn (Means of five genotypes)

Traits	Date of planting			
	Mar.	Jun.	Sep.	Dec.
Days to midbloom (days)	64 a	58 c	61 b	62 a
Ear height (cm)	127 a	124 a	93 b	106 b
Plant height (cm)	260 ab	273 a	214 c	240 bc
Ear length (cm)	18.2 a	16.1 b	16.0 b	15.6 b
Ear diameter (cm)	4.7 b	4.1 b	4.1 b	4.0 b
Leaf area (cm^2)	9,136 a	6,704 b	6,366 bc	5,605 c
Root lodging (%)	5.8 b	13.6 b	44.8 a	4.4 b
Stem lodging (%)	0.3 b	3.7 a	3.9 a	1.3 b
Grain yield (kg/ha)	5,737 a	3,176 b	2,674 b	2,939 b
Test weight (kg/ha)	72 b	70 c	75 a	74 a
Northern leaf blight	0.2 c	1.0 b	1.0 b	3.3 a
Southern leaf blight	0.1 c	0.5 b	1.7 a	0.3 bc
Corn bushy stunt	0.0 c	0.0 c	10.9 a	6.4 b
Southern rust	1.0 b	1.4 a	0.5 c	0.4 c

Figures within rows, followed by the same letter, do not differ significantly at the 0.05 probability level.

Comparisons among genotypes and locations for 14 traits of five corn genotypes is shown in Tables 4a & b. Pioneer hybrid 304C required an average of one day more to reach midbloom, compared to the remaining genotypes at both locations. Ear height for Diente de Caballo was significantly higher than for other genotypes at both locations. Genotypes exhibited similar plant heights at both locations, except Ohio S9 which was shorter at Isabela. Genotypes produced similar ear lengths, except Ohio S9, which was significantly shorter at both locations. Pioneer hybrid 304C produced the highest grain yield and ear diameter and showed the lowest northern leaf blight and root lodging. Leaf area was similar for all genotypes at both locations. Stem lodging of genotypes was similar at both locations, except for Ohio S9, which lodged significantly more at Isabela. Mayorbela showed the highest test weight at both locations as compared to the remaining genotypes. The incidence of southern leaf blight in Ohio S9 and Ohio S10 at both locations was significantly higher than that of the other genotypes. The genotypes most susceptible to the southern rust were PBH304C, Ohio S9 and Ohio S10.

Table 4a Effect of genotype on 14 traits of corn at Isabela (Means of 4 planting dates)

	Corn genotype				
Traits	X304C	Caballo	Mayorbela	OH S9	OH S10
Days to midbloom (days)	60 a	59 b	59 b	59 b	59 b
Ear height (cm)	107 ab	113 a	108 ab	100 b	105 ab
Plant height (cm)	251 a	243 ab	234 b	216 c	238 ab
Ear length (cm)	16.6 a	16.4 a	16.6 a	15.4 b	16.0 a
Ear diameter (cm)	4.4 a	4.0 c	3.7 d	4.2 ab	4.2 ab
Leaf area (cm2)	7,123 a	7,174 a	6,452 b	6,903 ab	6,790 ab
Root Lodging (%)	19.7 b	27.3 a	25.5 a	23.6 ab	26.3 a
Stem lodging (%)	3.1 b	4.0 b	3.5 b	10.0 a	6.0 b
Grain Yield (kg/ha)	4,335 a	3,173 b	3,222 b	2,219 c	2,299 c
Test weight (kg/ha)	76 c	78 b	81 a	76 c	75 c
North leaf blight	0.4 b	0.7 ab	0.8 ab	0.8 ab	0.9 a
Southern leaf blight	0.5 b	0.4 b	0.5 b	1.3 a	1.6 a
Corn busy stunt	11.6 c	16.8 abc	15.0 bc	23.1 a	22.3 ab
Southern rust	1.6 a	1.0 b	0.8 b	1.7 a	1.7 a

Figures within rows, followed by the same letter do not differ significantly according to Duncan's multiple range test (p=0.05).

Table 4b Effect of genotype on 14 traits of corn at Mayaguez (Means of 4 planting dates)

	Corn genotype				
Traits	X304C	Caballo	Mayorbela	OHS9	OHS10
Days to midbloom	62 a	61 b	61 b	61 b	61 b
Ear height (cm)	110 c	126 a	117 b	103 d	107 cd
Plant height (cm)	253 a	258 a	245 ab	235 b	245 ab
Ear length (cm)	16.9 a	16.7 ab	17.0 a	15.7 c	16.0 bc
Ear diameter (cm)	4.6 a	4.1 c	3.8 d	4.3 b	4.3 b
Leaf area (cm2)	7,181 a	7,116 a	6,638 a	7,037 a	6,792 a
Root Lodging (%)	5.3	25.3 a	28.0 a	8.7 c	17.5 b
Stem lodging (%)	2.0 a	2.0 a	2.2 a	3.4 a	1.7 a
Grain Yield (kg/ha)	4,735 a	3,740 b	3,299 bc	3,117 c	3,266 bc
Test weight (kg/ha)	69 d	74 b	77 a	71 c	72 bc
North leaf blight	0.7 a	1.4 a	1.5 a	1.7 a	1.6 a
Southern leaf blight	0.3 b	0.7 a	0.3 b	0.9 a	1.0 a
Corn busy stunt	2.0 a	6.1 a	3.9 a	5.7 a	3.7 a
Southern rust	1.0 a	0.4 b	0.5 b	1.0 a	1.0 a

Figures within rows, followed by the same letter do not differ significantly according to Duncan's multiple range test (p=0.05).

Figure 1 shows the relationship between daylight hours during the first 60-days growth period for the four planting dates and grain yield of the five corn genotypes at the two locations. In most cases genotypes showed a quadratic response over planting dates at both locations. Significant increases in grain yields up to the March planting were obtained at both locations. The strongest effect of plating date was observed for Diente de Caballo at Mayaguez. The highest grain yields were obtained with PBH304C giving 5,971 (Mayaguez) and 5,469 kg/ha (Isabela) in the March planting. Even though the highest grain yields were obtained by planting in March, prior to the initiation of the long day period, a potential exists to develop genotypes insensitive to daylength which could be grown all year round.

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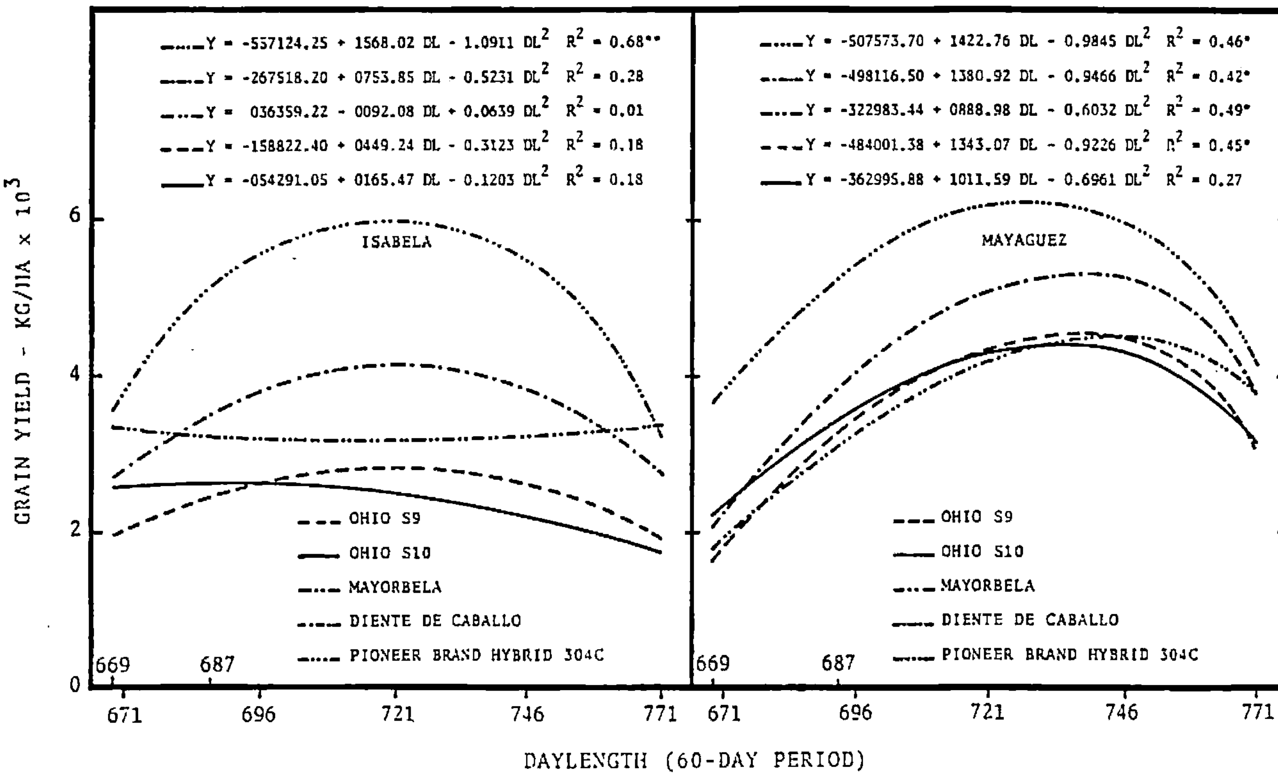

Fig. 1 Accumulative light hours for the first 60-day growth of five corn genotypes during four planting dates.

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