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EFFECT OF DAYLENGTH ON THE DEVELOPMENT OF INTERSPECIFIC *PENNISETUM* HYBRIDS

A. Sotomayor-Ríos[1], A. Quiles-Belén, S. Torres-Cardona and W. Hanna[2]

[1]USDA-ARS, Tropical Agriculture Research Station
Mayaguez, Puerto Rico and [2]USDA-ARS, Coastal Plain
Experiment Station, Tifton, Georgia

ABSTRACT

Pearl millet (*Pennisetum glaucum* L. Leeke) x napiergrass (*P. purpureum* Schum.) interspecific hybrids (PMN) have great potential as a forage crop in the tropics. The effect of daylength on the flowering of cytoplasmic-nuclear male sterile (cms) pearl millet Tifton 23A$_4$, and three napiergrasses (N14, N20, and N74) was determined in monthly plantings for a period of one year. Fifty days after planting, the male parents (napiergrass) were cut to the ground level (T1), to one meter above-ground (T2), or not cut (T3). Days from planting to flowering (PF) for pearl millet ranged from 44 to 47 across plantings and 50 or less for N14 and N74 (from August to December). Although flowering of the male parents was not influenced by the T2 and T3 treatments, the T1 treatment caused plants to flower later. With the exception of the T1 treatment, flower response to daylength was as expected. Seed of the PMN can be obtained from August through December in Puerto Rico but not during long days of (12 hours of daylight or more) unless day-neutral male parents are used.

INTRODUCTION

Hybrids between pearl millet (*Pennisetum glaucum*) and napiergrass (*Pennisetum purpureum*) have great potential for livestock production and as a biomass energy crop (2,6,7,8). Some reports (3,4) have suggested a method of producing triploid seed of the hybrid, but the proposed scheme has never been adopted by the seed industry. In Hawaii, Osgood et al. (3) demonstrated a potential method of commercial production of the PMN based on the use of cytoplasmic-nuclear male-sterile (cms) pearl millet as the female parent and napiergrass as the pollen parent. These authors tested several treatments to determine the best regime to maximize pollen production at the time of pearl millet anthesis. The most successful nick occurred when the napiergrass was cut four feet above ground on September 25th. At that time, acceptable PMN seed production was obtained. The objective of this study was to evaluate the effect of daylength on the flowering response of cms pearl millet and three napiergrass selections when planted monthly during one year in Puerto Rico.

MATERIALS AND METHODS

The experiment was conducted at the Isabela ARS experiment farm, 128 m elevation with ambient temperatures ranging from 18.5 to 29.4° C. The soil was an Oxisol (Typic Hapludox) with an organic matter content of 2.5% and pH of 5.0. The experimental design was a randomized complete block arranged in a split-split plot with two replications.

Planting dates (PD) were the main plots (made the 4th day of each month from December, 1992, (planting date 1), to November, 1993), (planting date 12); the grasses, the subplots (N14, N20, N74 and Tifton 23A$_4$); and cutting treatments the sub-subplots (T1 (ground level), T2 (one m above ground), and T3 (not cut)). The three napiergrasses and cms pearl millet Tifton 23A$_4$ were supplied by Wayne W. Hanna, USDA-ARS, Tifton, Georgia.

Twenty four basal clones from each male parent, 25 cm long with at least three nodes were placed in 20 cm pots and covered with a plastic bag during a two-week period prior to planting, which permitted the induction of adventitious roots. Seeds of the cms pearl millet (23A$_4$) were hand

drilled 0.5 m apart west of the male parents on the 23rd day of each month from January to December, 1993. The three cutting treatments were initiated 50 days after the male parents were planted (simultaneously with female planting). Weeds were controlled by hand-weeding. Overhead irrigation was applied to all plots as needed.

Days from planting to flowering (PF) were recorded when 50% of plants in the plot had reached anthesis. Percentage of seed set and quality of seed produced were determined for the PMN, and plant height (taken at 120 days for PMN and at 150 for check male parents) for all parents.

RESULTS AND DISCUSSION

In Puerto Rico's latitude (18°N), daylength ranges from 11.02 (December 20-22) to 13.13 hours (June 20-21), a factor which is determinant in the flowering response of photoperiod sensitive plants (Table 1). Reports indicate (1,8) that napiergrasses are photoperiod sensitive, flowering only under short-day periods. On the other hand, cms pearl millet is a day-neutral plant, flowering profusely throughout the year in the tropics. According to Hanna (personal communication), under the Tifton, Georgia, growing conditions of 11 hours or less, $23A_4$ PF ranges from 55-60. At daylength of over 11 hours, PF ranges from 75-80.

In this experiment, PF of $23A_4$ was very similar throughout the year. Under the Isabela, Puerto Rico, conditions it ranged from 44 (March planting) to 47 days (July planting). Apparently, the critical photoperiod of $23A_4$ is above 13.13 hours. Mean plant height of $23A_4$ ranged from 1.0 (December planting) to 1.4 m (April to July plantings). In general, $23A_4$ plant height averaged 1.0 m when it was planted during short days and 1.4 m when planted under long days of 12 hours or more (Table 2). Seed set on $23A_4$ ranged from 10% (August planting) to 60% (September to November plantings). Although seed set in the December, January, and February plantings was less than 60%, seed quality was superior (Table 2).

For any of the treatments to be effective, the napiergrass male parents must flower about the same time as the female plants or in about 46 days. The PF of N14 was delayed for more than five months when it was planted from December to June (T1 cutting treatment), from January to June (T2), and from January to May (T3). Our results indicate that PF of N14 decreased from 160 to 120, 105 to 90, and 120 to 35 days when it was planted from July to October, July to November, and June to December under T1, T2, and T3 cutting treatments, respectively (Table 3). When N20 was cut under T1 treatment, it took over 160 days to flower throughout the year. This was also true when it was planted from December to June under T2 and T3 treatments. The PF of N20 decreased from 110 to 100 (July to October plantings) and from 100 to 45 days (July to November plantings) when it was cut under T2 and T3 treatments, respectively. For N74, PF increased to over five months when it was planted from December to June, January to June, and February to May under T1, T2, and T3 cutting treatments, respectively. On the other hand, the PF of N74 decreased from 150 to 110 and 95 to 80 days when it was planted from July to October under T1 and T2 treatments, respectively. The greatest decrease in PF of N74 occurred between June and the December plantings (115 to 35 days), but there was a sharp increase in PF to 100 days for the January planting.

Floral initiation of N14 and N74 under T3 ranged from 50 to 35 days (September to December plantings) during short days, and these grasses can be regarded as potential pollen parents for the development of PMN. Daylength of over 12 hours had the greatest effect on N20, while a smaller effect was observed on N14 and N74.

This study demonstrated that a cutting treatment on male parents is not required to synchronize flowering for the female and male parents. From the data obtained, it can be concluded that a proper flowering synchronization is possible if pearl millet is planted simultaneously with N14 and N74 from August to December and with N20 from October to November.

Plant height (taken at 150 days period) of N14, N20 and N74 (Table 4) increased, respectively; from 2.3, 1.9 and 2.3 meters (December planting) to 3.1, 2.6 and 3.0 meters (July planting);

then decreased to 2.3, 1.9 and 2.3 meters (November planting). Plant height of the three napiergrasses was higher when they were planted during longer days (more than 12 hours of daylight).

This study demonstrates the need of utilizing day-neutral male parents if seed of the PMN is to be produced throughout the year in Puerto Rico. High quantity of high quality seed can be produced when genotypes similar to those used in this study are planted from November to January.

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Table 1. Mean daylength for the 1st, 15th, and last day of each month and monthly average daylength in Puerto Rico.

Month	Day 1st	15	20	21*	Last	Mean daylength
			hours			
January	11.04	11.10			11.21	11.11
February	11.22	11.34			11.47	11.30
March	11.47	12.02			12.18	11.86
April	12.20	12.34			12.47	12.32
May	12.48	12.59			13.09	12.59
June	13.09	13.12	13.13 (longest)		13.12	13.12
July	13.12	13.07			12.57	13.07
August	12.56	12.45			12.30	12.43
September	12.29	12.14			12.00	12.14
October	11.59	11.44			11.30	11.44
November	11.29	11.17			11.08	11.17
December	11.08	11.03	11.02 (shortest)		11.04	11.04

* Longest days (June 20-21) 13.13 hours; shortest days (December 20-22) 11.02 hours; 12-hour days occur March 13 and September 29.

Table 2. Days to midflower, plant height, grain quality and % seed set of Tift $23A_4$ when planted monthly during a period of one year at Isabela, P. R.

Planting Date[1/]	Days to Midflower	Plant height (m)	Grain quality[2/]1	% Seed set
January	46	1.1	1	40
February	47	1.3	2	15
March	44	1.3	-	0
April	46	1.4	-	0
May	45	1.4	-	0
June	45	1.4	-	0
July	47	1.4	-	0
August	45	1.3	3	10
September	46	1.3	3	60
October	47	1.3	3	60
November	45	1.1	3	60
December	46	1.0	2	50

[1/] Planted the 23rd day of each month.
[2/] 1 = good; 2 = intermediate; 3 = poor.

Table 3. Response of three napiergrass selections[1/] to three defoliation treatments[2/] when planted monthly during the period of one year at Isabela, P. R.

Napiers	N14			N20			N74		
Planting dates	Treatments T1	T2	T3	T1	T2	T3	T1	T2	T3
	-- DAYS TO ANTHESIS --								
December	---	120	35	---	---	---	---	110	35
January	---	---	---	---	---	---	---	---	100
February	---	---	---	---	---	---	---	---	---
March	---	---	---	---	---	---	---	---	---
April	---	---	---	---	---	---	---	---	---
May	---	---	---	---	---	---	---	---	---
June	---	---	120	---	---	---	---	---	115
July	160	105	100	---	110	100	150	95	95
August	150	100	66	---	100	70	140	90	45
September	125	100	50	---	100	70	120	80	45
October	120	90	45	---	100	45	110	80	40
November	130	90	40	---	110	45	130	90	40

[1/] N14, N20, N40

[2/] T1 = cut close to ground 50 days after planting.
T2 = cut at one meter above ground 50 days after planting.
T3 = no cut.

Table 4. Effect of daylength on plant height (m) of three napiers selection when planted monthly at Isabela, P.R.

Planting date	Napiers N14	N20	N74
December	2.3	1.9	2.4
January	2.5	2.0	2.5
February	2.7	2.2	2.7
March	2.8	2.4	2.8
April	3.0	2.5	3.0
May	3.1	2.5	3.0
June	3.1	2.5	3.0
July	3.1	2.6	3.0
August	3.1	2.4	2.8
September	2.8	2.3	2.8
October	2.6	2.0	2.4
November	2.3	1.9	2.3