SARE Project LS93-53

PLANTING DATE EFFECTS ON HGM™100 PEARL MILLET PHYSIOLOGICAL DEVELOPMENT AND AGRONOMIC CHARACTERISTICS

I.D. Teare*, D.L. Wright, and N.R. Usherwood

ABSTRACT

Physiological status in plants is dynamic with respect to soil water, atmospheric conditions, and ontogeny of the plant (indicated by stage of growth). Pearl Millet [Pennisetum glaucum (L.) R. Br., hybrid HGM™100] is a new crop in the Southeast suitable for grain or silage.. The objective of this study was to determine the effects of four planting dates on HGM™100 pearl millet ontogeny (expressed as physiological stages of growth (GS) and agronomic characteristics). This research was conducted on a Dothan sandy loam located on the North Florida Res. and Educ. Ctr., Quincy FL. The 17 May planting date produced the highest grain yield (65 bu/A) with 19.1 inches of water and the 15 July planting date produced the lowest grain yield (36 bu/A) with 18.2 inches of water. The 5 May and 15 June planting dates yielded about the same (57 and 53 bu/A, respectively) but received differing amounts of water (16.4 and 18.7 inches, respectively). Leaf area index (whole plant, main stem and tillers) and LAD (leaf area duration) are described.

INTRODUCTION

Knowledge of plant, insect and disease ontogeny in relation to date of planting as a function of plant growth stage makes it possible to compare or to combine limited bits of knowledge from all over the world to explain yield phenomena (Teare and Hodges, 1994).

Environmental changes associated with planting date of HGM™100 pearl millet (available water, day length and temperature) and the interactions with insect and disease cycles must be better understood to optimize crop yields. These interactions have been defined as Systems Agriculture in recent years.

Francis et al. (1984) conducted research that suggested "planting time may affect genotype yield stability" in sorghum [Sorghum bicolor (L.) Moench]. They observed less interaction for yield between genotypes and environment when hybrids were planted late than when planted early. This observation was attributed to more rapid development and less exposure to stress conditions in later plantings.

Herzog et al. (1988) reported an increase in soybean grain yield at Quincy, FL as planting dates were [Glycine max (L.) Merr.] delayed from April to 10 June. Soybean planting date after 10 June decreased grain yields.

Pearl millet has been reported as a low input management crop that requires limited fertilizer and water (Payne et al., 1990). Hattendorf et al. (1988) report that pearl millet had a greater daily water use when compared to sunflower (Helianthus annuus L.), sorghum, corn (Zea mays L.), and soybean. A high water use efficiency and the knowledge that pearl millet also had the greatest leaf area index of these crops suggest that pearl millet has the capacity for deep rooting as indicated by soil water extraction beyond 9.8 ft depth (Chaudri and Kanemasu, 1985) and a greater number of roots and/or increased rooting density compared to many crops (Davis-Carter, 1989).

The ontogeny of plants is a continuous process from seed germination to maturity. Understanding the physiology of the plant being studied is necessary for understanding how the timing of stress (drought, lack of a critical nutrient, pest attack, weed competition, etc.) affects the economic product. For example, soybean have a better chance of recovery from leaf injury if injury occurs before rather than after flowering (Teare and Hodges,1994).

Timing, intensity and duration of water stress accounted for 70 to 85 % of the variation in pearl millet grain yields within and across years in other studies (Mahalakshmi et al., 1988). Critical growth stages identified as being sensitive to water stress were flowering (growth stage [GS] 5.5 to 6.5) and grain filling (GS 7 to 8).

Timing of fertilizer application has been shown to be critical at certain growth stages in corn (Hanway, 1971).

North Florida Res. and Educ. Ctr. Quincy, FL 32351, Dept of Agronomy, Inst Food and Agric. Sci., Univ. of Florida, FL 32611); Potash and Phosphate Inst., 655 Engineering Dr., Suite 10, Atlanta, GA 30092. Fla. Agric. Expt. Stn. Journal Series No. R-04236.

Temperate corn should be sidedressed with nitrogen at GS 2 (two ft height), but tropical corn needs to be sidedressed earlier GS 1 (at one ft height) (Wright et al., 1988 and 1989). Gascho (personal communication, 1994) may have observed the need for additional P on pearl millet (HGM™100) at GS 4.

MATERIALS AND METHODS

These studies were conducted in 1993 on a Dothan sandy loam (fine, loamy siliceous, thermic Plinthic Kandiudult) located on the North Florida Research and Education Center, Quincy, Florida. The soil has a compacted layer located 8 to 14 inches below the surface.

The pearl millet hybrid used in this series of experiments was HGM™100. Tifton, Georgia. Pearl millet seed was no-till planted (in-row subsoiled strip tillage) with a Brown Ro-Til implement with KMC unit planters.

The pearl millet date of planting study was a split plot design with planting dates as whole plots and stages of development determined for six replications in relation to calendar date, development period, and total water as subplots. Planting dates, stages of development, and dates of irrigation are shown in Table 1. Plots were eight rows wide (rows were 36 inches apart) and 30 feet long. Pearl millet seed were planted 3/4" deep at 4 lbs/A (302,667 seeds/A). This resulted in approximately 166,467 plants/A, or approximately 55 % emergence.

Fertilizer (5-10-15 at 500 lbs/A) was applied three days prior to planting. Nitrogen was sidedressed at a rate of 120 lbs/A at boot stage (GS 5). Prowl @ 1 qt/A + Atrazine @ 2 qt/A were applied between third visible leaf (GS 1) and 5th visible leaf (GS 2) (Table 1), 10 to 15 days after planting when pearl millet was 3 to 5 inches tall).

Little rainfall occurred throughout the early growing season for this experiment. One half inch applications of irrigation were scheduled in response to paucity of rainfall (Table 1). Rainfall events and amounts are shown in Fig. 1.

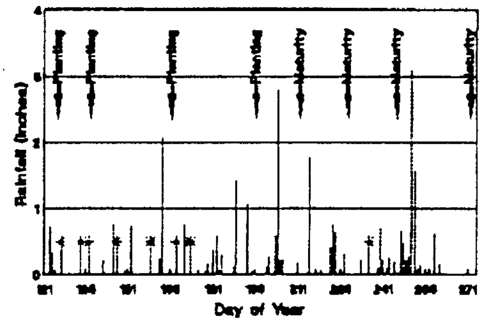

Fig 1. Rainfall during the 1993 pearl millet growing season for four planting dates in relation to rainfall amounts and dates of events.

RESULTS AND DISCUSSION

Physiological Stage of Development:

Water (rainfall/irrigation) events and four pearl millet planting dates, and maturity dates are shown in Fig. 1 in relation to time (days). Note the lack of rainfall throughout the season. Total water available (rainfall and irrigation) from planting to maturity for each planting date (PD) was: PD_1 = 16.4 inches, PD_2 = 19.1 inches, PD_3 = 18.7 inches, and PD_4 = 18.2 inches (Table 1). Physiological stage of development (GS) for each planting date is shown in relation to calendar date and day of year (Table 1). Days between 50 % emergence and panicle emergence (GS 0 and 3) were 20, 23, 14, and 15; panicle initiation and 50 % stigma emerged (GS 3 to 6) were 26, 30, 32, and 22; and 50 % stigma emerged and black layer (GS 6 to 9) were 35, 31, 28, 32 for PD^1, PD^2, PD^3, and PD4, respectively (Table 1).

Agronomic Characteristics:

Pearl millet head lengths are shown for each planting date (Table 2). The 15 July planting date (PD_4) produced less seed and sustained greater bird predation than the other planting dates. Lower yield at the later planting date probably wasn't a lack of available water (18.2 inches PD_4 compared to 16.4 inches for PD_1) that caused reduced yield.

Table 1. Planting date, stage of development, and 1/2" irrigation for calendar date and day of year at Quincy, FL, 1993.

Growth Stage	Description	Calendar date	Day of year	Amount Irrigation (inches)
PI	Preirrigation	30 April	120	1/2
PD_1	Planting date	5 May	125	
I	Irrigation	7 May	127	1/2
O	50% Emergence	10 May	130	
I	Irrigation	14 May	134	1/2
1	Third leaf visible	15 May	135	
I	Irrigation	17 May	137	1/2
2	Fifth leaf visible	21 May	141	
I	Irrigation	27 May	147	1/2
3	Panicle initiation[1]	30 May	150	
4	Flag leaf visible	5 June	156	
		8 June	159	1/2
5	Boot stage	12 June	163	
I	Irrigation	17 June	168	1/2
I	Irrigation	22 June	173	1/2
6	50% stigma emerged	25 June	176	
7	Milk stage, 1/2 length	10 July	191	
8	Dough stage, 1/2 length	19 July	200	
9	Black layer, 1/2 length	30 July	211	
			86[2]	4.0[3]
TR	Total rainfall			12.4[4]
				16.4[5]

Table 1. Continued

Growth Stage	Calendar date	Day of year	Amount Irrigation (Inches)
PI	14 May	134	1/2
PD_2+I	17 May	137	1/2
O	22 May	142	
I	27 May	147	1/2
1	30 May	150	
I	8 June	159	1/2
2	9 June	160	
3	14 June	165	
I	17 June	168	1/2
4	21 June	172	
I	22 June	173	1/2
5	25 June	175	
6	14 July	195	
7	3 Aug	215	
8	12 Aug	224	
9	16 Aug	226	
		89[2]	3.0[3]
TR			16.1[4]
			19.1[5]

[1] Panicle initiation occurs when fifth leaf fully extended.
[2] Days from planting to black layer formation at 1/2 length.
[3] Total irrigation.
[4] Total rainfall during growing period: PD_1 (1 May to 30 July), PD_2 (14 May to 16 Aug), PD_3 (11 June to 5 Sept), PD_4 (12 July to 30 Sept)
[5] Total water during growing period.

Table 2. Pearl millet means for agronomic characteristics at maturity unless otherwise specified in relation to date of planting, Quincy, FL 1993.

Planting Date	Plant[1J] Ht. (inches)	Head length[2J] (inches)	Stem DW (Ton/A)	Leaf DW (Ton/A)	Leaf + stem DW (Ton/A)	Seed size (lb/1000 seeds)
5 May	82	13.5	7.1	3.3	10.4	0.015
17 May	76	15.0	8.8	4.5	13.3	0.022
15 June	78	12.5	7.1	4.9	12.1	0.014
15 July	65	11.8	5.1	3.3	8.4	0.008

[1J] Approximately 166,467 pl/A.

[2J] Approximately 144,600 hd/A.

Table 1. Continued.

Growth Stage	Calendar date	Day of year	Amount Irrigation (inches)
PI	8 June	159	1/2
PD_3	15 June	166	
O	20 June	171	
I	22 June	173	1/2
1	26 June	177	
2	30 June	181	
3	4 July	185	
4	14 July	195	
5	20 July	201	
6	5 Aug	217	
7	17 Aug	229	
8 & I	24 Aug	236	1/2
9	2 Sept	245	—
		79[2]	1.5[3]
TR			17.2[4]
			18.7[5]

Table 1. Continued.

Growth Stage	Calendar date	Day of year	Amount Irrigation (inches)
PD_4	15 July	196	
O	21 July	202	
1	26 July	207	
2	30 July	211	
3	5 Aug	217	
4	12 Aug	224	
5	19 Aug	231	
I	24 Aug	236	1/2
6	27 Aug	239	
7	15 Sept	258	
8	21 Sept	264	
9	28 Sept	271	—
		75	
[2] 0.5[3]			
TR			17.7[4]
			18.2[5]

Table 2. (Continued).

Grain Yield Cage Harvested (lb/A)	(T/A)	(Bu/A)	Grain÷Stalk (% grain)	Max LAI Main Stem	Tillers	Plant	LAD[4] days
3266	1.63	57	15.6	1.4	3.0	4.4	50
3705	1.85	65	13.9	5.6	2.9	8.5	53
2998	1.50	53	12.4	2.6	2.4	5.0	50
2029	1.01	36	12.0	2.1	3.4	5.6	40

[3] Grain (T/A) / Stalk (T/A) = % grain; stalk = leaf DW + stem DW

[4] LAD = leaf area duration, the days from LAI of 3.5 to black layer formation (LAI = 3.5).

Contrary to Mahalakshmi et al. (1988), we found differences in seed size (lb/1000 seed) due to planting date (Table 2). Seed size in relation to planting date indicates that environment affected grain yield. One would expect that the 15 July planting date (PD_4), with fewer seeds per head, should have large seeds like PD_2 or at least seeds the same size as PD_1 and PD_3, but the seed size and number of seeds was less than the earlier plantings. Seed size (lb/1000 seed, Table 2) and grain yield were increased by increased available water (19.1 inches for PD_2, Table 1) and extended the no. days from planting date to maturity to 89 (Table 1). Thus, PD_2 (17 May) may be the optimum planting time for pearl millet in North Florida.

Maximum leaf area per plant, main stem, and tillers are shown in Table 2, in relation to planting date. Two peaks in LA occurred in PD_1, PD_2, and PD_3 (data not shown). The first peaks were at GS 6, 5.5, and 5.7, respectively. The second peaks were at GS 8,8, and 7; respectively. The leaf area for PD_4 only peaked at GS 6.5. Leaf area duration (LAD) is the days that LAI was greater than 3.5. Leaf area duration occurred from the boot stage (GS 5) to black layer formation (GS 9) for all PD's but PD_3 which attained a LAI of 3.5 when the flag was visible (GS 4) and remained at 3.5 until black layer formation (GS 9).

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