PEARL MILLET PRODUCTION IN A NO-TILLAGE SYSTEM

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ABSTRACT

Pearl millet [Pennisetum americanum (L.) Leeke] is a potentially productive, high-quality grain or silage crop that will produce grain and silage with limited soil moisture. Our objectives were to compare no-till and conventional tillage methods for pearl millet and tropical corn (Zea mays L.) planted after wheat (Triticum aestivum L.), determine pearl millet response to N fertilization rates on grain and silage yields, determine tolerance to herbicide, compare In vitro organic mater digestibility (IVOMD) of pearl millet silage with tropical corn, and evaluate pearl millet response to growth regulators. This research was conducted on a Norfolk sandy loam located on the North Florida Research and Education Center, Quincy, FL with HGM-100 (W.W. Hanna, Tifton, GA) pearl millet hybrid. Pearl millet (HGM-100) grain and total silage yields were higher in the no-till, in-row subsoil method of planting than in the conventional method in 1992, but no differences were found between methods of planting for tropical corn (Pioneer 3098) in relation to grain or silage yields. Pear1 millet grain yields increased with increasing N fertilization. Atrazine 1 1/2 qt + Prowl 1 pt + oil 1 qt is the most satisfactory chemical herbicide (not significantly different). Pearl millet silage with grain is more digestible (64.7% IVOMD) compared with silage without grain (49.4% IVOMD). In vitro organic mater digestibility of HGM-100 > Pioneer 3098 > Pioneer X304C. Although yields from growth regulator were not significantly different, Pix resulted in higher yields.

INTRODUCTION

Pearl millet is a potentially productive, high-quality (Burton et al., 1986 and Kumar et al., 1983) grain or silage crop that appears superior to sorghum (Sorghum bicolor L. Moench) in establishment (Smith et al., 1989b) and production under limited soil moisture (Smith et al., 1989a). It is the principle grain crop in the Sahel (Niger and Senegal, West Africa) and is grown under low-input management conditions (noncrusting, sandy soils with little fertilizer and limited water; Payne et al., 1990). Timing and intensity of water stress account for 70 to 85% of the variation in grain yields within and across years (India; Mahalakshmi et al., 1987 & 1988). Critical growth stages receiving stress were flowering and grain filling. Grain yield and grain number, but not grain size, were affected by time of stress onset in relation to flowering. Effects of timing are also dependent on the intensity and duration of the stress period (Mahalakshmi and Bidinger, 1985).

Hattendorf et al, (1988) has published measured ET/reference ET for pearl millet, which shows the greatest water use at 0.52 of the growing season, about when 50% bloom occurs. Boot stage occurred at 0.42 and soft dough stage at 0.69 of the growing season. Water use values during the season were similar for sorghum and pearl millet and less than corn, soybean, or sunflower. However, pearl millet had a higher daily water use rate than corn or sorghum. This indicates that pearl millet has a greater rooting depth and density (Davis-Carter, 1989) than corn or grain sorghum. Since greater available water usually results in greater evaporation and aboveground biomass of crops (Teare, 1977), it follows that pearl millet should produce a large aboveground biomass. Hattendorf et al. (1988) report that pearl millet had the greatest leaf area index of all the crops studied, and only corn produced a significantly greater aboveground biomass. The corn seed yield was three times greater than the pearl millet yield. Aboveground dry matter was 20.1, 15.7, and 15.6 Mg ha^{-1} and seed yield was 7.6, 63, and 2.5 Mg ha^{-1}, respectively for corn, sorghum [Sorghum bicolor (L.) Moench] and pearl millet. Average emergence dates were 26 May, 10 June, and 10 June, respectively.

Bationo et al. (1990) have shown that increases in fertilization and plant density increase grain yield of pearl millet in average or wet years and only reduce yield slightly in a drought year. Alagarswamy and Bidinger (1987) assessed the differences for nitrogen use efficiency among 20 diverse pearl millet genotypes from a field study. These genotypes differed little in total N uptake, but considerable differences existed in the amount of biomass produced, hence, nitrogen use efficiency.

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In vitro organic matter digestibility is a reliable estimate of in vivo digestibility of forage harvested from sandy soils (Moore and Mott, 1974). Pearl millet has been shown to be highly digestible by swine (Haydon and Hobbs, 1991), beef cattle (Hill and Hanna, 1990), poultry (Smith et al., 1989b), and catfish (Burtle et al., 1992). Hanna et al. (1974) have shown that hairy pearl millet leaves were more digestible than trichomeless pearl millet (33.5 and 25.5% IVOMD, respectively). Monson et al. (1986) found that lines of pearl millet resistant to rust (Puccinia substriata var. indica) were more digestible than rust-infected, rust-susceptible lines (rust-resistant IVOMD means were 64.6 and 57.6%, respectively, for 1981 and 1982). They also compared leaves for rust-resistant and rust-infected, rust-susceptible lines of pearl millet and found IVOMD 58.8 and 54.5%, respectively.

Pearl millet (Pennisetum glaucum L) has been shown to reduce root-lesion nematode [Pratylenchus penetrans (Cobb) Filipjev & Schur-Stekhoven] populations in soils for following crops of alfalfa (Petersen et al., 1991). This aspect should be investigated with Pennisetum americanum Leeke in relation to reducing other nematode populations in southern soils for the following soybean or peanut crops.

The objectives of this study were to 1) compare no-till and conventional methods of planting pearl millet with tropical corn in a double-crop system after wheat, 2) determine N influence on pearl millet grain and silage yields, 3) determine pearl millet tolerance to herbicide, 4) to evaluate the IVOMD of pearl millet silage with and without grain and heads for comparison with tropical corn, and 5) determine irrigation and growth regulator effects on pearl millet.

MATERIALS AND METHODS

These studies were conducted in 1992 on a Norfolk sandy loam (fine, loamy siliceous, thermic Typic 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 was HGM-100, developed as a grain pearl millet by W.W. Hanna (1991), Tifton, Georgia.

The planting method comparison for tropical corn (Wright et al., 1990) and pearl millet was planted in a split plot arrangement on 25 June. Seed of pearl millet were planted % inch deep at 3 Lb/A and tropical corn seed were planted 3/4 inch deep and 20,000 plants/a. The split was tropical corn vs. pearl millet within each replication, but the no-till vs. conventional tillage methods were allocated at random. Each plot had eight rows 36 inches apart and 25 feet long. The conventional method of tillage consisted of four separate operations; harrow, chisel, harrow, and plant with a Brown Ro-Ti1 implement with KMC planters. The no-till consisted of planting in wheat stubble with a Brown Ro-Ti1 implement with KMC planters. Starter fertilizer (19-9-3 LB/a) was applied to the side of the row. Nitrogen was sidedressed at 120 lb/A on 16 July. Atrazine at 2 qt/A + Gramoxone at 1 pt/A + X-77 surfactant was used for burndown of weeds. Harvest date for pearl millet was 4 Sept and 21 Oct for tropical corn. Much rain occurred throughout the growing season (Fig. 1) and only six irrigations were necessary (described in irrigation-growth regulator methods).

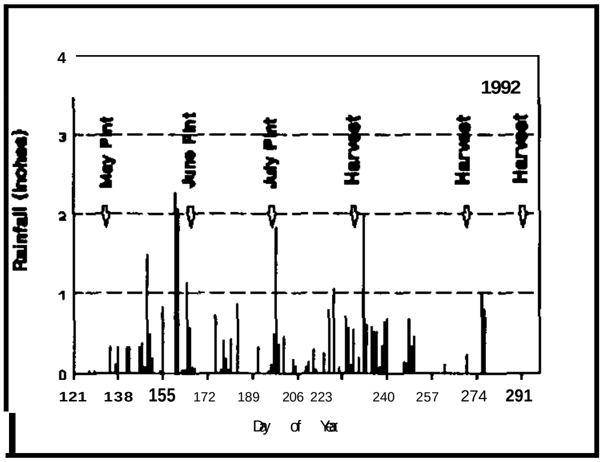

Figure 1. Rainfall during the 1992 pearl millet growing season in relation to rainfall amounts and dates of events.

The nitrogen study was planted conventionally after chisel plowing and harrowing on 20 May. Fertilizer was broadcast after chiseling at the rate of 0-40-60 lb/A for P_2O_5 and K_2O, respectively. Atrazine at 1% qt + crop oil was applied when millet was 3 to 5 inches tall. The N treatments were applied a few days after emergence. Nitrogen treatment rates were 0, 50, 100, and 150 lb/A Three planting dates were planted for grain and silage yields, hut only the 20 May planting had harvestable grain (harvested on 19 Aug) because of bird damage on later plantings.

The herbicide study was conventionally prepared by chisel plowing on 19 May with fertilizer applied after chiseling at the rate of 20-40-60 lb/A broadcast and harrowed. Pearl millet seed was planted at a 1/2-inch depth at 3 lb seed/A on 20 May. Millet emerged on 25 May, and herbicides were applied (Table 1) on 6 June when millet was 3 to 5 inches tall. Pearl millet grain and silage (with and without grain) were harvested on 19 Aug to determine the grain yield and silage yield components. Grain harvesting was accomplished by raising the combine header to maximum height and threshing the heads and grain. Then silage yields were taken by chopping the remainder of the plant with a small plot silage harvester. The reason for this method of harvest was to study the management option of harvesting the heads for seed and the remainder of the plant for silage or all for silage. By correcting for chaff and upper stalk loss, total silage was computed for other comparisons in Table 1. Silage was corrected to 35% DM.

Four silage replicates were taken of each pearl millet herbicide treatment and two tropical corn hybrids (Pioneer 3098 and Pioneer X304C) for IVOMD analysis as described in Moore and Mott (1974). The two tropical corn hybrids were in an adjoining corn hybrid experiment with similar planting dates (14 May, but with later harvest date of 5 Oct).

An irrigation-growth regulator study was conventionally prepared and planted on 17 June to determine 1) irrigation response of grain millet and 2) yield response to growth regulators. Irrigation was scheduled when tensiometers at a 6-inch depth reached 20 cb and applied in 0.33-inch quantities on 15, 18, 21, 22, 26 May and 10 July with an overhead sprinkler system (total = 2 inches). This is in addition'to the 20 inches of rainfall received during the pearl millet growing season (17 June to 21 Sept, 1992) (Fig. 1). Fertilizer was applied at the rate of 20-40-60 lb/A of N, P_2O_5, K_2O, respectively. Nitrogen was sidedressed soon after emergence at 100 lb/A. Atrazine at 1% qt + oil was applied when millet was in the 3- to 5-leaf stage (this herbicide treatment killed some of the millet plants). Growth regulator treatments (Pix at 3/4 pt/A), Cerone at 3/4 pt/A) were applied on 24 July when millet was about 2 ft tall. By 1 Sept, hundreds of blackbirds were in these plots before harvesting on 2 Oct 1992. Since there was little grain left in the heads, grain yields were calculated from silage data with grain. Silage ratios of the Atrazine 1/2 qt + Prowl 1 pt + oil 1 qt treatment are given in Table 3. Since there was some bird damage to the May planting, the estimates are conservative.

RESULTS AND DISCUSSION

Grain and total silage yields of grain millet and tropical corn grown following wheat under different tillage methods are shown in Table 1. The components of silage yield are also shown for pearl millet. The no-till plus in-row subsoiling method of planting significantly increased pearl millet grain and silage yields, but had no significant effect on tropical corn yield.

Optimum N rates may not have been reached in the N study since grain yields continued to increase with N application to 150 lb/A (Table 2). The study was harvested on 19 Aug, about 90 days after planting, with some bird damage evident. Further studies will be conducted in larger fields in the future to avoid this damage.

The herbicide study (Table 3) showed that best yields lor both silage and grain were obtained from the hand-weeded check Treatments with Atrazine + oil and Atrazine + Prowl + oil were not different from the hand-weeded check Adding Pursuit herbicide did not affect silage yield dramatically but did significantly reduce grain yields. Accent herbicide gave 100% control of the grain millet and should never be applied to a production field. The Atrazine, Prowl, and oil treatments used on corn may be satisfactory for millet; however, more work over a wider range of environmental conditions needs to be completed along with normal labeling procedures for pesticides before making large scale recommendations. Ratios of grain and total silage are of interest when evaluating silage for ruminant animals. Our range of ratios are similar to the 0.11 to 0.19 range calculated for the Nebraska pearl millet grain type experimentals used in their experiment.

In vitro dry matter digestibility values show that pearl millet silage with grain (64.7%) was more digestible than silage without grain (49.4%) (Table 4). HGM-100 silage (64.7%) was more digestible than Pioneer 3098 (61.9%) or Pioneer X304C (59.9%) tropical corn silage.

The growth regulator Pixwas not different from the control, but Cerone produced less silage yield than the other treatments (Table 5).

Rust (Puccinia substrata var. indica) occurs on pearl millet in most years (Monson et al., 1986). We have not observed the rust problem on HGM-100, but have observed some anthracnose and fall armyworm

Table 1. Influence of planting method (planting date 25 June) to compare tropical corn [harvested 21 Oct, 43" rainfall (rf)] and pearl millet [harvested 4 Sept, (30" rf)], Quincy, FL, 1992.

Method of Planting	Pearl Millet[1]				Tropical Corn[2]		
	Grain[3]	Silage[1]			Grain[3]	Silage[4]	
	-bU/A-	------ton/A-----			bu/A	--ton/A--	
No-till and in-row subsoil	64.9	2.7	10.9	18.5	43.4	1.8	9.5
Conventional	55.9	2.3	9.5	16.1	43.0	1.8	9.4

[1] Pearl millet grain was not harvested because of bird damage, but calculated according to Table 1 ratios.
[2] Pioneer Brand 3098.
[3] Corrected to 35% DM.
[4] Corrected to 15.5% moisture.

Table 2. Influence of nitrogen rate on grain moisture, grain yield, and seed weight of pearl millet planted 20 May and harvested 19 Aug (24" rf), Quincy, FL, 1992.

N Rate (lb/A)	Grain Moisture (%)	Grain Yield[1] (bu/A)	Seed wt (gm/200 seed)
0	13.8	29.5	1.08
50	13.6	55.3	1.42
100	13.4	65.6	1.31
150	13.5	81.5	1.37

[1] Corrected to 15.5% moisture

Table 3. Influence of herbicide on millet grain and silage yields at the 20 May date of planting. Harvest date was 19 Aug., Quincy, FL, 1992.

Treatments	Grain[1,2] yield (bu/A)	Silage Yield[3] (ton/A) Grain only	Top only	Sil w/o G&T	Total Silage	Gr:Sil[3] Grain/Total
Hand-weed check	64.6a	2.6	6.7	10.9	20.2	0.13
Atraeine 1½ qt + oil 1 qt	55.9a	2.3	4.2	11.8	18.3	0.13
Atrazine 1½ qt + Prowl 1 pt + oil 1 qt	60.0a	2.5	4.6	10.3	17.4	0.14
Unweeded Control	63.8a	2.6	4.9	8.7	16.2	0.16
Atrazine 1½ qt + Pursuit 2 oe + oil 1 qt	38.8b	1.6	6.3	8.3	16.2	0.10
Atrazine 1½ qt + Accent ⅔ oz + oil 1 qt	0.0c	0.0	0.0	0.0	0.0	0.0
$LSD_{.05}$	16.7					

[1] Weans in a column followed by different letters are significantly different at the 5% level of probability.
[2] Corrected to 15.5% moisture.
[3] Corrected to 35% DM (G = grain, T = top)

Table 4. In *vitro* organic matter digestibility (IVOMD) of pearl millet silage samples with and without grain and top and tropical corn (Pioneer 3098). Pearl millet for silage and grain was planted 20 May and harvested on 19 Aug. Tropical corn for silage, including grain, was planted 14 May and harvested 5 Oct (43" rf), Quincy, FL, 1992.

	IVOMD %[1]	
Pearl Millet (HGM-100)	Silage w/grain	Silage w/o grain
Hand-weed check	67.6 a	42.8 b
Atra. 1/2 qt + Prowl 1 pt + oil 1 qt	65.4 ab	49.2 ab
Unweeded control	64.0 ab	49.5 ab
Atra. 1/2 qt + Pursuit 2 oz + oil 1 qt	63.4 b	56.4 a
Atra. 1/2 qt + oil 1 qt	63.1 b	48.9 ab
HGM-100 mean	64.7 A	49.4 B
Tropical Corn		
Pioneer 3098 mean	62.3 B	---
Pioneer X304C mean	60.4 C	---

1 Means with the same letter are not significantly different with the Duncan's multiple range test.

Table 5. Influence of growth regulators and irrigation on silage yields (w/o grain) of grain millet (planted 17 June and harvested 21 Sept, 20" rf), Quincy, FL. 1992.

	Silage Yield 35% D.M. (ton/A)			
Treatment	control	Pix	Cerone	Avg.
Irrigated	21.0	21.0	19.7	20.5
Not Irrigated	21.9	22.2	17.6	20.5
Avg.	21.4	21.6	18.6	

[Spodoptera frugiperda (J.E Smith)] damage on pearl millet, but the damage was minor compared with that on tropical corn in 1992.

Again, more work needs to be conducted at locations where bird damage will be less of a problem (larger fields of pearl millet). Much more research needs to be done with the grain millet to determine silage and grain yield potential, management, and its effect on nematode populations on crops in rotation, i.e., peanut and soybean.

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