SARE Project LS93-53

PREDICTING GRAIN YIELD OF BIRD DAMAGED PEARL MILLET WITH HEAD LENGTH

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ABSTRACT

Pearl millet [Pennisetum glaucum (L.)R. Br.] is highly susceptible to red winged blackbird [Agelaius phoenicens] -damage in small plots and in areas around the outside of large fields. Research plots in the center of a large field of pearl millet are also susceptible on a plot basis if treatments speed development to the soft dough stage ahead of other treatments. This research was conducted on a Dothan sandy loam located on the North Florida Res. and Educ. Ctr., Quincy FL with HGM™100 (W.W. Hanna, Tifton, GA) pearl millet hybrid. Our objective was to relate pearl millet grain yields to head length measurements of undamaged panicles and to compare with pearl millet head lengths subjected to three induced stressors: 1) date of planting/soil water stress, 2) herbicide stress, and 3) plant density stress (row width/seeding rate). Three hundred and sixty pearl millet (HGM™100) panicles (not damaged by birds) were selected at random for three different lengths of panicle (15, 12, and 9 inches) for predicting grain yield by linear regression analysis. The resultant simple linear regression equation for predicting grain yield per head of bird damaged pearl millet from head lengths was: $Y = -0.0317 + 0.0048\,X$, where Y = pearl millet head yield (lb/head) and X = head length (inches). If the head yields are measured and number of heads counted on a unit area, then head yield (bu/head) x heads/A = grain yield (bu/A). This equation is useful for salvaging valuable small plot research that has been subject to bird depredation.

Head lengths for 5 May, 17 May, and 15 June plantings accurately predicted grain head yields, but 15 July planting produced less seed with moderately long heads. Preplant applications of Dual with 2,4-D or Atrazine, Ramrod alone or with Atrazine significantly ($P < 0.05$) increased head length in till and no-till treatment. The mean head length across row widths for the 6 lb/A seeding rate was significantly ($P < 0.05$) shorter than the 2 and 4 lb/A seeding rates. The mean head length across seeding rates for the 5 inch row width was significantly ($P < 0.05$) greater than the 15 and 30 inch row widths.

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INTRODUCTION

Pearl millet is a potentially productive high-quality grain (Kumar et al., 1983). It is grown under low-input management conditions (noncrusting sandy soils with little fertilizer and limited water; Payne et al., 1990) and fits the summer growing season (Wright et al., 1993) presently occupied by crops such as soybean [Glycine max (Merr.)], peanut [Arachis hypogeae L.], sorghum [Sorghum bicolor L. (Moench)], tropical corn [Zea mays L.], bahiagrass [Paspalum notatum (Flugge)], and bermudagrass [Cynodon dactylon L. (Pers.)] in year-round multiple cropping systems of the southeastern United States.

One major problem is the susceptibility to extensive bird damage, particularly in the soft dough stage. Wright et al. (1993) experienced extensive bird damage to pearl millet grain yields in small plot research in 1992 and needed a parameter for estimating grain yield. They used a grain/silage-without grain ratio from an undamaged pearl millet herbicide study to develop the equation and predicted grain yield for other bird damaged research plots. Although useful, a better predictor was still needed. Estimating grain yield is a function of the equation: $D = M/V$, where D = bulk density, M = mass, and V = volume (Teare and Mott, 1965 and Wilson and Teare, 1972). Therefore head length was considered a parameter for predicting grain yield/head with the assumption that grain yield/inch of head remained constant.

Different stressors have been reported to affect grain yield. Water stress has been reported to reduce pearl millet grain yields 70 to 85 % during flowering and grain filling (Mahalakshmi, 1988). Herbicide stress to pearl millet from Pursuit and Accent has also been reported to reduce grain yield compared to a handweeded check of pearl millet (HGM-100) by 60 and 100 percent, respectively (Wright et al., 1993). Objective one was to evaluate head length of pearl millet as a consistent and reliable method for accurately predicting pearl millet grain yields. Objective two was to determine the impact of some induced stressors on pearl millet head length. Stressors included date of planting/soil water stress, herbicide stress, and plant density stress (row width/seedling rate).

MATERIALS AND METHODS

General

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.

Cultural practices common to all studies were: fertilizer (5-10-15 at 500 lbs/A) was applied three days before planting the hybrid HGM™100, developed as a grain pearl millet by W.W. Hanna (1991), Tifton, Georgia. Nitrogen was sidedressed two inches to the side of the row at 120 lbs/A at boot stage (stage 5). Prowl @ 1 qt/A + Atrazine @ 2 qt/A were applied between stage 1 and 2 (10 to 15 days after planting when pearl millet was 3 to 5 inches tall) (Wright et al.,1993). Lannate-LV @ 1 pt/A (0.6 # active ingredient) was applied to the crop for control of corn earworm on 8 July, and all plots were treated with 2,4-D @ 0.5 lb (a.i.)/A for broad leaf weed control approximately 3 weeks after planting (stage 2).

Pearl millet heads were dried in a greenhouse, and threshed with a clover threshing machine that required 20 heads per sample for the threshing operation. Pearl millet heads were measured from top to bottom of panicle (Pudelko et al., 1993).

Yield Prediction

Pearl millet seed was no-till planted in a weed fallow field with a Brown Ro-Til implement with KMC planters in a completely randomized block design with six replications on 29 May 1993. Before the millet was planted, weeds were burned down with applications of Round-up (7 May) at 2 pt/A and Gramoxone (21 May) at 3 pt/A. Seed were planted 3/4" deep at 4 lbs/A (322,000 seeds/A) with an emergence of approximately 177,000 plants/A (55% emergence). Plots were 24' X 30' with eight rows 36" apart.

Twenty pearl millet heads were carefully selected for each six replications of three specific head lengths (9, 12, and 15 inch). Concomitant measurements of head grain yields and head lengths were used in regression analysis to develop the prediction and then multiplied by heads/A to get grain/ A.

Little rain occurred throughout the growing season for this rainfed experiment. A total of 19.0 inches of rainfall was received during the pearl millet growing season from 29 May to 28 Aug, 1993 (Fig. 1).

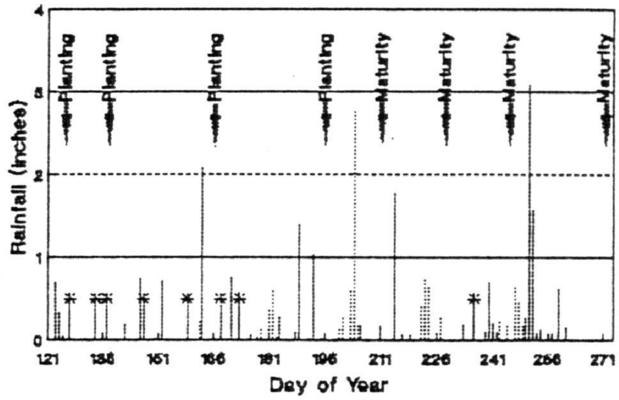

Figure 1. Rainfall during the 1993 pearl millet growing season for four planting dates in relation to rainfall amounts and dates of events.

Date of Planting/Soil Water Differences

The pearl millet date of planting study was a randomized complete block design with six replications. Planting dates, maturity, and date of irrigation are shown in Fig. 1. Plots were eight rows wide (rows were 36 inches apart) and 30 feet long. Seed of pearl millet were planted 3/4" deep at 4 lbs/A (302 667 seeds/A). This resulted in approximately 166,467 plants/A, or 55% emergence.

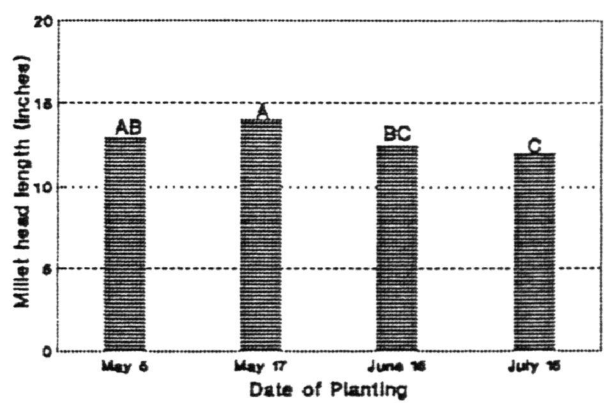

Figure 2. Pearl millet head lengths in relation to date of planting. Columns topped by the same letter are not different at the 5% level of significance.

Twenty pearl millet heads were carefully selected at random for each replication after black layer formation with concomitant measurements of head grain yields, head lengths, counts of heads per length of row harvested and grain yield per length of row.

Herbicide Study

A herbicide study on pearl millet was conducted on a field where weeds had not been controlled for a year. The field was very weedy. Before it was planted, the field was mowed. It was subsoiled to 12-inch depth on 12 May and S-tine harrowed 2 June. It was sprayed with Gramoxone on 2 June at the rate of 3.0 pt/A primarily for nutsedge control.

Pearl millet seed was treated with Concep to "safen" herbicide application (particularly Dual), planting occurred on 23 June followed by irrigation with 3/4 inch of water on the day of planting, the seeding rate was 4 lb/A in plots 12 feet by 25 feet in 36" rows (plant density of 166,000 plants per acre).

Seventeen pre-emerge herbicide treatments were applied in different herbicide combinations [Dual (metolachlor), Ramrod (propachlor), Prowl (pendimethalin), Atrazine, and 2,4,-D] on 25 June (Table 1). One hand weeded treatment and two treatments without weed control completed the 20 treatments used in this study (Table 1).

The experiment was a split plot design with tillage systems (no significant differences, not reported) as whole plots and herbicide treatments as sub-plots. All treatments were replicated four times. Results were subjected to analysis of variance and means were separated using Fishers Least Significant Difference Test at the 5 % level of probability.

Row Width/Seeding Rate Study

The row width-seeding rate study was planted on 28 June. Row widths and seeding rates used in the study are shown in Table 2. Plot size was 5 feet wide X 25 feet long.

The experiment was a split plot design with tillage systems (no significant differences, not reported) as whole plots and herbicide treatments as sub-plots. All treatments were replicated four times. Results were subjected to analysis of variance and means were separated using Fishers Least Significant Difference Test at the 5 % level of probability.

Table 1. Pearl millet mean head length (ft.) in relation to herbicide treatments in No-Till (1993).

Treatment	Rate per A	No-Till System Head Length[1]	
1. Atrazine without oil	1.5 lbs	0.875	FG
2. Atrazine without oil	2.0 pt	0.900	FG
3. Atrazine with oil	1.0 lb + 1 qt	0.878	FG
4. Atrazine with oil	1.5 lbs + 1 pt	0.945	EF
5. Dual + 2,4 D	1.0 pt + 0.5 lb (a.i.)	1.100	AB
6. Dual + 2,4 D	1.5 pts + 0.5 lb (a.i.)	1.120	AB
7. Dual + 2,4 D	2.0 pts + 0.5 lb (a.i.)	1.085	B
8. Ramrod (42%) + 2,4 D	3.0 qt + 0.5 lb (a.i.)	0.990	DE
9. Ramrod (42%) + 2,4 D	4.5 qt + 0.5 lb (a.i.)	1.005	CDE
10. Prowl + 2,4 D	1.0 pt + 0.5 lb (a.i.)	0.882	FG
11. Prowl + 2,4 D	1.5 + 0.5 lb (a.i.)	0.938	EFG
12. Dual + Atrazine with oil	1.0 pt + 1.0 lb	1.075	BC
13. Dual + Atrazine with oil	1.5 pt + 1.0 lb	1.173	A
14. Ramrod + Atrazine with oil	3.0 qt + 1.0 lb	0.888	FG
15. Ramrod + Atrazine with oil	4.5 qt + 1.0 lb	1.058	BCD
16. Prowl + Atrazine with oil	1.0 pt + 1.0 lb	0.865	G
17. Prowl + Atrazine with oil	1.5 pt + 1.0 lb	0.900	FG
18. Check hand weed control		0.889	FG
19. Check without weed control		0.897	FG
20 Check without weed control		0.905	FG
Mean[1]		0.968	

[1] Mean values in columns followed by the same letter are not significantly different at the 5% level of significance.

Table 2. Plant population density (plants/A) and plants/linear foot of row[1] are shown for each combination seeding rate and row width.

Row width (inches)	Seeding Rate[2] (lb/A) 2	4	6
5	89,000 (0.85)	172,000 (1.65)	264,000 (2.53)
15	88,000 (2.54)	176,000 (5.06)	266,000 (7.64)
30	88,000 (5.08)	177,000 (10.16)	265,000 (15.23)

[1]Plants/linear foot of row in brackets

[2]Emergence rate approximately 55% of seeding rate

RESULTS AND DISCUSSION

Yield prediction

We agree that the best measure of grain yield is from undamaged pearl millet heads per unit area, but using predictions of head grain yield from head length X number of heads per unit area can salvage time-consuming small plot research damaged by birds.

Pearl millet grain yields were significantly different for each head length (15, 12, or 9 inches) (Table 3).

A simple linear regression equation was developed to predict head yield where head length explained 92% of the variation in head grain yield: $Y = -0.0317 + 0.0048X$, where Y = pearl millet grain yield (lb/head) and X = head length (inches) with a coefficient of correlation $(r) = 0.96$ and $P < 0.0001$.

Planting date/water

Note the lack of rainfall-throughout the season (Fig. 1). Total water available 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.

Pearl millet head lengths are shown for each planting date (Fig. 2) (columns topped with the same letter are not significant at the 5 % level of significance). Head lengths for 5 May, 17 May, and 15 June plantings were related to total water during the growing season and accurately predicted grain head yields $P < 0.0001$) by the equation: $Y = -0.0317 + 0.0048X$.

Table 3. Pearl millet grain yield for six replications of each head length (9, 12, and 15 inch); Quincy, FL, 1993.

Rept.	Head length[1] (inch)	Grain yield[2] (lb/head)
1	15	0.0467
2	15	0.0377
3	15	0.0398
4	15	0.0452
5	15	0.0382
6	15	0.0410
$\bar{x}$		0.0414 A
1	12	0.0225
2	12	0.0220
3	12	0.0221
4	12	0.0218
5	12	0.0299
6	12	0.0314
$\bar{x}$		0.0250 B
1	9	0.0130
2	9	0.0144
3	9	0.0154
4	9	0.0111
5	9	0.0112
6	9	0.0096
$\bar{x}$		0.0124 C

[1] Three specific head lengths selected at random from non-bird-damaged pearl millet. Each replication is the mean of 20 pearl millet heads.

[2] Mean values in columns followed by the same letter are not significantly different at the 5% level of significance.

However, the 15 July planting date produced very little seed. The average number of seeds per 20 non-bird damaged heads was only 105 for reasons we can't explain. It probably wasn't lack of available water (18.2 inches compared to 16.4 inches for PD_1). Figure 2 indicates that head length was greatest for the 17 May planting date. This may be related to total water (19.1 inches). Thus, planting date two (17 May) may be the optimum planting time for pearl millet in North Florida.

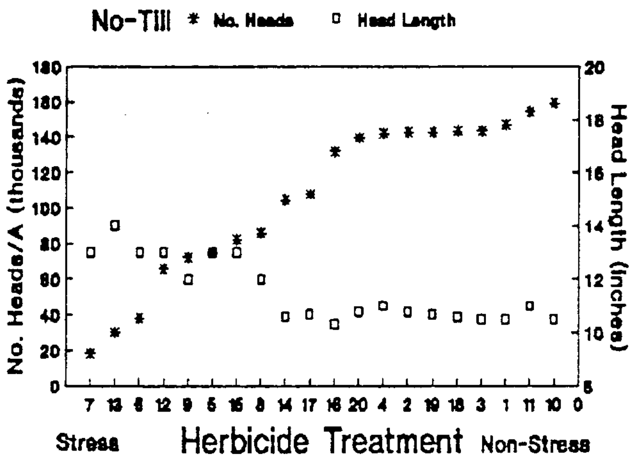

Figure 3. Herbicide stress indicated by number of heads/A in relation to herbicide treatment and head length (inches) of no-till systems.

Herbicide Study

Herbicide treatments and their numerical codes are shown in Table 1.

Figure 3, with herbicide treatments ordered in relation to number of heads/A, shows the lowest number of heads/A or greatest herbicide stress at the left of the X axis and least herbicide stress at the right of the X axis. Head lengths (Fig. 3) were significantly longer ($P < 0.05$) with Dual + 2,4-D (trt 5, 6 and 7), Dual + Atrazine (trt 12 and 13), Ramrod + 2,4-D (trt 8 and 9), Ramrod + Atrazine (trt 13), than with no-herbicide (trt 18, 19, and 20). Prown + 2,4-D (trt 10 and 11), Prowl + Atrazine (trt 1, 2, 3, and 4) head lengths were not significantly different from the no-herbicide head lengths.

Row Width/Seeding Rate Study

Plant population densities (plants per acre and plants per linear foot of row) are shown in Table 2.

Population density increased in rows from left to right according to seeding rate, but population density in columns from top to bottom across row widths remained constant. Plants/linear foot of row increased for each row width from left to right and from top to bottom for all seeding rates across row widths (Table 2).

Population density effects on pearl millet head lengths are shown in Table 4. The mean head length across row widths (Table 4) for the 6 lbs/A seeding rate was significantly shorter than the 2 and 4 lb/A seeding rate ($P < 0.05$). The mean head length across seeding rates (Table 4) for the 5 inch row width was significantly greater than the 15 and 30 inch row widths ($P < 0.05$).

Table 4. Pearl millet head lengths[1] (inches) in relation to row width and seeding rate.

	Seeding Rate (lb/A)			
Row Width	2	4	6	$\bar{x}$
5	1.013	0.995	0.998	1.002 A
15	0.975	0.992	0.848	0.938 B
30	0.970	0.955	0.895	0.940 B
$\bar{x}$	0.986 X	0.981 X	0.913 Y	

[1]Mean values followed by the same letter are not significantly different at the 5% level of significance.

CONCLUSIONS

1. Head lengths for 5 May, 17 May, and 15 June plantings accurately predicted pearl millet head yields ($\underline{P} < 0.05$) with equation $Y = -0.0317 + 0.0048\ X$.
2. The 15 July planting date produced very little seed although head lengths averaged over 12 inches long.
3. Pre-emerge applications of Dual + 2,4-D, Dual + Atrazine, Ramrod + Atrazine increased head length over nonherbicide check in no-till systems.
4. The mean head length across row widths for the 6 lb/A seeding rate was significantly shorter than the 2 and 4 lb/A seeding rates ($\underline{P} < 0.05$).
5. The mean head lengths across seeding rates for the 5 inch row width was significantly greater than the 15 and 30 inch row widths ($\underline{P} < 0.05$).

Information from this study will help in defining those situations where pearl millet lengths could be used to predict grain yield in small research plots.

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