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WEED MANAGEMENT SYSTEMS FOR PEARL MILLET IN THE SOUTHEASTERN UNITED STATES

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ABSTRACT

Pearl millet is a potentially-productive, high-quality grain being developed for the Southeastern United States. Published research on weed management systems for pearl millet is virtually nonexistent. During the past several years, field and greenhouse experiments have been conducted by the University of Florida and USDA-ARS to evaluate herbicide and cultural practices, which would effectively and economically control weeds, specifically annual grasses, in pearl millet. Atrazine applied as early post-emergence was the most effective single herbicide controlling a broad spectrum of weeds in pearl millet. Combinations of Atrazine with Prowl and Ramrod or Ramrod with 2,4-D generally controlled grass and broadleaf weeds and did not seriously injure pearl millet. Dual caused moderate to severe pearl millet injuries and reduced yield. Conventional, no-till, or stale seedbed preparation generally did not affect level of weed control or pearl millet production. Cultural practices such as plant population and row spacing can increase effectiveness of weed control systems in pearl millet. Presently, there are no federally registered herbicides treatments for pearl millet grown as grain. Utilizing no-till or stale seedbed techniques that use Gramoxone Extra to kill existing vegetation before pearl millet emerges is an effective, economical, and legal procedure.

INTRODUCTION

Pearl Millet [Pennisetum glaucum (L.)] is a potentially-productive, high-quality grain or silage crop (Burton et al., 1986 and Kumar et al., 1983). It can be grown under relatively low-input management conditions with reduced fertilizer and water application.

With the development of pearl millet as a potential grain crop for the Southeastern U.S. there is an urgent need to develop weed management systems that will result in improved quality and quantity of the grain produced.

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Presently, there are only two herbicides, Banvel and 2,4-D, that are registered for use on millet. There is no federally approved registration for these herbicides on pearl millet as a grain crop. Banvel is registered under a special, local needs (24C) permit in several western states for use on millet. The labeling of 2,4-D suggest its use for forage crops, which would include millet. Therefore, the registered use of these herbicides on pearl millet as a grain crop is unclear. Weed pressures and diversity in the southeastern U.S. require development of effective and efficient weed management systems for pearl millet. In addition to a wide range of broadleaf weeds, annual grasses such as Texas panicum, crabgrass, and crowfootgrass present major production problems for pearl millet.

Published research data on use of herbicides on pearl millet for grain is virtually non-existent. The herbicides imazethapyr and nicosulfuron reduced pearl millet grain yield 60 and 100 percent, respectively, compared to an untreated check (Wright et al., 1993). Specific effects of herbicide stress on pearl millet have only been reported in relation to head length (Pudelko, et al., 1993).

The potential narrow herbicide selectivity range between annual grass weeds and pearl millet presents a major problem in developing weed management systems. Research in Florida and Georgia, during the past few years, has emphasized systems that will selectively control annual grasses in pearl millet. The objectives of developing weed management systems are to: 1) selectively control annual grasses and broadleaf weeds in pearl millet; 2) develop low cost weed control programs; 3) prevent potential injury and yield reduction from weed management systems; and 4) provide efficacy data for potential registration of herbicides or herbicide combinations for use in pearl millet.

METHODS AND MATERIALS

Weed control experiments in pearl millet were conducted under both greenhouse and field conditions from 1988-1994. Pearl millet hybrid seed HGM^{TM}100, developed by the pearl millet breeding program of the USDA-ARS, Coastal Plain Experiment Station, was used in all experiments.

The experiments were conducted on a Norfolk sandy loam or Tifton loamy sand (fine, loamy, siliceous, thermic Typic Kandiudults) located at the North Florida Research and Education Center, Quincy, Florida, and the Coastal Plain Experiment Station, Tifton, Georgia, respectively.

Weed species varied from year to year, but included Texas panicum, crabgrass, crowfootgrass, smallflower morningglory, morningglory spp., Palmer amaranth, cocklebur, carpetweed, purple nutsedge, and yellow nutsedge. Crop injury and weed control efficacy was determined by visual observation of each plot with 0 = no effect and 100 = complete kill. Bird damage was devastating to experimental plots, but yield on some experiments were measured in two ways: 1) predicting grain yield by regression analysis from head lengths as reported by Pudelko, et al., 1993 or 2) bagging of 10 heads/plot after pollination, allowing the grain to mature and dry, weighing the threshed grain, and then converting the yield data to lb/A based on the number of heads/acre.

In Florida, the no-till systems were established on land that had been fallowed for one year. The experimental area was mowed and treated with Gramoxone Extra to kill existing vegetation before planting pearl millet. In Georgia, stale seedbed systems were established by preparing a conventional seedbed and then delaying planting of pearl millet 10-14 days. This allowed the first flush of weeds to emerge, which were killed by applying Gramoxone Extra at planting.

Pearl millet was planted 0.75 to 1.0 inch deep in either 18 or 36 inch rows. Herbicides were applied with a conventional boom sprayer, applying 20 gal/A at approximately 30 PSI. Where necessary, a nonionic surfactant or crop oil concentrate was used with post-emergence herbicides.

The herbicides used in these experiments are listed in Table 1.

TABLE 1. Herbicides evaluated on pearl millet in Florida and Georgia.

Common Name	Trade Name
atrazine	Atrazine
bromoxynil	Buctril
metolachlor	Dual
paraquat	Gramoxone Extra
pendimathalin	Prowl
propachlor	Ramrod
2,4-D	Weedar-64

The experiments were either a split plot or randomized complete block design with three or four replications. Results were subjected to analysis of variance and means were separated using Fisher's Least Significant Difference Test, at the 0.05 level of probability.

RESULTS AND DISCUSSION

Florida

Weed control for individual herbicide treatments was similar in till and no-till systems in 1993 and 1994 (Tables 2, 3, 4, and 5). In 1993, the level of control of both grass and broadleaf weeds was good to excellent (83-100 percent). Treatments that included Atrazine controlled 95-100 percent of all broadleaf weeds. The addition of a crop oil concentrate increased the activity of Atrazine on grasses when compared to Atrazine alone. Herbicide combinations of Dual, Ramrod, and Prowl with 2,4-D or atrazine did not significantly improve weed control over Atrazine applied alone in 1993. In 1994, herbicide combinations of Ramrod and Prowl generally improved grass control compared to Atrazine applied alone. However, the level of broadleaf weed control was not improved by herbicide combinations compared to Atrazine alone.

Treatments that included Dual or Ramrod caused moderate to severe pearl millet injury in 1993. The data in Tables 2 and 3 show that Dual injured pearl millet more than Ramrod. Herbicide treatments that included Prowl also caused moderate injury to pearl millet. The injury ratings were recorded approximately two to three weeks after herbicide treatment. As the growing season progressed, pearl millet recovered from this herbicide injury as reflected in yield data in Tables 2 and 3. Severe herbicide injury, caused by

TABLE 2. Activity of selected herbicide treatments on pearl millet and weeds in conventional seedbed. Quincy, FL 1993

Treatment	Rate lb/A	Percent Control		Percent injury	Yield lb/A
		Grass	Broadleaf		
Atrazine[1]	1.5	83	98	9	3016
Atrazine	2.0	88	98	15	2954
Atrazine*	1.5	94	98	25	2675
Atrazine*	2.0	95	98	20	2405
Dual + 2,4-D	1.0 + 0.5	88	88	81	2435
Dual + 2,4-D	1.5 + 0.5	99	85	95	1553
Dual + 2,4-D	2.0 + 0.5	100	88	96	1506
Ramrod + 2,4-D	3.0 + 0.5	94	85	33	3128
Ramrod + 2,4-D	4.5 + 0.5	90	95	43	3202
Prowl + 2,4-D	0.5 + 0.5	100	98	21	3073
Prowl + 2,4-D	0.75 + 0.5	95	95	16	2806
Dual + Atrazine*	1.0 + 1.0	100	100	95	1353
Dual + Atrazine*	1.5 + 1.0	100	100	100	1612
Ramrod + Atrazine*	3.0 + 1.0	99	100	64	2901
Ramrod + Atrazine*	4.5 + 1.0	99	99	59	2544
Prowl + Atrazine*	0.5 + 1.0	95	100	13	2970
Prowl + Atrazine*	0.75 + 1.0	93	98	25	2877
Hand weed check		100	100	0	2575
Non-treated		0	0	0	2754
Non-treated		0	0	0	2563
Ramrod	4.5	94	100	0	2909
Prowl + Atrazine*	0.5 + 1.0[1]				
Prowl	0.5	99	100	0	2561
Prowl + Atrazine*	0.5 + 0.5[1]				
LSD (0.05)		6	5	8	311

*Crop oil concentrate at 1 qt/A.

[1]All treatments of Atrazine applied postemergence.

ted herbicide treatments on pearl millet and weeds in a no-till system. Quincy, FL 1993

Rate lb/A	Percent Control		Percent injury	Yield lb/A
	Grass	Broadleaf		
1.5	94	100	7	2720
2.0	90	100	11	2819
1.5	95	99	17	2641
2.0	94	100	25	3087
1.0 + 0.5	98	93	83	1971
1.5 + 0.5	89	96	96	1199
2.0 + 0.5	98	90	97	509
3.0 + 0.5	98	85	45	2173
4.5 + 0.5	94	83	44	1823
0.5 + 0.5	95	97	16	3066
0.75 + 0.5	98	100	13	3382
1.0 + 1.0	98	99	89	1892
1.5 + 1.0	100	97	97	1001
3.0 + 1.0	98	97	31	2103
+ 1.0	98	100	76	2319
0.5 + 1.0	99	97	10	2348
0.75 + 1.0	100	97	14	2678
	100	100	0	2807
	0	0	0	2785
	0	0	0	2799
	7	5	7	322

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millet in 1994 caused
ate injury to pearl millet shortly after treatment, but the crop completely recovered later in the growing season (data not shown). When compared to yield data for the handweeded check, Dual, Atrazine at 2 lbs/A, Ramrod + 2,4-D at 2.25 + 0.45 lbs/A, and Prowl + Atrazine at 0.75 + 1.0 lb/A reduced pearl millet silage yield (Table 4). In the 1994 no-till system, most of the herbicide treatments resulted in significant reduction in pearl millet silage yield, as compared to the handweeded check (Table 5).

Georgia

Control of grasses such as Texas panicum was a major concern for developing weed control systems in pearl millet. Preliminary experiments in greenhouse and under field conditions were directed to controlling grasses in pearl millet. Previous experience in grain sorghum and corn indicated an early post-emergence applications of Atrazine and/or Prowl would control seedling (1-2 leaf) Texas panicum. Greenhouse experiments confirm that Atrazine or Atrazine + Prowl would control seedling grasses, but could also significantly injure pearl millet. At rates and timing normally used in field corn or grain sorghum, Atrazine in excess of 1 lb/A to 2-3 leaf pearl millet caused moderate to severe injury, but suppressed Texas panicum emerging or in the 1-2 leaf stage. Application of Atrazine at 1 lb/A to 4-leaf pearl millet did not cause significant injury, but did not control Texas panicum beyond the 1-2 leaf stage. Several greenhouse experiments involving rates and timing of application with Atrazine in various combinations confirmed these results (data not shown). In 1991, two field demonstration plots treated early postemergence with Atrazine at 1 lb/A confirmed greenhouse experiments (Table 6).

The growth habit of pearl millet dictated that cultural aspects of weed management needed to be evaluated. This include plant population, row spacing, and the concept of stale seedbed preparation. Preliminary greenhouse experiments indicated that delaying pearl millet planting 10-14 days after seedbed preparation and killing the existing vegetation at planting would be feasible.

In 1992, a field demonstration plot of pearl millet was planted in 18 and 36 inch row spacing and then treated with paraquat at 0.5 lb/A within 48 hours of planting. Weed control observations, 14-21 days after planting, showed overall weed control at 95%, which included weeds such as Texas panicum, crabgrass, Smallflower morningglory, and Palmer amaranth.

At approximately 21 days after planting, canopy closure (overlapping the row middles) of pearl millet planted in 18 inch rows occurred and provided shade and competition for weeds for the remainder of the growing season. Pearl millet planted in 36 inch rows required about 4 weeks after planting for canopy closure, which provided an opportunity for some weeds to emerge and grow in the row middles. The use of stale seedbed techniques utilizing Gramoxone Extra was very effective and economical as a weed

TABLE 6. Effect of atrazine on weed control and pearl millet yield. Tifton, GA 1991

Row Spacing (in.)	Spacing in Row (in.)	Texas panicum	Crowfoot-grass	Crab-grass	Florida beggarweed	Florida pusley	Palmer amaranth	Planting Date 5-24	Planting Date 6-14
		% Control[1]						Yield, lb/A[2]	
36	3	80	95	95	95	95	95	3,020	3,334 ab
36	6							2,943	2,889 b
18	3	90	95	100	100	100	100	2,942	2,975 b
18	6							2,745	3,636 a
								NS	

[1]Atrazine applied at 1 lb/A to 2-leaf pearl millet.

[2]Data within column followed by the same letter are not significantly different as determined by DMRT at P = 0.05.

management program in pearl millet. A second demonstration plot, in 1992, indicated that pearl millet planted in a stale seedbed and treated with Gramoxone Extra at 0.25 lb/A at planting, followed by Atrazine at 0.75 lb/A as an early post-emergence treatment was also very effective in controlling a broad spectrum of annual weeds and that 18 inch row spacing provided more shade and competition to weeds than 36 inch row spacing.

In 1993 and 1994, experiments evaluated selected post-emergence herbicide treatments on pearl millet grown in conventional and stale seedbed (Tables 7, 8, 9 and 10). In 1993, the control of all weeds generally ranged

from good to excellent. Some treatments caused slight to moderate injury to pearl millet, but pearl millet recovered by maturity. A direct comparison between conventional and stale seedbed results could not be made because these were separate experiments, but the data in Tables 7 and 8 indicate very little

TABLE 7. Effect of postemergence herbicide treatments to weeds in pearl millet on conventional seedbed. Tifton, GA 1993

Treatment			% Weed Control[1]				
Herbicide	Rate lb/A	Row Spacing (in.)	Weed control	Crowfoot-grass	Texas panicum	Palmer amaranth	Wild radish
Atrazine	0.75	36	98	97	100	100	100
Atrazine	0.75	18	100	100	100	100	100
Buctril	0.38	36	94	93	97	95	100
Buctril	0.38	18	98	100	100	97	100
Buctril	0.38	36	98	97	100	98	100
Atrazine	0.75						
Buctril	0.38	18	100	100	100	100	100
Atrazine	0.75						
2,4-D	0.5	36	95	90	97	98	100
2,4-D	0.5	18	98	93	99	99	100

[1]Weed control data collected two weeks after application.

TABLE 8. Effect of postemergence herbicide treatments to weeds in pearl millet on stale seedbed [1]. Tifton, GA 1993

Treatment			% Weed Control[2]					
Herbicide	Rate lb/A	Row Spacing (in.)	Weed control	Crowfoot-grass	Texas panicum	Palmer amaranth	Wild radish	Injury %
Atrazine	0.75	36	96	93	100	100	100	5
Atrazine	1.0	18	97	95	97	100	100	7
Buctril	0.38	36	95	93	100	87	100	6
Buctril	0.38	18	97	95	100	100	100	0
Buctril	0.38	36	97	97	97	100	100	13
Atrazine	0.75							
Buctril	0.38	18	97	95	100	100	100	27
Atrazine	0.75							
2,4-D	0.5	36	96	95	95	100	100	0
2,4-D	0.5	18	90	70	93	100	100	7

[1]All plots treated with paraquat at 0.5 lb/A after planting.

[2]Weed control data collected two weeks after application.

difference in the level of weed control between seedbed preparation and specific herbicide treatments. Yield data were not collected in 1993 because of severe bird damage.

In 1994, data in Tables 9 and 10 indicate a much higher level of weed control in stale seedbed than in the conventional seedbed. Again, statistical comparison could not be made because these are separate experiments. But, the control of Smallflower morningglory and Palmer amaranth was much higher and more consistent in the stale seedbed experiment. The type of seedbed preparation did not appear to affect pearl millet yield (Tables 9 and 10). There was a general trend for better weed control for pearl millet planted in 18 inch rows as compared to pearl millet planted in 36 inch rows. Pearl millet canopy planted in 18 inch rows closed (overlapped the row middles) about 7-10 days earlier than pearl millet planted in 36 inch rows, which would provide greater competition to the weeds present.

It was also observed in border areas outside the experimental plots that weed control in the stale seedbed experiment was much higher than in the conventional seedbed experiment.

TABLE 9. Effect of postemergence herbicide treatments to weeds in pearl millet on conventional seedbed. Tifton, GA 1994

Treatment		Row	% Weed Control					
Herbicide	Rate lb/A	Spacing (in.)	Crowfoot-grass	Carpet-weed	Smallflower morningglory	Palmer amaranth	Nutsedge	Yield lb/A
Atrazine	0.75	18	0	100	17	47	97	2,174
Atrazine	0.75	36	0	100	30	40	100	1,829
Atrazine	1.0	18	10	100	27	60	100	2,702
Atrazine	1.0	36	0	100	17	47	100	2,183
Buctril	0.38	18	0	100	10	57	100	2,350
Buctril	0.38	36	0	100	17	7	100	2,033
Buctril	0.38	18	3	100	67	80	100	2,486
Atrazine	0.75							
Buctril	0.38	36	3	100	20	73	100	2,102
Atrazine	0.75							
2,4-D	0.5	18	3	100	17	40	100	2,111
2,4-D	0.5	36	0	100	0	27	100	2,079
								NS

TABLE 10. Effect of postemergence herbicide treatments to weeds in pearl millet on stale seedbed [1]. Tifton, GA 1994

Treatment		Row	% Weed Control						
Herbicide	Rate lb/A	Spacing (in.)	Crowfoot-grass	Crab-grass	Carpet-weed	Smallflower morningglory	Palmer amaranth	Nutsedge	Yield lb/A
Atrazine	0.75	36	3	78	83	93	100	100	2,340
Atrazine	0.75	18	7	73	100	90	100	100	2,491
Atrazine	1.0	36	7	93	100	93	100	100	2,266
Atrazine	1.0	18	3	77	100	100	100	100	2,412
Buctril	0.38	36	3	63	100	80	100	100	1,970
Buctril	0.38	18	0	40	100	75	100	100	1,985
Buctril	0.38	36	5	85	100	90	100	100	2,334
Atrazine	0.75								
Buctril	0.38	18	10	87	100	83	100	100	2,777
Atrazine	0.75								
2,4-D	0.5	36	0	27	90	57	100	100	2,757
2,4-D	0.5	18	0	43	93	83	100	100	2,372
									NS

[1] All plots treated with paraquat at 0.5 lb/A after planting.

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