Efficacy of Herbicides for Weed Control in Pearl Millet

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Abstract

Field experiments were conducted under rainfed conditions during the 1987 and 1988 *kharif* season on pearl millet (*Pennisetum glaucum* (L) R. Br) to test the comparative efficacy of pre-emergence herbicides atrazine and terbutryne applied separately, in mixture and in combination, with hand-hoeing. Weed density and dry weight significantly reduced by herbicide application and hand-hoeing. Atrazine or terbutryne alone at 1.0 kg a.i./ha or in combination at 0.5 kg a.i./ha each, resulted in mortality of pearl millet plants. Pre-emergence application of atrazine at 0.5 kg a.i./ha followed by hand-hoeing at 30 days after sowing gave effective weed control, and resulted in more grain yield compared to the unweeded-control.

Introduction

Pearl Millet (*Pennisetum glaucum* (L) R.Br) is an important rainy-season crop in arid and semi-arid regions. Its grain is used as staple food, and its succulent plants as fodder (Malik *et al.,* 1980). Heavy weed infestation is one of the major production constraints in these areas, limiting the productivity of pearl millet to 50-60% with associated losses in profitability (Tomer *et al.,* 1978, Malik *et al.,* 1980). Further, the first 20-30 days after sowing (DAS) are critical for crop growth (Umrani *et al.,* 1980). Farmers usually control weeds mechanically, but with migration of villagers to urban areas, farm labour has become expensive and scarce (Malik *et al.,* 1980). The use of herbicides to control weeds therefore seems to be a possible solution. However, work on the chemical weed control in pearl millet is limited (Gupta and Lamba, 1978).

Atrazine and terbutryn are commercially used for weed control in most cereals. Usually, low concentrations of these chemicals (upto 1.0 kg a.i./ha) are reported to be effective in arid and semi-arid regions of India (Joshi, 1990). It was therefore considered essential to compare the effectiveness of hand-hoeing and herbicide application, alone and in combination to identify the most efficient method of weed control in pearl millet.

Materials and Methods

Trials were carried out at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India during the 1987 and 1988 *kharif* seasons. The soil was a medium deep Alfisol, sandy clay loam in texture with a pH of 8.4 It contained 19.2 kg/ha available inorganic (NH_4 + NO_3) nitrogen, 12.5 kg/ha available phosphorus, and 158 kg/ha potassium. Rainfall during the cropping season (June-October) was 463 mm in 1987 and 886 mm in 1988.

Herbicide applications and weed control practices evaluated in the experiments are described in Table 1. In addition to these treatments atrazine and terbutryne alone at 1.0 kg a.i./ha and a mixture of these herbicides at 0.5 kg a.i./ha were also evaluated. Since these treatments killed the pearl millet plants completely, they were not included in statistical analysis. Treatments were replicated thrice in a randomized complete block design. Each plot was 9.0 x 7.0 m^2. Plots received 60 kg N and 36

kg P_2O_5/ha of which 18 kg N and 36 kg P_2O_5/ha was applied at planting. Pearl millet (cv. WC-C75) was seeded on 23 June 1987 and 18 June 1988 with a tractor-drawn seed drill in rows 60 cm apart. After emergence, plants were thinned to 10 cm spacing between plants.

Height and number of effective tillers per plant were recorded from 10 plants selected randomly at maturity. Grain yields were recorded from a net plot measuring 8 x 4 m^2 at harvest. Weeds, collected 60 DAS from a randomly placed quadrant at 1.0 m, were separated, counted, washed and then oven dried to compute weed density and dry weight. A knapsack sprayer was used to apply the herbicides. The data on density and dry weight of weeds was subjected to $\sqrt{x + 0.5}$ transformation for statistical analysis. The clean-weeded control was maintained by repeated hand-hoeings every 10 days until harvest.

Results and Discussion

Important weed species recorded in the experimental field were *Echinochloa colonum* L., *Trianthema portulacastrum* L., *Digera arvensis* Forsk., *Digitaria sanguinalis* L. Scep and *Cyperus rotundus* L. Average distribution of these weeds species was 39, 32, 23, 5 and 1% in the unweeded control, respectively.

Maximum denstiy of *E. colonum* (44%), *T. portulacastrum* (32%) and *D. arvensis* (24%) was observed in the unweeded control at 60 DAS (Table 1). All weed control methods, reduced weed density significantly compared to unweeded control. Pre-emergence application of terbutryne at 0.75 kg a.i./ha and terbutryne or artrazine at 0.5 kg a.i./ha followed by hand-hoeing at 30 DAS was superior to all the other treatments. Among herbicides, terbutryne, and atrazine were comparable to each other in their efficiency in reducing weed density. However, at 0.5 kg a.i./ha they were equivalent to one hand-hoeing at 30 DAS.

The dry weight of weeds at 60 DAS was lowest in plots treated with terbutryne or atrazine (0.5 kg a.i./ha) followed by one hand-hoeing at 30 DAS (Table 1). All weed control methods significantly reduced weed dry weight compared to the unweeded control. Weed dry weight was significantly lower in plots which received hand-hoeing at 30 DAS in comparison to those treated with herbicides alone. Increasing herbicide dosage inhibited the emergence of weeds in the later stages of crop growth. Brar *et al.* (1980) also reported that herbicide activity in groundnut was apparent only up to 30 DAS at lower application rates (0.75 kg a.i./ha), while Kulandaivelu and Shankaran (1986) observed weed dry weight reduction upto harvest with a higher dosage (1.0-1.5 kg a.i./ha). Hence, the dosage of herbicides applied determines its effectiveness and persistence for weed control. Results of the present study also confirm that herbicide persistence depends on the rate, but herbicide alone failed to control all the weeds. The use of herbicides along with hand-hoeing ie., integration of chemical and mechanical methods, provided effective and season-long weed control.

Pre-emergence application of atrazine at 0.5 kg a.i./ha was safer to pearl millet. However, 0.75 kg a.i./ha caused leaf tip scorching and stunted growth, while 1.0 kg a.i/ha resulted in the death of the seedlings. Terbutryne was injurious to the crop at all concentrations, but the intenstiy was different. At 0.5 kg a.i./ha chlorosis and leaf tip scorching were noticed, while 0.75 kg a.i./ha resulted in delayed emergence, stunted plant growth and leaf tip scorching; and 1.0 kg a.i./ha led to crop mortality. A mixture of atrazine and terbutryne (0.5 kg a.i./ha each) was also lethal to pearl millet. However, crop was able to recover from phytotoxicity caused by atrazine at 0.75 a.i./ha and terbutryne at 0.5 and 0.75 kg a.i./ha in about 20 days.

Table 1. Effect of weed control treatments on density and dry weight of weeds (60 days after sowing)

Treatment	*Echinochloa*		*Trianthema*		*Digera*		Total weeds/m^2		Dry weight of weeds (g/m^2)	
	1987	1988	1987	1988	1987	1988	1987	1988	1987	1988
Unweeded	111	144	82	104	61	78	254 (15.9)	326 (18.1)	229 (15.0)	273 (16.5)
Weeded	0	0	0	0	0	0	0 (0.7)	0 (0.7)	0 (0.7)	0 (0.7)
Hand-hoeing 30 DAS	16	23	20	23	14	19	50 (7.1)	65 (8.1)	35 (6.0)	61 (7.8)
Terbutryn 0.50 kg a.i./ha	19	37	16	17	6	11	41 (6.4)	65 (8.1)	114 (10.7)	128 (11.3)
Terbutryn 0.75 kg a.i./ha	12	17	8	6	4	6	24 (4.9)	29 (5.4)	77 (8.8)	92 (9.6)
Atrazine 0.50 kg a.i./ha	22	39	25	32	11	11	58 (7.6)	82 (9.1)	132 (11.5)	151 (12.3)
Atrazine 0.75 kg a.i./ha	11	21	14	18	8	9	33 (5.8)	48 (6.9)	88 (9.4)	98 (9.9)
Terbutryn (0.5 kg a.i./ha) + hand-hoeing	7	8	5	5	3	5	15 (3.9)	18 (4.3)	16 (4.1)	43 (5.2)
Atrazine (0.50 kg a.i./ha + hand-hoeing	6	6	8	8	4	4	18 (4.3)	18 (4.3)	17 (4.2)	21 (4.6)
SE ±	-	-	-	-	-	-	9 (0.6)	9 (0.6)	5 (0.6)	9 (0.3)

DAS = Days after sowing.
Data on weed density and dry weight transformed to $\sqrt{x + 0.5}$ are given in parentheses.

Pearl millet plants were tallest under the mechanically weeded control and were comparable to those grown under pre-emergence application of atrazine at 0.5 kg a.i./ha followed by hand-hoeing at 30 DAS. The height of plants was significantly reduced by all the other weed control practices. At higher herbicide dosages, the plants were shorter than those in unweeded control. The negative effect of herbicides on plant height at higher concentrations was also noticed by Malik *et al.* (1980) and Balyan, *et al.* (1987).

Effective tiller number per plant was not influenced by atrazine at 0.5 kg a.i./ha as a pre-emergene treatment, or by atrazine at 0.5 kg a.i./ha followed by hand-hoeing at 30 DAS, and was comparable to the unweeded control. All the other weed control treatments, and the unweeded control had low number of tillers. The reduction in tillers per plant in the unweeded control can be attributed to weed competition. A significant reduction in the tiller number due to weed competition was also reported by Balyan *et al.* (1987). However, reduction by terbutryne (0.5 and 0.75 kg a.i./ha) and atrazine (0.75 kg a.i./ha) could be due to transient herbicide injury. Umrani and Bhoi (1982) and Klingman (1973) also described injury caused by traizine herbicides in cereal crops.

Millet grain yield was maximum under season-long weed-free conditions (Table 2). Atrazine at 0.5 mg a.i./ha, hand-hoeing at 30 DAS and atrazine at pre-emergence followed by hand-hoeing at 30 DAS also resulted in yields comparable to unweeded control. All the other weed control treatments, and the unweeded control had low number of tillers. The reduction in tillers per plant in the unweeded control can be attributed to weed competition. A significant reduction in the tiller number due to weed competition was also reported by Balyan *et al.* (1987). However, reduction by terbutryne (0.5 and0.75 kg a.i./ha) and atrazine (0.75 kg a.i./ha) could be due to transient herbicide injury. Umrani and Bhoi (1982) and Klingman (1973) also described injury caused by triazine herbicides in cereal crops.

Table 2. Effect of weed control on plant height, ears per plant, and grain yield

Treatment	Plant height (m)		Effective tillers		Grain yield (t/ha)	
	1987	1988	1987	1988	1987	1988
Unweeded	1.41	1.52	1.50	1.80	1.48	1.64
Weeded	1.83	2.01	2.50	3.00	2.55	3.12
Hand-hoeing 30 DAS	1.72	1.82	2.30	2.80	2.12	2.60
Terbutryn 0.50 kg a.i./ha	1.45	1.61	1.50	1.80	1.62	2.10
Terbutryn 0.75 kg a.i./ha	0.90	1.12	1.40	1.60	1.49	1.94
Atrazine 0.50 kg a.i./ha	1.71	1.86	2.30	2.80	2.21	2.63
Atrazine 0.75 kg a.i./ha	1.27	1.38	1.80	2.30	1.94	2.24
Terbutryn (0.5 kg a.i./ha) + hand-hoeing	1.58	1.72	2.00	2.40	1.89	2.41
Atrazine (0.5 kg a.i./ha) + hand-hoeing	1.79	2.00	2.40	3.10	2.50	3.01
SE ±	0.02	0.04	0.20	0.10	0.18	0.21

DAS = Days after sowing.

Millet grain yield was maximum under season-long weed-free conditions (Table 2). Atrazine at 0.5kg a.i./ha, hand hoeing at 30 DAS and atrazine applied at pre-emergence followed by hand-hoeing at 30 DAS also resulted in yields comparable to weeded control. Unchecked weed growth in the unweeded control reduced grain yields by 42-48%. Similarly, increased concentrations of terbutryne and atrazine resulted in 38-42% and 24-29% reduction in grain yields during 1987 and 1988, respectively. Yield reduction in plots treated with higher concentrations of herbicides was due to chemical injury. Toxic effects of atrazine and terbutryne at higher levels (0.75 kh a.i./ha) on the plant growth, vigour, and ear number resulted in reduced grain yields. Singh and Rao (1974) also observed the toxicity of triazine herbicides depending on the concentration used.

It can be concluded from the data that (atrazine at 0.5 kg a.i./ha) mechanical hand-hoeing at 30 DAS or a combination of chemical and mechanical methods are equally effective in minimizing the weed competition. However, if chemical method alone is to be employed, the herbicide must keep the fields weed-free for 20-30 DAS. However, pre-emergence herbicides dissipate over time and late-emerging and herbicide-tolerant weeds become a problem. Mechnical weed cotrol on the other hand becomes difficult for reasons such as inaccesibility of fields due to rainfall, tenderness of seedlings, etc., and exposes the crop to weed competition during the critical period. Therefore, for effective weed control, it would be ideal to integrate chemical and mechanical methods rather than to apply any one method.

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