The Pharma Innovation Journal 2023; SP-12(10): 1297-1300

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(10): 1297-1300

www.thepharmajournal.com
Received: 18-08-2023
Accepted: 21-09-2023

Digambar S Mundphane
PG Scholar, College of Agriculture, VNMKV, Badnapur, Maharashtra, India

Kiran T Jadhav
Professor of Agronomy, College of Agriculture, VNMKV, Badnapur, Maharashtra, India

Pranali S Sarwade
PG Scholar, College of Agriculture, VNMKV, Badnapur, Maharashtra, India

Vijay S Gavande
PG Scholar, College of Agriculture, VNMKV, Badnapur, Maharashtra, India

Corresponding Author:
Digambar S Mundphane
PG Scholar, College of Agriculture, VNMKV, Badnapur, Maharashtra, India

Weed management in summer pearl millet

Digambar S Mundphane, Kiran T Jadhav, Pranali S Sarwade and Vijay S Gavande

Abstract
A field test was conducted during the summer season of 2020-2021 on medium black soil at Agriculture Technical School, Aurangabad (MH), to evaluate the effect of weed management in summer pearl millet (*Pennisetum glaucum* L.). Nine weed control strategies were used in the experiment pre and post emergence herbicides (Atrazine, 2,4-D, Halosulfuron methyl, Chlorimuron ethyl and Metsulfuron methyl) in randomized block design with three replications. The maximum grain yield was recorded with weed free plot (T_2), which was at par with tank mix of Atrazine 50% WP @ 500 g a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 g a.i./ha (T_8). The better performance of (T_8) might be attributed to significantly lower weed dry weight, lower weed index and higher weed control efficiency which reflected in higher values of plant height, number of effective tillers/plant, earhead length, earhead girth and 1000 grain weight. Maximum net returns (Rs. 77715) and B:C ratio (3.09) were observed in tank mix of Atrazine 50% WP @ 500 g a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 g a.i./ha (T_8) as compared to weed free plot.

Keywords: Pearl millet, weed, weed management, herbicide, pre emergence, post emergence

Introduction
The Poaceae family includes pearl millet (*Pennisetum glaucum* L.) R. Br. emend. Stuntz. In terms of geography, it is India's fifth-most important food grain crop after rice, wheat, sorghum, and maize. 90% of the world's output of pearl millet comes from India and Africa. Approximately 10% of the world's production of food grains is made up of pearl millet. A low-cost food grain crop, pearl millet is also known as bajra or bajri throughout much of India. Pearl millet grains have a significant nutritional value thanks to their 69.4% carbohydrate, 12.1% protein, 4.3% to 5.0% fat, 2.0% to 7.0% mineral content, and 2.4% sugar content. It is also easy to digest, rich in vitamins like thiamine and riboflavin, and it gives you a lot of energy (Pal *et al*. 1996) [6]. In the 2018–19 growing season, Maharashtra produced 3.1 lakh tons of pearl millet on 5.0 lakh hectares, with a productivity of 620 kg ha-1. Major pearl millet farming districts in Maharashtra include Ahmadnagar, Beed, Solapur, Satara, Osmanabad, Aurangabad, Jalna, and portions of other districts with guaranteed irrigation facilities during the summer. Weed competes with the crop for moisture, nutrients, space, and light, which is one of the main reasons for pearl millet's low yield. However, they can raise production costs, spread plant and insect diseases, and reduce the quality of the output. Banga *et al*. (2000) [2] found that the pearl millet crop had an average 55% loss as a result of high weed infestation. Due to pearl millet's incredibly slow development in the early stages, weed competition was most noticeable during this period of the crop's growth. Therefore, it is more crucial to control weeds in pearl millet during the crop's early growth stage. The yield may be comparable to a weed-free situation if weed infestation is kept to a minimum during a crucial time of crop weed competition. In order to maximize the output of pearl millet, it is crucial to manage the weeds using a variety of techniques during the crop weed competition phase. The purpose of the current experiment was to ascertain how weed management affected the production, weed dynamics, and economics of summer pearl millet.

Materials and Methods
Weed management in summer pearl millet (*Pennisetum glaucum* L.) was the topic of the current inquiry, which was conducted in the summer of 2021 at the Farm section of the Agriculture Technical School (ATS), Aurangabad. The soil at the test site had a clayey texture, moderate nitrogen availability, little phosphorus, and a lot of potassium availability. The gross plot sized 4.5m x 4.5m whereas the net plot measured 4.2m x 3.6m.

On February 4, 2021, BIOSEED-448, a pearl millet hybrid, was sown with 45 cm x 5 cm spacing. The recommended amount of fertilizers, 60-30-30 kg of NPK ha^{-1}, was administered to all of the treatments in the form of urea, single super phosphate, and muriate of potash. Full dose of P & K and half dose of N was applied at the time of sowing and remaining 50% N was applied 30 days after sowing.

The experiment was laid out in randomized block design with three replications and nine treatments *viz*., weedy check (T_1), weed free (hand weeding as and when required) (T_2), directed spray of Atrazine (PE) 50% WP @ 500gm a.i. /ha at 3 DAS (T_3), tank mix of Halosulfuron (75 gm a.i./ha^{-1}) + 2,4-D Dimethyl amine salt 58% SL @ 500 gm a.i. /ha as POE 15 DAS (T_4), Metsulfuron methyl 20% WP + Chlorimuron ethyl 25% WP (4 gm/ha) on 10 DAS (T_5), directed spray of 2,4-D Dimethyl amine salt 58% SL @ 500 gm a.i./ha as POE at 15 DAS (T_6), Atrazine 50% WP @ 500 gm a.i./ha + Halosulfuron (75 gm a.i./ha) 10 DAS (T_7), tank mix of Atrazine 50% WP @ 500 gm a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 gm a.i./ha 10 DAS (T_8) and directed spray of Halosulfuron (75 gm a.i./ha) 15 DAS (T_9).

At 30, 45, and 60 DAS, as well as at harvest, weed dry matter and count were recorded from a 0.5 m^2 quadrant. To evaluate the effectiveness of various weed control techniques, weed control efficiency and weed index were developed. Five randomly chosen plants were used to collect data on growth and yield attributes at 30, 45, 60, and at harvest. The harvest took place on May 10, 2021. Based on market pricing for inputs and outputs, the economic parameters were computed. After statistical analysis, a year's worth of pooled data was displayed.

Results and Discussion

Studies on Weeds

The major weed species observed in the experimental plot were grassy weeds like *Cynondon dactylon*i *Dinebra retroflexa*i *Brachiaria eruciformis*; broad-leaf weeds like *Parthenium hysterophorus*i *Xanthium strumarium*i *Phyllanthus niruri*i *Digera arvensis*i *Euphorbia geniculata*i *Physalis minuma*; and sedges like *Cyperus rotundus.*

Weed count, weed control efficiency and weed index

The total number of weeds and their dry matter were reduced by all weed management methods. In the weed-free plot (manual weeding as and when necessary), the weed count and dry matter were noticeably lowest. Among the herbicidal weed management treatment weed count (4 & 6.97 m^2) was lower in tank mix of Atrazine 50%WP @ 500 gm a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 gm a.i./ha 10 DAS (T_8) as compared to other treatments at 45 DAS and at harvest, respectively. In weed free treatment, there was no weed dry matter due to absence of weeds. The weedy check recorded the highest weed biomass. Similar results were reported by Ramakrishna (1994) [7] in which they observed that the best weed control and grain yield of pearl millet were achieved with a pre-emergence treatment of atrazine @ 0.50 kg a.i. ha^{-1} combined with one-hand weeding.

Table 1: Effect of weed management practices on weed count, weed dry matter, weed control efficiency and weed index

Treatment	Weed count (m2)		Weed dry matter (g)		Weed control efficiency (%)		Weed index (%)
	45 DAS	At harvest	45 DAS	At harvest	45 DAS	At harvest	
T_1: Weedy check (Control)	18.00	28.67	23.11	48.76	100	100	35.01
T_2: Weed free (Hand weeding as and when required)	0	0	0	0	0	0	0
T_3: Directed spray of Atrazine (PE) 50%WP @ 500g a.i. /ha at 3 DAS	8.67	16.99	10.68	23.81	53.72	51.17	14.90
T_4: Tank mix of Halosulfuron (75gm a.i./ha-1) + 2,4- D Dimethyl amine salt 58% SL @ 500gm a.i. /ha as POE 15 DAS	4.33	9.61	8.24	18.97	64.83	61.11	3.59
T_5: Metsulfuron methyl 20% WP + Chlorimuron ethyl 25% WP (4 gm/ha) on 10 DAS	11.33	24.34	11.14	28.96	51.61	40.57	38.20
T_6: Directed spray of 2,4-D Dimethyl amine salt 58% SL @ 500 gm a.i./ha as POE	6.67	16.00	12.19	24.51	47.21	49.77	14.74
T_7: Atrazine 50% WP @ 500 gm a.i./ha + Halosulfuron (75 gm a.i./ha) 10 DAS	4.33	13.33	9.41	21.93	59.14	55.03	12.52
T_8: Tank mix of Atrazine 50%WP @ 500 gm a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 gm a.i./ha 10 DAS	4.00	6.97	6.74	16.52	70.86	66.07	2.54
T_9: Directed spray of Halosulfuron (75gm a.i./ha) 10 DAS	8.33	15.01	11.09	25.25	51.79	48.19	25.67
SE(m)+	1.12	0.63	0.50	0.89	2.06	1.76	1.22
CD at 5%	3.39	1.90	1.51	2.68	6.19	5.29	3.68
General mean	7.28	14.56	10.29	23.19	44.30	41.32	16.35

At harvest tank mix of Atrazine 50% WP @ 500 g a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 g a.i./ha (T_8) recorded highest weed control efficiency (66.07%) and it was at par with tank mix of Halosulfuron (75 g a.i./ha^{-1}) + 2, 4- D Dimethyl amine salt 58% SL @ 500 g a.i. /ha as post emergence (T_4) (61.11%), respectively. By recording 100% weed control efficiency, the weed free treatment was found to be noticeably superior. In a study, Sharma and Jain (2003) [8] found that three hand weeding at 30, 45, and 60 DAS was more effective at controlling weeds than 2,4-D applied at 0.50 kg a.i. ha^{-1} followed by one hand weeding.

Among the weed control treatments, application of tank mix of Atrazine 50% WP @ 500 g a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 g a.i./ha (T_8) recorded lower weed index (2.54%) and it was at par with tank mix of Halosulfuron (75 g a.i./ha^{-1}) + 2, 4- D Dimethyl amine salt 58% SL @ 500 g a.i. /ha as post emergence (T_4) (3.59%). Weed free treatment recorded the lowest weed index (0%) indicating that there was no reduction in grain and fodder yields due to weed infestation. The highest weed index (38.20%) was recorded in Metsulfuron methyl 20% WP + Chlorimuron ethyl 25% WP (4 g/ha) (T_5). Similar results were obtained by Gautam and Kaushik (1984) [5] in which application of 2, 4-D @ 1 kg a.i. ha^{-1} with or without one hoeing after three weeks dramatically reduced weed population and dry weight of weeds compared to an unweeded control. According to Banga *et al.* (2000) [2] application of (Atrazine + Acetachlor) yielding similar results to mechanically weeded (20 and 35 DAS) and weed free plots.

Performance of pearl millet

When compared to weedy check and application of Metsulfuron methyl + Chlorimuron ethyl, which showed phytotoxic symptoms on pearl millet and ultimately resulted in low grain and fodder yield as compared to other weed management treatments, all weed control measures significantly increased the grain and fodder yield of pearl millet. (Table 2). The yields of grain and fodder were significantly higher in the weed-free treatment (3390 and 4779 kgha^{-1}, respectively) and were comparable to those of the tank mix of atrazine 50% WP at 500 gm a.i./ha plus 2,4-D Dimethyl amine salt 58% SL at 500 gm a.i./ha (T_8) (3310 and 4688 kgha-1, respectively). Among the herbicide treatments, tank mix of Atrazine 50% WP @ 500 gm a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 gm a.i./ha (T_8) (3310 and 4688 kgha-1) recorded maximum grain and fodder yield, which was comparable to tank mix of Halosulfuron (75 g a.i./ha-1) + 2, 4-D Dimethyl amine salt 58% SL.

The Metsulfuron methyl + Chlorimuron ethyl treated plot had the lowest grain and fodder yield (2095 and 3458 kgha^{-1}, respectively) due to phytotoxicity, and the weedy check had the highest yield despite competing with more weeds for nutrients, moisture, light, and space. These findings closely matched those of Deshveer (2005) [3], who found that all weed management methods considerably boosted the seed and stover production of pearl millet when compared to weedy control. They also reported that Oxyfluorfen @ 0.2 kg ha^{-1} followed by one hand weeding at 25 DAS recorded significantly higher seed (2408 kgha^{-1}) and stover (5220 kgha^{-1}) yield over all the weed control measures. The next best treatment with respect to grain and stover yield was atrazine at 0.5 kg ha^{-1} hand weeding at 25 DAS. Combination of Atrazine and 2, 4-D have proved better due to combine effect on weed control and resulted in good seed and fodder yield.

Economics

Due to the greater price of halosulfuron, the cost of cultivation was highest in the tank mix of halosulfuron (75 g a.i./ha^{-1}) + 2, 4-D Dimethyl amine salt 58% SL @ 500 g a.i./ha as post emergence (T_4) and atrazine 50% WP @ 500 g a.i./ha + halosulfuron (75 g a.i./ha) (Rs. The weed-free plot (T_2) (Rs. 79373 ha^{-1}) produced the highest gross financial results. While the tank mix of atrazine 50% WP at 500 g a.i./ha and 2,4-D Dimethyl amine salt 58% SL at 500 g a.i./ha (T_8) (Rs. 52460 ha^{-1}) with a greater B:C ratio of (3.09), produced the highest net financial returns.

Table 2: Effect of weed management practices on growth and yield parameters of pearl millet

Treatment	Plant height (cm)	No. of effective tillers/ plant	Earhead length (cm)	1000 grain weight (g)	Grain yield (kg/ha)	Fodder yield (kg/ha)	Gross returns	Cost of cultivation	Net returns (kgha^{-1})	B:C ratio
T_1	133.57	1.20	20.12	10.93	2203	3695	52176	24455	27631	2.13
T_2	145.37	2.13	25.49	11.52	3390	4779	79373	27905	51468	2.84
T_3	136.87	1.33	22.91	11.23	2885	4564	68042	24755	43287	2.74
T_4	142.20	1.93	24.62	11.38	3260	4671	76590	30425	46164	2.51
T_5	103.07	0.93	18.33	10.88	2095	3458	49555	26205	23350	1.89
T_6	139.20	1.33	23.01	11.16	2891	4409	68011	24755	43256	2.75
T_7	141.20	1.53	23.83	11.24	2966	4635	69904	30425	39479	2.29
T_8	144.40	2.00	24.78	11.39	3310	4688	77515	25055	52460	3.09
T_9	137.60	1.27	21.86	11.26	2520	4131	59579	30125	29454	1.98
SE(m)+	1.22	0.13	0.34	0.05	42.45	45.70	938.01	-	933.1	-
CD at 5%	3.66	0.39	1.03	0.16	127.78	137.56	2823.7	-	2808.8	-
Gen. mean	135.72	1.52	22.77	11.23	2837	4337	66749	-	39616	-

Results indicated that application of tank mix of Atrazine 50% WP @ 500 g a.i./ha + 2,4-D Dimethyl amine salt 58% SL @ 500 g a.i./ha (T_8) and tank mix of Halosulfuron (75 g a.i./ha^{-1}) + 2, 4- D Dimethyl amine salt 58% SL @ 500 g a.i. /ha as post emergence (T_4) appeared to be the best weed management practice to control the weeds and obtaining good yield.

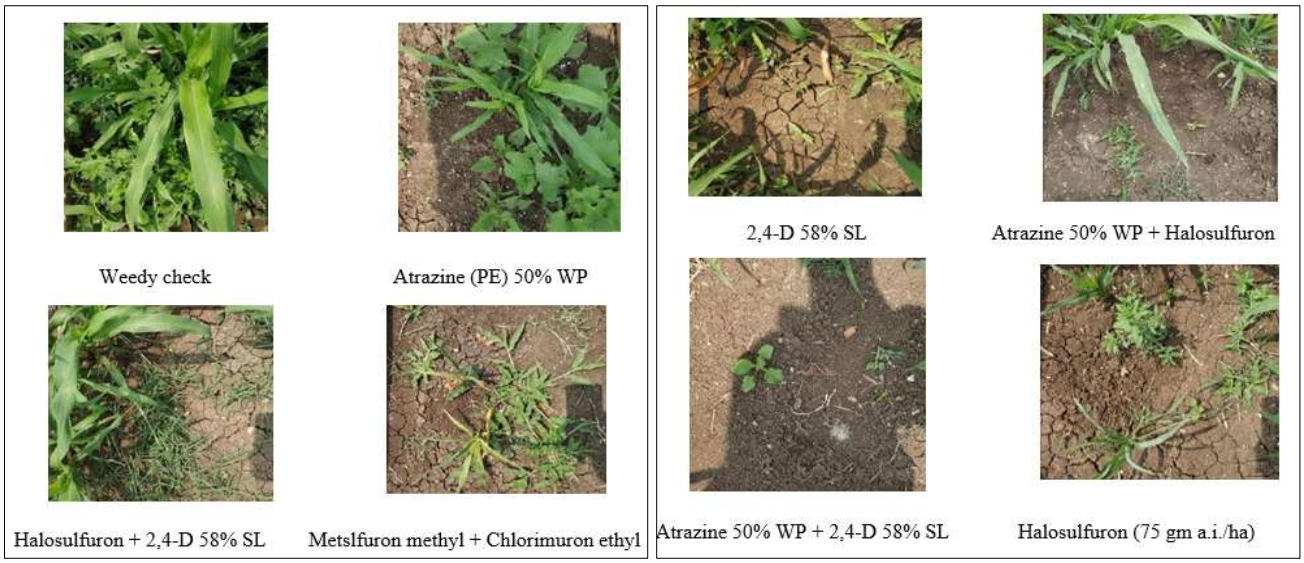

Fig 1: Effect of different weed management treatments and weed population 45 days after sowing

Conclusion

In the present investigation, an attempt was made to study the effect of different weed management treatments on growth and yield of pearl millet. With the weed studies *viz*., weed index, weed control efficiency their economics following conclusions were obtained.

1. When post-emergence herbicides were applied in a tank mix with atrazine 50%WP and 2,4-D Dimethyl amine salt 58% SL, the grain yield of pearl millet was increased (T_8).
2. The application of a tank mix of atrazine 50%WP at 500 g a.i./ha plus 2,4-D Dimethyl amine salt 58% SL at 500 g a.i./ha (T_8) produced the highest net returns and benefit cost ratio. Despite the hand weeding producing the best grain yield, the tank mix of atrazine 50%WP at 500 g a.i./ha and 2,4-D Dimethyl amine salt 58% SL at 500 g a.i./ha (T_8) had higher net returns and a lower benefit cost ratio because to higher cultivation costs.
3. Lower weed index and enhanced weed control efficacy were observed in (T_8) pearl millet when atrazine 50%WP and 2,4-D Dimethyl amine salt 58% SL were applied in tank mix.
4. One herbicide investigated that caused some financial loss was Metsulfuron methyl 20% WP + Chlorimuron ethyl 25% WP (4 g/ha) (T_5). When it is applied, crop development is slowed and the leaves begin to darken. The grain yield significantly decreased.

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