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Efficacy of Herbicides for Weed Control in Pearl Millet [*Pennisetum glaucum* (L.) R. Br. Emend Stuntz]

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ABSTRACT

A field experiment was conducted under loamy sand soil during *kharif*, 2016. The treatments comprising nine weed control measures [Weedy check, one HW at 20 DAS, two HW at 20 and 40 DAS, atrazine at 0.5 kg/ha (PE), atrazine at 0.5 kg/ha + one HW at 20 DAS, alachlor at 1.0 kg/ha (PE), alachlor at 1.0 kg/ha + one HW at 20 DAS, oxyfluorfen at 200 g/ha (PE) and oxyfluorfen at 200 g/ha + one HW at 20 DAS] were replicated thrice in Randomized Block Design. Pearl millet variety'RHB-173' was used as a test crop. Results showed that two HW at 20 and 40 DAS, atrazine at 0.5 kg/ha + one HW at 20 DAS and oxyfluorfen at 200 g/ha + one HW at 20 DAS significantly reduced the weed density and weed dry matter by increasing the weed control efficiency and decreasing weed infestation. Atrazine at 0.5 kg/ha + one HW at 20 DAS also provided lower weed desity/m^2 (36.58%), minimum weed infestation (60.01%), lower weed dry matter (363.2 kg/ha), minimum weed index (1.95%), weed index (1.95) and highest yield (1742 kg/ha^{-1}) and harvest index of 27.71% than weedy check treatment and thus found at par with two HW treatment. Atrazine at 0.5 kg/ha and one HW at 20 DAS were better and equally effective treatments recording lower weed indices (14.29 and 14.93%).

Keywords : Weed density, Weed dry matter, Weed control efficiency, Weed index, Yield.

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br. emend Stuntz], also known as candle millet, cattail millet, bulrush millet or bajra, is one of an important millet crops of India. India is the largest producer of pearl millet in the world occupying 7.38 mha with annual production of 9.13 million tonnes and average productivity of 1237 kg ha^{-1} (Anonymous 2017-18). Pearl millet is a warm weather corase cereal grown in semi-arid and arid climate of tropical and subtropical regions, as it is endowed with greater ability to with stand harsh environment.It is nutritionally better than many cereals as it is a good source of carbohydrate (67%), protein (12.6%), fat (5%) and minerals 2.8%. The energy level of 361 K cal is the highest among grain cereals or millets (Anonymous 2012). It is also rich in vitamins A and B, thiamin, riboflavin and imparts substantial energy to the body digestibility. Apart from grain, the stover for animal feed and fuel

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is an important secondary product for resource poor farmers (Arshewar et al. 2018). Like other rainy season crops, peari millet too faces severe weed competition in the initial stages leading to reduction in grain yield to the tune of 20-30%, however, under humid rainy season and extremely weedy situations, the loss may be as high as 55% (Banga et al. 2000) and 72% (Das and Yaduraju 1995). Hence, the crop should be kept free from weeds at least for the initial 25-30 DAS after which it picks up growth, start tillering and become more competitive against weeds.

The predominant methods of weed management are inter-culturing and hand weeding in pearl millet crop. The use of herbicides has revolutionized weed management and reduces the cost of cultivation. Though lot of research has been conducted on the use herbicides across crops but research and adoption of the same for effective weed control in pearl millet is meager. On the other hand, benefits of mechanical measures viz. loosening of soil, root aeration, deep root penetration, moisture conservation cannot be ignored. Hence, integrated weed management are effective and workable practices that may be used ecologically and economically viable to the farmers. Unavailability of adequate labor during peak period of weeding and difficulty in use of mechanical weeding in heavy rains create problem for effective weed management in crops (Nainwal et al. 2010). Therefore integrated approaches for weed management using chemical and manual methods were evaluated for efficient weed management and economic benefits in pearl millet.

MATERIALS AND METHODS

Field experiment was conducted under loamy sand soil during *Kharif* 2016 at Agronomy farm, S.K.N. College of Agriculture, Jobner is situated 45 km west of Jaipur at $26^{0}05'$ N-latitude and $75^{0}28'$ E- longitudes and at an altitude of 427 meters above mean sea level in jaipur district of Rajasthan. The region falls in Agroclimatic zone III-A (Semi-arid Easterm Plain). The average annual rainfall of this tract varies from 450 mm to 500 mm most of which is received during the period of July to September.The soil of the experimental field was loamy sand in texture, alkaline in reaction, poor in organic carbon with low available nitrogen and sulfur and medium in available phosphorus and potash. The treatments comprising nine weed control measures [Weedy check, one HW at 20 DAS, two HW at 20 and 40 DAS , atrazine at 0.5 kg/ha (PE), atrazine at 0.5 kg/ha +one HW at 20 DAS, alachlore at 1.0 kg/ha (PE), alachlor at 1.0 kg/ha + one HW at 20 DAS, oxyfluorfen at 200 g/ha (PE) and oxyfluorfen at 200 g/ha + one HW at 20 DAS] were replicated thrice in Randomized Block Design. Pearl millet variety 'RHB-173' was used as a test crop. The application of atrazine, alachlor, and oxyfluorfen were applied through aatrex 50 WP, lasso 50 EC,and rota 23.5 EC, respectively through a knap-sack hydraulic sprayer was used for spraying the herbicides using a spray volume of 800 liters/ha. Atrazine, alachlor, and oxyfluorfen were applied as pre emergence treatment to the respective plots one day after sowing of pearl millet. In the plots earmarked for hand weeding, the operation was done at 20 and 40 days after sowing (DAS) as per treatment. Data on weed density/m^2, weed infestation, weed dry matter and weed index were calculated as per the standard precedures.

RESULTS AND DISCUSSION

Weed infestation is obvious from the data (Table 1) that all the weed control treatments differed significantly in influencing weed infestation at different stages of crop. Unrestricted growth of weeds under weedy check treatment resulted in infestation of crop with weeds as high as 87.91, 86.60 and 85.28 per cent at 30 DAS, 60 DAS and at harvest stage, respectively. On the other hand, atrazine at 0.5 kg/ha + one HW at 20 DAS registered the lowest weed infestation value of 64.82 per cent at 30 DAS. At 60 DAS and at harvest, the lowest weed infestation (56.32 and 52.63%) was recorded under two HW treatment which was very closely followed by atrazine 0.5 kg/ha + one HW at 20 DAS (57.92 and 60.01%) and oxyfluorfen at 200 g/ha + one HW at 20 DAS (58.53 and 55.85%). These were followed in the order of a atrazine at 0.5 kg/ha, one HW at 20 DAS and alachlor at 1.0 kg/ha + one HW at 20 DAS. However, they remained at par among themselves. This increase in density and biomass of weeds under weedy check

Table 1. Effect of weed control treatments on density and infestation of weeds at different stages of crop.

Treatments	Weed density/m^2			Weed infestation (%)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Weedy check	12.88 (160.01)	12.14 (147.60)	11.45 (131.10)	87.91	86.60	85.28
One HW at 20 DAS	7.58 (57.50)	7.84 (61.45)	4.95 (48.27)	68.60)	70.01	67.16
Two HW at 20 and 40 DAS	7.71 (59.46)	5.63 (32.78)	5.26 (27.69)	70.05	56.32	52.63
Atrazine @ 0.5 kg/ha (PE)	8.75 (76.54)	7.41 (54.96)	7.19 (51.72)	75.77	69.19	68.42
Atrazine @ 0.5 kg/ha (PE) + one HW at 20 DAS	6.80 (46.20)	5.87 (34.510	6.05 (36.58)	64.82	57.92	60.01
Alachlor @ 1.0 kg/ha (PE)	9.62 (92.48)	8.86 (78.42)	8.36 (69.81)	79.82	72.04	75.93
Alachlor @ 1.0 kg/ha (PE) one HW at 20 DAS	8.39 (70.39)	7.58 (54.45)	6.96 (48.43)	74.91	70.90	67.73
Oxyfluorfen @ 200 g/ha (PE)	8.84 (78.14	8.22 (67.65)	7.17 (51.45)	77.86	75.27	70.31
Oxyfluorfen @ 200 g/ha (PE) + one HW at 20 DAS	6.46 (41.78)	5.73 (61.65)	5.27 (27.80)	65.07	58.53	55.85
SEm ±	0.39	0.37	0.30	3.76	3.17	2.82
CD (P=0.05)	1.17	1.10	0.91	11.25	9.51	8.44

plots might be attributed to the uninterrupted growth of weeds coupled with more competitive ability than crop that was almost smothered due to profuse growth of weeds. Heavy infestation and dry weight of weeds under unweeded control in pearl millet has also been reported by Singh and Singh (2010).

All the treatments evaluated for weed control in pearl millet under present study recorded significantly lower density of weeds at all the stages of observation in comparison to weedy check (Table 1). The lowest density at 30 DAS (41.78/m^2) was recorded under oxyfluorfen at 200 g/ha + one HW at 20 DAS. Remaining at par with strazine at 0.5 kg/ha + one HW at 20 DAS. At 60 DAS and at harvest stage, the lowest density was recorded under two HW 20 and 40 DAS. Remaining at par with oxyfluorfen at 200 g/h + one HW at 20 DAS and atrazine at 0.5 kg/ha + one HW at 20 DAS, it reduced the weed count by 35.7, 39.8, 46.7, 51.5, 58.2 and 77.8 per cent at 60 DAS and 42.6, 42.8, 46.2, 46.5, 60.3 and 78.9 per cent at harvest stage in comparison to atrazine at 0.5 kg/ha, alachlor at 1.0 kg/ha + one HW at 20 DAS, one HW at 20 DAS, oxyfluorfen at 200 g/ha + one HW at 20 DAS, oxyfluorfen 200 g/ha and weedy check treatments, respectively. Atrazine at 0.5 kg/ha + one HW 20 DAS and oxyfluorfen at 200 g/ha + one HW at 20 DAS reduced the weed count by 76.6 and 75.9 per cen at 60 DAS and 72.1 and 78.8 per cent at harvest, respectivelythan weedy check and thus found at par with two HW treatment. Atrazine 0.5 kg/ha, alachlor at 1.0 kg/ha + one HW at 20 DAS and one HW at 20 DAS were the next better treatments that resulted 6.2.8, 63.1 and 58.1 per cent lower weed density at 60 DAS and 60.5, 63.1 and 63.2 per cent at harvest stage, respectively than weedy check treatment. All the treatments evaluated for their weed control efficacy differed significantly in their effect on periodical weed dry matter production (Table 2). Pre-emergence application of atrazine at 0.5 kg/ha + one HW at 20 DAS recorded the significantly lowest dry matter 88.0 kg/ha at 30 DAS. However, it was found at par with alachlor at 1.0 kg/ha + one HW at 20 DAS and oxyfluorfen at 200 g/ha + one HW at 20 DAS. These treatments registered 74.2, 69.9 and 66.3 per cent lower weed dry matter at 30 DAS stage than weedy check treatment, respectively. The lowest dry matter of weeds at 60 DAS and at harvest (184.1 and 250.3 kg/ha) was recorded under two HW at 20 and 40 DAS treatment.It registered 86.2 and 86.0 per cent lower dry matter than weedy check

Table 2. Effect of weed control treatments on weed dry matter production and weed control efficiency at different stages of crop.

Treatments	Weed dry matter (kg/ha)			Weed control efficiency (5%)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
Weedy check	341.7	1329.8	1783.1	-	-	-
One HW at 20 DAS	190.5	479.2	650.6	44.23	63.97	63.51
Two HW at 20 and 40 DAS	185.9	194.1	250.3	45.60	86.16	85.96
Atrazine @ 0.5 kg/ha (PE)	240.1	340.3	756.5	29.72	59.37	57.58
Atrazine @ 0.5 kg/ha PE) + one HW at 20 DAS	88.0	251.6	324.7	74.26	81.08	81.79
Alachlor @ 1.0 kg/ha (PE)	256.7	610.4	815.6	24.85	54.10	54.26
Alachlor @ 1.0 kg/ha (PE) + one HW at 20 DAS	102.9	278.5	363.2	69.88	79.06	79.63
Oxyfluorfen @ 200 g/ha (PE)	270.7	620.7	835.9	20.78	53.32	53.12
Oxyfluorfen @ 200 g/ha (PE) + one HW at 20 DAS	115.3	273.2	349.4	66.26	79.45	80.40
SEm ±	10.4	23.5	29.2	2.00	3.19	2.88
CD (p = 0.05)	31.1	70.4	87.6	5.98	9.56	8.61

tretment. However, it was found at par with atrazine at 0.5 kg/ha + one HW at 20 DAS (251.6 and 324.7 kg/ha), wherein, the corresponding reduction was 81.1 and 81.2 per cent. Pre emergence application of oxyfluorfen at 200 g/ha + one HW at 20 DAS also represented 79.5 and 80.4 per cent lower weed dry matter at these two stages and thus showed statistical equivalence with atrazine at 0.5 kg/ha + one HW at 20 DAS treatment. Alachlor at 1.0 kg/ha + one HW at 20 DAS, one HW at 20 DAS and atrazine at 0.5 kg/ha were noted to be the next better treatments, wherein, 79.0, 63.9 and 59.4 per cent lower dry mater of weeds at 60 DAS and 79.6, 63.5 and57.8 per cent at harvest stage was observed in comparision to unweeded control, respectively. One HW treatment could provide the weed free environment to crop up to 30-35 DAS, only. Thereafter, the population and dry weight of weeds increased progressively with the advancement of crop growth due to later flushes of weeds and thus resulted in more density and dry matter of weeds at subsequently stages. On the other hand, another HW done at 40 DAS under two HW treatments effectively controlled the subsequent flushes of weeds that emerged at later stages and thus provided complete weed free environment to crop throughout the growing season. Theresults are in close conformity with the findings of Das et al. (2013) and Mishra et al. (2017) in pearl millet.

The maximum weed control efficiency of 74.26 at 30 DAS was recorded under atrazine at 0.5 kg/ha + one HW at 20 DAS. It was found at par with alachlor at 1.0 kg/ha + one HW at 20 DAS and oxyfluorfen at 200 g/ha + one HW at 20 DAS. The maximum weed control efficiency of 86.16 and 85.96 at 60 DAS and at harvest stages was recorded under two HW at 20 and 40 DAS. It was accompanied by atrazine at 0.5 kg/ha + one HW 20 DAS, oxyfluorfen at 200 g/ha + one HW at 20 DAS and alachlor at 1.0 kg/ha + one HW at 20 DAS. These three treatments controlled the weeds the tune of 81.1, 79.5 and 79.1 per cent at 60 DAS and 81.7, 80.4 and 79.6 per cent at harvest stages, respectively and showed statistically similarity with two HW at 20 and 40 DAS. The superiority of these treatments could mainly be ascribed to the fact that application of herbicide alone inhibited the germination and emergence of weeds during initial growth stage of crop only but at later stages, these herbicides dissipated and deactivated in the soil and second flush of weeds appeared in such plots. The hand weeding done at 20 DAS effectively controlled the weeds that emerged at later stage and thus kept the field weed free for a longer duration. Accelerated growth of crop due to looseness of soil and aeration in root zone incurred due to hoeing could by assigned as another reason of lower density and dry matter of weeds obtained under these treatments. The luxuriant crop growth achieved in weed free situation due to hoeing and aeration during initial stages under this treatment fully covered the plots and suppressed the later weed growth.

Table 3. Effect of weed control treatments on yield, harvest index and weed index of pearl millet.

Treatments	Yield (kg/ha) Grain yield	Stover yield	Biological yield	Harvest index (%)	Weed index (%)
Weedy check	897	2621	3518	25.50	48.51
One HW at 20 DAS	1482	3991	5473	27.08	14.93
Two HW at 20 and 40 DAS	1742	4545	6287	27.71	-
Atrazine @ 0.5 kg/ha (PE)	1493	4006	5499	27.15	14.29
Atrazine @ 0.5 kg/ha (PE) + one HW at 20 DAS	1708	4521	6229	27.42	1.95
Alachlor @1.0 kg/ha (PE)	1106	3146	4252	26.01	36.51
Alachlor @ 1.0 kg/ha (PE) + one HW at 20 DAS	1298	`3608	4906	26.46	25.49
Oxyfluorfen @ 200 g/ha (PE)	1096	3152	4248	25.80	37.08
Oxyfluorfen @ 200 g/ha (PE) + one Hw at 20 DAS	1286	3560	4846	26.54	26.18
SEm±	65	138	200	1.17	1.87
CD (p = 0.05)	194	414	598	NS	5.60

The experimental findings presented in Table 3 clearly showed that yield of pearl millet were significantly influenced due to different weed control treatments. The highest grain yield (1742 kg/ha^{-1}) was recorded under two HW 20 and 40 DAS treatment which was found at par with atrazine at 0.5 kg ha^{-1}+1 HW at 20 DAS, however, both these treatment significantly increased grain yield over weedy check. 1 HW at 20 DAS, Atrazine @ 0.5 kg ha^{-1} (PE), alachlor @ 1.0 kg/ha^{-1} (PE). alachlor @ 1.0 kg/ha^{-1} (PE) + 1 HW at 20 DAS, oxyfluorfen 2 200 ha^{-1} (PE), oxyfluorfen @ 200 g ha^{-1} (PE) + 1 HW at 20 DAS. Two HW 20 and 40 DAS treatment significantly improved grain yield to the extent of 94.2% over weedy check. The corresponding increases in grain yield due to application of atrazine at 0.5 kg ha^{-1} + 1 HW at 20 DAS was 90.4% . The maximum crop-weed competition due to unrestricted growth of weeds in weedy check plots resulted the highest reduction of 48.50 per cent in grain yield of pearl millet than two HW at 20 DAS and 40 das treatment. On the other hand, the least reduction in grain yield due to presence of weeds after two HW at 20 DAS and 40 DAS was observed in pre-emergence application of atrazine at 0.5 kg/ha + one HW at 20 DAS treated plots (1.95%). Application of atrazine at 0.5 kg/ha, one HW at 20 DAS, alachlor at 1.0 kg/ha + one HW at 20 DAS and oxyfluorfen at 200 g/ha + one HW at 20 DAS were found to be the next superior treatments inreducing crop weed-competition that was reflected in lower weed competition indices of 14.29, 14.93, 25.49 and 26.18 per cent under these treatments. Alachlor at 1.0 kg/ha and oxyfluorfen at 200 g/ha witnessed comparatively higher weed competition indices of 36.51 and 37.08 per cent due to their poor weed control efficiency. Reduction in crop-weed competition under these treatments saved a substantial amount of nutrients for crop which led to accelerated growth enabling the crop to utilize more soil moisture and nutrients. All these favorable effects resulted significant increase in various yield determining characters of pearl millet viz., number of grains/ear, length of car and test weight by improving source-sink relationship. The higher value of yield attributes coupled with higher dry matter recorded under these treatments might be the most probable reason of higher grain yield. In the presence of weeds, although vegetative growth occurred but sink was not sufficient enough to accumulate the meaningful food assimilates translocating towards grain formation. The most severe competition throughout the crop season due to unrestricted weed growth under weedy check plots increased the depletion and moisture by weeds, thus adversely affecting the crop growth and ultimately the lowest yield of crop. These results are strongly supported with the findings of Kaur and Sing (2006), Kiroriwal et al. (2012) and Munde et al. (2013) in pearl millet.

CONCLUSION

Based on one year experimentation, it may be concluded that pre emergence application of atrazine @ 0.5 kg/ha + one HW at 20 DAS was found the most superior treatment for weed control in pearl millet.

REFERENCES

Anonymous (2012) Nutritional and physical evaluation of selected pearl millet [*Pennisetum glaucum* (L.)] cultivars. Asian J Chem 24(12) : 5885—5888.

Anonymous (2017-18) Government of India, Ministry of Agri culture & Farmers Welfare, Department of Agriculture, Cooperation & Farmers Welfare, Directorate of Economics and Statistics, 86—88.

Arshewar SP, Karanjikar PN, Dambale AS, Kawde MB (2018) Effect of nitrogen and zinc levels on growth, yield and economics of pearl millet (*Pennisetum glaucum* L.). Int J Bio-resource and Stress Manag 9 (6) : 729—732,

Banga RS, Yadav A, Malik RK, pahwa SK, Malik RS (2000) Evaluation of tank mixture of acetachlore and atrazine or 2, 4-D Na against weeds in pearl millet. Ind J Weed Sci 32 (3 & 4) : 194—198.

Das J, Patel BD, Patel VJ, Patel RB (2013) Comparative efficacy of different herbicides in summer pearl miller.Ind J Weed Sci 45 (3) : 217—218.

Das TK, Yaduraju NT (1995) Crop weed competition studies in some *kharif* crops: 11, nutrient uptake and yield reduction. Annals of Pl Prot Sci 3 (2) 95—99.

Kaur A, Singh VP (2006) Weed dynamics as influenced by planting methods mulching and weed control in rainfed hybrid pearl millet (Pennisetum glancum) Ind J Weed sci 38 (1&20 : 135—136.

Kiroriwal A, Yadav RSK Kumawat A (2012) Weed management in millet based intercropping system. Ind J Weed Sci (3) : 200—203.

Mishra PS, Ramu RY, Subramanyam D, Umamahesh V (2017) Impact of intergrated weed management practices on weed dynamics, growth and yield of pearl millet [Pennisetum glaucum L, Br. Emend Stuntz]. Int J Agric Sci 9 : 3677—3679.

Munde SD, Patel JC, Ali S, Aghav VD (2013) Weed control study in kharif pearl millet (Pennisetum glaucum). Bioinfolet 10 (2A) : 464—468.

Nainwal RC, Saxena SC, Singh VP (2010) Effect of pre and post emergence herbicides on weed infestation and productivity of Soybean. Ind J Weed Sci 42 (1&2) : 17—20.

Singh Ragluvir, Singh HR (2010) Effect of methods of sowing and herbicides on the yield of pearl millet (Pennisetum glaucum).Programic Agric 10 (1) : 111—113.