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Study on Comparitive Efficacy of Pre and Post Emergence Herbicides for Weed Management in Pearl Millet (*Pennisetum glaucum* (L.) R. Br. Emend. Stunz)

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Abstract

A field experiment was conducted during *kharif,* 2016 at Regional Agricultural Research Station, Tirupati, Acharya N.G. Ranga Agricultural University with an objective to study the efficacy of different herbicides for effective weed control in pearl millet. The results revealed that pre-mergence (PE) application of oxyflourfen@75 g *a.i* ha^{-1} affected the crop germination and phytotoxic symptoms were observed on the emerged seedlings with yellowing of leaf tips and stunted growth. However the plants were gradually recovered and the visual phytotoxicity scoring was 4. Post-emergence (POE) application of chlorimuron-ethyl + metsulfuron-methyl @ 4 g *a.i* ha^{-1} at 2-4 leaf stage of weeds had effectively controlled broad leaved weeds and sedges compared to POE application ethoxysulfuron @ 37.5 g *a.i* ha^{-1} . The lowest weed density and dry weight, highest weed control efficiency were recorded with hand weeding (HW) twice at 20 and 40 DAS, followed by PE application of atrazine @ 750 g *a.i* ha^{-1} + hand weeding at 30 DAS. However, the higher net returns (Rs. 31777/ha) and B:C ratio (2.89) were obtained with PE application of atrazine @ 750 g *a.i* ha^{-1} fb POE application of chlorimuron – ethyl + metsulfuron-methyl @ 4 g *a.i* ha^{-1} at 2-4 leaf stage of weeds followed by PE application of atrazine @ 750 g *a.i* ha^{-1} + hand weeding at 30 DAS. Hence, the choice of weed management practice in pearl millet may be followed based on the feasibility for hand weeding, availability and cost of labour.

Key words : *Pearl millet, pre-emergence, post-emergence, atrazine, oxyflourfen, chlorimuron ethyl+ metsulfuron-methyl, pearl millet.*

Introduction

Pearl millet (*Pennisetum glaucum* (L.) R. Br. Emend. Stuntz.) is an important coarse cereal dual purpose crop predominantly being cultivated in arid and semi-arid regions of India. It has drought tolerance contributing potentially for food, fodder and nutritional security with a major role in crop diversification. Pearl millet is cultivated in an area of 6.93 M ha with production of 8.61 M tonnes and productivity of 1243 kg/ha (1).

During *kharif* season, pearl millet is grown as a subsistence crop in marginal and sub-marginal lands with low inputs. Wider spacing of the crop coupled with nature of slow initial growth aggravates the weed infestation along with continuous rains throughout the crop period. Thus due to the susceptibility of the crop at early growth stage, weeds deprive pearl millet for nutrients and moisture resulting in 40 per cent or more reduction of the grain yield (2). Though hand weeding and intercultivation are widely adopted for effective weed control, it is not feasible to practice in time during rainy season apart from escalating labour charges with scarcity of labour. In the changing scenario of agriculture, chemical weed management alone or in combination with mechanical methods is emerging as an alternate strategy for effective weed control.

Pre-emergence application of herbicide control weeds effectively for initial 30 days. But in few instances their usage is not feasible and their higher doses of soil application lead to environmental pollution. At present, many new generation low volume herbicides for post-emergence application are being evolved which can provide effective and economical weed control in various crops (3). In this context, the experiment was conducted to study the phytotoxic effect of various herbicides and their efficacy of weed control in pearl millet.

Materials and Methods

A field experiment was conducted during *kharif,* 2016 at RARS, Tirupati of ANGRAU campus, Andhra Pradesh. The soil was sandy loam in texture with low in organic carbon (0.58%) and available nitrogen (212 kg ha^{-1}), high in available phosphorus (73 kg ha^{-1}) and medium in available potassium (204 kg ha^{1}). The experiment was laid out in randomized block design replicated thrice with hybrid ABH-06. The recommended dose of 80 kg nitrogen in the form of urea was applied in two splits as half at sowing and remaining half at 30 DAS whereas 40 kg P_2O_5 and 30 kg K_2O ha^{-1} were applied at the time of sowing. The crop was sown at 45 cm x 10 cm and thinning was carried out at 10 DAS with one seedling hill^{-1}.

The weed management treatments consisted of T_1 – PE of atrazine @ 750 g a.i. ha^{-1}, T_2 - PE of oxyflourfen @ 75 g a.i. ha^{-1}; T_3 - T_1 + HW at 30 DAS ; T_4 - T_1 + HW at 30 DAS ; T_5 - T_1 fb POE of chlorimuron ethyl + metsulfuron-methyl @ 4 g a.i. ha^{-1}; T_6 - T_1 fb POE of ethoxysulfuron @

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37.5 g a.i. ha^{-1}; T_7 - T_2 fb POE of chlorimuron-ethyl + metsulfuron-methyl @ 4 g a.i. ha^{-1}; T_8 – T_2 fb POE of POE of ethoxysulfuron @ 37.5 g a.i. ha^{-1}; T_9 – HW at 20 and 40 DAS and T_{10} – Weedy check. Pre-emergence application of atrazine and oxyflourfen was done immediately after sowing, whereas the post- emergence application of chlorimuron – ethyl + metsulfuron-methyl @ 8 g *a.i* ha^{-1} and ethoxysulfuron was carried out at 2- 4 leaf stage of weeds i.e at 20 DAS with a spray fluid of 500 l/ha through knap sack sprayer fitted with flat fan nozzle. Two hand weddings were carried out at 20, 30 and 40 DAS in the respective treatments. Weed parameters i.e the various predominant weed species present in the experimental field were observed throughout the crop growth period along with weed density and dry weight at 50 DAS and harvest were recorded by placing a quadrant of 0.5 m x 0.5 m randomly at two places in each plot. The data was subjected to square root transformation. Weed control efficiency in different weed management plots was calculated based on the reduction of the weed dry matter with following formula (4).

$$WCE = \frac{WDM_C - WDM_T}{WDM_C} \quad 100$$

WDM_C = Weed dry weight in weedy check plot

WDM_T = Weed dry weight in treatmental plot

Results and Discussion

Effect on weeds : The major weed flora observed in the experimental field are *Echinochloa colona, Panicum repens, Cynodon dactylon, Dactyloctenium aegyptium, Digitaria sanguinalis* among grasses, *Amaranthus viridis, Boerhavia diffusa, Boreria hispida, Cleome viscosa, Commelina bengalensis, Euphorbia hirta, Merrimia emerginata, Phyllanthus niruri, Trianthema portulacastrum, Trichodesma indica,* grasses are among broad leaved weeds and *Cyperus* sps in sedges group.

The herbicides applied either as pre or post emergence have effectively controlled the weeds in terms of density and dry weight compared to weedy check. Two HW at 20 and 40 DAS recorded lowest weed density and dry weight of weeds and highest weed control efficiency (WCE) (Table-1). PE application of atrazine fb HW at 30 DAS was the next best integrated weed management practice that resulted in lesser weed density and dry weight along with higher WCE and was comparable to PE application of oxyflourfen fb HW at 30 DAS, which might be due to the effect of these herbicides in hindering the weed seeds germination and in continuation of the hand weeding imposed at 30 DAS had eliminated the weeds at later stages. Among the POE application of herbicides, chlorimuronethyl + metsulfuron- methyl @ 4 g a.i ha^{-1} was proved to be effective than ethoxysulfuron @ 37.5 g a.i ha^{-1} in respect to weed density and dry weight. Hence, PE application of atrazine or oxyflourfen fb post-emergence application of chlorimuron ethyl + metsulfuron-methyl registered higher WCE at 50 DAS and even at harvest. PE application of atrazine or oxyflourfen alone is not sufficient to ensure the weed control upto 50 DAS and hence when it is integrated either with HW or followed by POE application of chlorimuron ethyl + metsulfuron-methyl@ 4 ga.i./ha was effective in continuous control of all the weeds at later stages of crop growth. Weedy check resulted in significantly higher weed density and dry weight with least WCE compared to all the other weed control treatments.

Effect on Crop : Pre-emergence application of atrazine did not show any phytotoxic symptoms and not affected germination, oxyflourfen @ 75 g a.i ha^{-1} had shown phytotoxic symptoms with a score of 3.0 at 10 days after sowing as severe leaf chlorosis and poor seedling vigour with a doubt of further recovery even after 15 DAS. However the POE application of chlorimuron ethyl + metsulfuron-methyl @ 4 g a.i. ha^{-1} and also ethoxysulfuron @ 37.5 g. a.i ha^{-1} caused slight discoloration and recovered completely by 15 DAS.

The growth parameters of pearl millet *viz*., plant height, no of leaves $plant^{-1}$, tillers $plant^{-1}$ recorded at harvest differed significantly due to different weed management practices. (Table-3). Significantly the higher growth stature of the crop was recorded with two HW at 20 and 40 DAS which was comparable to PE application of atrazine fb either with HW at 30 DAS or POE application of chlorimuron ethyl + metsulfuron-methyl @ 4 g a.i./ha. Hand weeding at 20 and 40 DAS provided effective weed control and created an ambient micro environment to the crop for efficient utilization of available resources during the critical crop weed competition period which resulted in improved growth parameters. However, the PE application of atrazine provided weed free environment from the beginning without deleterious effect on crop and the HW imposed at 40 DAS as well as POE application of chlorimuron ethyl + metsulfuron-methyl @ 4 g a.i./ha continuously reduced weed population and enhanced the growth parameters. The phytotoxic effect of oxyflourfen lead to poor germination, stunted growth and chlorosis of leaves and resulted in inflated growth stature.The results were supported by (5, 6, 7, 8, 9).

With regard to yield attributes, HW at 20 and 40 DAS produced inflated stature with higher number of productive tillers $plant^{-1}$, panicle length, grain weight $panicle^{-1}$, weight $panicle^{-1}$ which was in parity with PE application of atrazine fb HW at 30 DAS and PE application of atrazine fb POE application of chlorimuron ethyl+ metsulfuron-methyl @ 4 g a.i./ha. (Table-3). This

Table-1 : Weed density, dry weight and weed control efficiency in bajra as influenced by different weed management practices.

Treatment	Weed Density (No./m^2)		Weed Dry Weight (g/m^2)		Weed Control Efficiency (%)	
	50 DAS	At Harvest	50 DAS	At Harvest	50 DAS	At Harvest
T_1 - PE of atrazine @ 750 g a.i. ha^{-1}	9.55 (100.66)	11.06 (126.0)	7.67 (58.4)	9.39 (87.2)	60.2	52.5
T_2 - PE of oxyflourfen @ 75 g a.i. ha^{-1}	10.17 (106.33)	11.59 (134.0)	8.01 (61.7)	9.65 (92.3)	57.9	49.8
T_3 - T_1 + HW at 30 DAS	5.02 (31.33)	6.64 (43.66)	3.65 (12.7)	4.92 (23.5)	93.4	87.2
$4T_4$ - T_1 + HW at 30 DAS	5.09 (34.66)	7.12 (50.33)	3.75 (13.4)	5.26 (27.2)	90.9	85.2
T_5 - T_1 fb POE of chlorimuron ethyl + metsulfuron-methyl	6.35 (47.33)	7.62 (57.66)	5.39 (28.4)	7.07 (49.3)	80.7	73.1
T_6 - T_1 fb POE of ethoxysulfuron @ 37.5 g a.i. ha^{-1}	7.23 (64.66)	9.03 (81.66)	6.14 (36.9)	7.62 (57.3)	74.8	68.8
T_7 - T_2 fb POE of chlorimuron-ethyl + metsulfuron-methyl @ 4 g a.i. ha^{-1}	6.74 (52.66)	8.79 (77.00)	5.61 (30.7)	7.40 (54.0)	79.1	70.6
T_8 – T_2 fb POE of POE of ethoxysulfuron @ 37.5 g a.i. ha^{-1}	8.74 (52.66)	10.22 (104.33)	6.24 (38.2)	7.73 (59.2)	73.9	67.8
T_9 – HW at 20 & 40 DAS	2.61 (7.66)	5.44 (29.33)	2.53 (5.8)	4.05 (16.8)	96.0	91.4
T_{10} – Weedy check	12.40 (153.00)	12.90 (166.66)	12.13 (146.3)	13.50 (183.7)	—	—
	0.218	0.265	0.312	0.232		
	0.65	0.79	0.93	0.69		

Table-2 : Growth parameters and Yield attributes of bajra as influenced by different weed management practices.

Treatment	Plant height (cm)	Tillers/ plant	No. of leaves/ plant	Productive tillers/ plant	Panicle length (cm)	Grain weight/ panicle	Test weight (g)
T_1 – PE of atrazine @ 750 g a.i. ha^{-1}	193.6	2.33	11.23	1.83	31.9	12.0	6.89
T_2 - PE of oxyflourfen @ 75 g a.i. ha^{-1}	170.6	2.30	11.13	1.60	28.3	9.54	5.86
T_3 - T_1 + HW at 30 DAS	201.5	3.20	12.53	2.50	32.6	12.50	7.10
T_4 - T_1 + HW at 30 DAS	178.5	2.53	11.13	1.70	29.7	10.28	6.12
T_5 - T_1 fb POE of chlorimuron ethyl + metsulfuron-methyl @ 4 g a.i. ha^{-1}	199.7	3.12	12.53	2.36	33.1	12.31	7.05
T_6 - T_1 fb POE of ethoxysulfuron @ 37.5 g a.i. ha^{-1}	195.8	2.98	12.13	2.35	32.3	12.29	6.94
T_7 - T_2 fb POE of chlorimuron-ethyl + metsulfuron-methyl @ 4 g a.i. ha^{-1}	174.6	2.50	11.23	1.73	28.3	10.17	6.08
T_8 – T_2 fb POE of ethoxysulfuron @ 37.5 g a.i. ha^{-1}	173.2	2.47	11.23	1.67	27.2	9.86	5.92
T_9 – HW at 20 & 40 DAS	202.3	3.23	12.93	2.64	33.4	12.92	7.12
T_{10} – Weedy check	155.7	1.74	8.53	1.13	24.8	8.37	5.32
S.Em ±	4.31	0.118	0.271	0.144	0.664	0.377	0.162
C.D. (P=0.05)	12.7	0.35	0.80	0.43	1.97	1.12	0.48

might be due to the enhanced growth parameters i.e higher number of tiller primordia initiation in turn resulted in productive tillers and more number of leaves contributed to higher photosynthetic efficiency. Hence, the photosynthates produced effectively by the enhanced source size facilitated their translocation to the sink and improved number of grains panicle^{-1}, grain weight panicle^{-1} and test weight. Further, the elevated yield attributes were projected as higher grain and straw yields with two HW at 20 and 40 DAS and however in parity with the integrated weed management practice of PE application of atrazine fb HW at 40 DAS or sequential application of PE of atrazine fb POE application of chlorimuron ethyl + metsulfuron-methyl @ 4g a.i./ha.

In weedy check the unrestricted germination and growth of weeds lead to increase in weed population and offered severe competition to crop which resulted in deflated stature of growth and yield attributes of pearl millet and resulted in 50.2 and 47.3 per cent reduction in

Table-3 : Yield and economics of bajra as influenced by different weed management practices.

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	H.I	Net Returns (Rs./ha)	B:C ratio
T_1 - PE of atrazine @ 750 g a.i. ha^{-1}	1983	3327	37.3	25362	2.58
T_2 - PE of oxyflourfen @ 75 g a.i. ha^{-1}	1543	2873	34.9	16138	2.00
T_3 - T_1 + HW at 30 DAS	2395	3824	39.0	30000	2.64
T_4 - T_1 + HW at 30 DAS	1791	3032	37.1	15984	1.50
T_5 - T_1 fb POE of chlorimuron ethyl + metsulfuron- methyl	2337	3769	39.6	31777	2.80
T_6 - T_1 fb POE of ethoxysulfuron @ 37.5 g a.i. ha^{-1}	2046	3417	37.4	25242	2.45
T_7 - T_2 fb POE of chlorimuron-ethyl + metsulfuron- methyl @ 4 g a.i. ha^{-1}	1692	2985	36.2	18313	2.08
T_8 - T_2 fb POE of ethoxysulfuron @ 37.5 g a.i. ha^{-1}	1534	2906	34.5	16603	1.94
T_9 - HW at 20 & 40 DAS	2535	3902	39.4	29637	2.30
T_{10} - Weedy check	1263	2584	32.8	11238	1.73
S.Em ±	67.8	66.9		1383	0.084
C.D. (P=0.05)	200	256		4122	0.25

grain yield compared to two HW at 20 and 40 DAS and PE application of atrazine + HW at 30 DAS respectively.

Economics : The higher net returns (Rs.31777/ha) and B:C ratio (2.89) were obtained with pre-emergence application of atrazine fb post emergence application of chlorimuron ethyl + metsulfuron-methyl @ 4g a.i./ha followed by the integrated weed management practice of pre-emergence application of atrazine fb HW at 40 DAS (Rs.30000/ha and 2.30) (Table.4). Though two HW at 20 and 40 DAS resulted in higher grain and straw yields of pearl millet, the increased cost of cultivation due to the labour charges incurred towards hand weeding reduced the net returns and benefit cost ratio (Rs.29637/ha and 2.30).

Conclusions

PE application of atrazine @750g a.i.ha^{-1} fb HW at 30 DAS is the best integrated weed management practice for higher grain yield of bajra. However the sequential application of herbicides *i.e* PE application of atrazine @750g a.i./ha fb POE application of chlorimuron ethyl + metsulfuron-methyl @ 4 g a.i./ha at 2-4 leaf stage of weeds proved to be an effective combination against wide range of weeds and an economical weed management strategy in bajra.

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