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Evaluation of post-emergence herbicides in pearl millet (*Pennisetum typhoides*)

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Abstract
To study the effect of different post-emergence herbicides against weeds in pearl millet a field experiment was conducted at Agricultural College Farm, Bapatla during *Kharif* 2016. Results of the experiment showed that the application of metsulfuron + chlorimuron ethyl 4 (2+2) g a.i./ha was effective and economical in controlling weeds in pearl millet without any phytotoxic effect on the crop and is thus an effective alternative for manual weeding

Keywords: Post-emergence herbicides, phytotoxicity, weed density, weed control efficiency, pearl millet

1. Introduction
Pearl millet, also known as candle millet, bulrush millet or bajra, is an important crop of rainfed areas of India. It is the fifth important cereal after paddy, wheat, maize and sorghum. In pearl millet the critical period of weed competition is up to 35 days after sowing, suggesting the importance of maintaining weed free environment during this period. Weeds cause reduction in grain and straw yields of *Kharif* pearl millet. On an average, 55% yield reduction due to heavy weed infestation in pearl millet crop was observed by Banga *et al*. (2000) [1].
Weeds emerge along with the crop during rainy season, cause serious competition with the crop plant during initial growth period of crop resulting in yield loss up to 40% or more (Sharma and Jain, 2003) [4].
Though manual weeding is effective, it does not ensure weed removal at critical stages of crop-weed competition and bad weather conditions. Thus herbicide usage seems indispensable and an economic alternative method for weed control.
With the discovery of synthetic herbicides in the early 1940s, there was a shift in control methods towards high input and target-oriented ones. Although the pre-emergence application of herbicides found to be effective in controlling weeds, their usage is not only difficult but also can cause crop injury and effect environment because of higher doses used. Ecological problems emanating from the use of higher dose herbicides lead to the birth of environmentally safer new generation of post-emergence herbicides, which are effective at very low doses in different crops (Dhiman Mukherjee and Singh, 2002) [2]. Hence the present study was taken up to know the efficacy and phytotoxic effect of different post-emergence herbicides in pearl millet.

Material and Methods
An experiment was conducted at Agricultural College Farm, Bapatla during *Kharif* 2016. The soil of the experimental plot was sandy in texture with pH of 7.4, low in organic carbon (0.4%) and available nitrogen (159.5 kg/ha), medium in available phosphorus (20 kg/ha) and available potassium (330.5 kg/ha). A total rainfall of 541.30 mm was received in 22 rainy days during the crop growth period.
The experiment was laid out in a randomized block design with nine treatments and replicated four times. Recommended doses of 60:30:20 kg/ha nitrogen, phosphorus and potassium were applied in the form of urea, SSP and MOP, respectively. Entire quantity of phosphorus, potassium and half of nitrogen was applied as basal. The remaining nitrogen was applied as top dressing at 35 days after sowing. Bold and healthy seeds were hand dibbled by adopting a spacing of 45 cm x 15 cm. Seed rate (3 kg/ha) was calculated based on test weight and germination percentage.

In weedy check, weeds are allowed to grow throughout the crop growth period, where as in second treatment weed free conditions were maintained. First hand weeding was done at 20 days after sowing followed by a second hand weeding at 40 days after sowing to remove weeds. Treatments involving the application of post-emergence herbicides were sprayed uniformly with a knapsack sprayer fitted with flood jet nozzle at 20 days after sowing. The spray volume used for the herbicide application was 500 L/ha.

The data on weed density and weed drymatter were recorded at 60 days after sowing and harvest and were subjected to square root transformation ($\sqrt{X+0.5}$) before statistical analysis to normalize the distribution. The growth and yield attributes were recorded at the time of maturity. Economics of different treatments were calculated taking into account of the prevailing market prices of input and output.

Results and Discussion

Cleome viscosa, *Boerhavia diffusa* and *Commelina benghalensis* among broad leaved weeds; *Dactyloctenium aegyptium* and *Echinochloa colona* among grasses; *Cyperus rotundus* and *Fimbristylis milliacea* among sedges are the predominant weed species that were observed in the experimental field during investigation.

Among the weed management treatments, application of penoxsulam 22.5 g a.i./ha resulted in the lowest weed density, drymatter and highest weed control efficiency, which is on par with the application of metsulfuron + chlorimuron ethyl 4 (2+2) g a.i./ha.

Herbicide application exhibited profound influence on growth parameters of pearl millet, *viz*. plant height and drymatter accumulation at different stages of crop growth. At harvest the highest plant height was recorded with hand weeding at 20 and 40 days after sowing over the other treatments. Among the herbicidal treatments the maximum height was observed with the application of 2, 4-D 800 g a.i./ha and the highest drymatter accumulation was obtained in hand weeding twice at 20 and 40 days after sowing (9684.66 kg/ha). Among the herbicide treatments, penoxsulam 22.5 g a.i./ha (8209.99 kg/ha) recorded highest drymatter accumulation. Highest grain yield and low weed index were obtained in the treatment *i.e.* metsulfuron + chlorimuron ethyl 4 (2+2) g a.i. /ha.

Among the various herbicides applied, metsulfuron + chlorimuron ethyl, penoxsulam, ethoxysulfuron, bispyribac sodium and fenoxaprop ethyl+ safenor showed phytotoxicity symptoms. metsulfuron + chlorimuron ethyl, penoxsulam and ethoxysulfuron have slight discoloration and recovered in 7 to 14 days after application. The symptoms of slight stunting and discoloration were observed by application of bispyribac sodium which gradually vanished by 14 to 21 days after application. fenoxaprop ethyl+ safenor proved to be phytotoxic to the crop with complete loss of crop stand.

Economics of various herbicide applications revealed that the better growth and yield performance of pear lmillet was achieved with the application of metsulfuron + chlorimuron ethyl 4 (2+2) g a.i./ha, which resulted in the highest net returns (□25,728) and the highest benefit cost ratio (2.19).

On the basis of results obtained in the present experiment, it can be concluded that the application of metsulfuron + chlorimuron ethyl 4 (2+2) g a.i./ha was effective and economical in controlling weeds in pear lmillet without any crop injury and is thus an effective alternative for manual weeding.

Table 1: Phytotoxic effects of different herbicidal treatments on pearl millet

Treatments	Crop injury score		
	Days after spraying		
	7	14	21
Weedy check	-	-	-
Hand weeding 20 and 40 DAS	-	-	-
cyhalofop butyl 100 g a.i. / ha as POE at 20 DAS	2	1	0
fenoxaprop ethyl+ safenor 63 g a.i. /ha as PoE at 20 DAS	5	9	10
metsulfuron + chlorimuron ethyl 4 (2+2) g a.i. /ha as PoE at 20 DAS	1	1	0
bisphyribac sodium 25 g/ha as PoE at 20 DAS	3	3	2
penoxsulam 22.5 g a.i. /ha as PoE at 20 DAS	1	0	0
2, 4-D 800 g a.i. /ha as PoE at 20 DAS	0	0	0
ethoxysulfuron 18.75 g a.i. /ha as PoE at 20 DAS	1	1	0

*Score was given according to phytotoxicity score card given by Rao (2000).

Table 2: Effect of weed management practices on yield attributes, harvest index (%), weed

Treatments	1000 grain weight (g)	Grain yield (kg /ha)	Stalk yield (kg /ha)	Harvest index (%)	Weed index (%)	B:C ratio
Weedy check	10.39	1926	4750.00	28.99	43.04	1.53
Hand weeding at 20 and 40 DAS	10.42	3393	6750.00	34.50	0.00	1.66
cyhalofop butyl 100 g a.i./ha as PoE at 20 DAS	10.20	1765	5000.00	25.84	48.54	1.30
fenoxaprop ethyl+ safenor 63 g a.i. ha^{-1} as PoE at 20 DAS	0.00	0.00	0.00	0.00	100.00	0.00
metsulfuron + chlorimuron ethyl 4 (2+2) g a.i. /ha as PoE at 20 DAS	11.26	2994	5350.00	35.82	12.07	2.19
bisphyribac sodium 25 g a.i. /ha as PoE at 20 DAS	10.47	2130	5500.00	27.62	36.18	1.48
penoxsulam 22.5 g a.i. /ha as PoE at 20 DAS	11.07	2631	5700.00	32.25	22.25	1.87
2, 4-D 800 g a.i. /ha as PoE at 20 DAS	11.21	2387	6000.00	28.75	29.82	1.84
ethoxysulfuron 18.75 g a.i./ha [1] as PoE at 20 DAS	11.45	2295	5150.00	30.77	31.45	1.72
LSD (p=0.05)	NS	806	NS	NS	22.54	
CV (%)	9.11	22	25.24	17.09	41.86	

Table 3: Effect of weed management practices on weed density (No. /m^2), Weed drymatter (kg /ha), Weed control efficiency (%),Plant height (cm) and Plant drymatter (kg /ha) at harvest.

Treatments	Weed density (No.m^{-2})	Weed drymatter (kg/ha)	Weed control efficiency (%)	Plant height (cm)	Plant drymatter (kg/ha)
Weedy check	14.53 (230.00)	137.95	-	175.90	6279.35
Hand weeding at 20 and 40 DAS	10.06 (104.50)	5.83	95.78	185.33	9684.66
cyhalofop butyl 100 g a.i. /ha as PoE at 20 DAS	14.71 (227.25)	97.40	29.37	157.61	6390.30
fenoxaprop ethyl+ safenor 63 g a.i. /ha as PoE at 20 DAS	12.24 (156.00)	64.53	53.21	0.00	0.00
metsulfuron + Chlorimuron ethyl 4 (2+2) g a.i. /ha as PoE at 20 DAS	15.08 (230.00)	58.13	57.64	167.92	8103.63
bisphyribac sodium 25 g a.i. /ha as PoE at 20 DAS	15.32 (237.50)	90.15	34.74	124.04	7282.69
penoxsulam 22.5 g a.i. /ha as PoE at 20 DAS	12.73 (172.00)	48.80	64.63	172.58	8209.99
2, 4-D 800 g a.i. /ha as PoE at 20 DAS	16.83(293.00)	95.65	30.63	177.71	7993.68
ethoxysulfuron 18.75 g a.i. /ha as PoE at 20 DAS	16.06 (263.00)	68.23	50.53	168.54	7018.34
LSD (p=0.05)	NS	12.06	9.08	27.09	1192.61
CV (%)	23.68	10.86	11.64	10.88	10.44

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