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Evaluation of some post-emergence herbicides and their mixtures for weed control in wheat (*Triticum aestivum* L.)

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ABSTRACT

A field experiment was carried out during rabi season of 2015-16 to evaluate of some post-emergence herbicides and their mixtures for weed control in wheat on calcareous clayey soil having medium status of available N, P and K at Junagadh. The results revealed that pendimethalin 900 g ha^{-1} as pre-emergence fb either pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1} or clodinafop + metsulfuron 60 + 4 g ha^{-1}as post-emergence at 30 DAS enhanced growth parameters viz., plant height, dry matter/ plant and number of total tillers m^{-1} row length, yield attributes viz., number of effective tillers m^{-1} row length, length of spike, number of spikelets spike^{-1}, number of grains spike^{-1}, grain weight spike^{-1}, 1000-grain weight, 1000-grain volume and ultimately gave higher grain and straw yield.

Keywords: Herbicides, weed management, wheat

Weeds are one of the most prominent constraints in achieving potential yield of wheat. They use the soil fertility, available nutrients and moisture and compete for space and sunlight with the crop plants. The losses caused by weeds vary depending on the weed species, their abundance, crop management practices and environmental factors. In India the losses due to weeds in wheat yield ranged from 15 to 60 per cent depending on the type of weed flora (Malik *et al.*, 2007). Wheat is the second most important crop in India next to rice. In Indian agriculture, wheat assumes a special significance on account of its utilization as food, feed and fodder besides several industrial uses. In Gujarat, irrigated wheat occupies an area of 9.76 lakh hectares producing 28.79 lakh tonnes grains, while the productivity is 2950 kg ha^{-1} (Anon., 2016). Wheat crop suffers with mix flora of weeds. Manual weeding is expensive, energy and time consuming as well as difficult in early stage of crop growth. The problem of complex weed flora in wheat was successfully solved through sequential application of clodinafop, isoproturon, fenoxaprop or sulfosulfuron at 30-35 DAS *fb* 2,4-D, metsulfuron or carfentrazone, but it required two separate operations for aforesaid herbicide applications. Another herbicide as pre-mix formulation of sulfosulfuron + metsulfuron was recommended against complex weed flora and it did very well but residual toxicity of this herbicideon sensitive succeeding crops in rotation put a question mark on its wide acceptability.

To evaluate the bio-efficacy of some post-emergence herbicides and their mixture, a field experiment was carried out during *rabi* season of 2015-16 at Junagadh Agricultural University, Junagadh. The soil of the experimental field was clayey in texture and slightly alkaline in reaction with pH 8.10 and EC of 0.36 dS/m. The soil was low in available nitrogen (242 kg ha^{-1}), medium in available phosphorus (39.20 kg ha^{-1}), high in available potash (292 kg ha^{-1}) and medium in available sulphur (19.05 ppm).

Wheat variety 'GW 366' was sown at 10th November during 2015-16 in a plot of 4.0 × 1.8 m, by using seed rate of 100 kg ha^{-1}. Recommended dose of fertilizers (120-60-60 N_2-P_2O_5-K_2O kg ha^{-1}) and irrigations were applied uniformly in all plots. Twelve weed control treatments, *viz*. HW at 30 DAS (T_1), Metsulfuron 4g ha^{-1} (T_2), Isoproturon 500 g ha^{-1} (T_3), Clodinafop 50 g ha^{-1} (T_4), Sulfosulfuron 30 g ha^{-1} (T_5), Carfentrazone 25 g ha^{-1} (T_6), Pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1} (T_7), Pre-mix clodinafop + metsulfuron 60 + 4 g ha^{-1} (T_8), Tank-mix clodinafop + sulfosulfuron 25 + 15 g ha^{-1} (T_9), HW at 15 and 30 DAS (T_{10}), Weed free (T_{11}) and Unweeded check (T_{12}) were tested in a randomized block design with 3 replications. All herbicides alone and as combination were applied as post-emergence at 30 DAS as per treatment with knapsack power sprayer using 500 litre water per hectare. Pendimethalin 900 g ha^{-1}was applied as pre-emergence in the treatments T_1 to T_9.

The data recorded on various observations were tabulated and then subjected to statistical analysis as per the method of analysis of variance for randomized block design. The data on weeds have considerable variation and hence subjected to square root transformation $\sqrt{x+0.5}$ before analysis.

Effect on weeds

The weed flora in the experimental site constituted by monocot weeds *viz*., *Brachiaria* Mutica (16.24%),

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Short Communication

Table 1: Effect of weed control treatments on total weed count, weed dry weight, weed index and weed control efficiency

Treatments	Total weed count m^{-2}			Weed dry weight (kg ha^{-1})	Weed index (%)	Weed control efficiency (%)
	60 DAS[#]	90 DAS	Harvest			
T_1 - HW[¶] at 30 DAS	2.67 (6.67)	3.29 (10.33)	3.93 (15.00)	155	10.2	89.1
T_2 - Metsulfuron 4 g ha^{-1}	4.78 (22.33)	5.24 (27.00)	5.82 (33.33)	268	34.6	81.3
T_3 - Isoproturon 500 g ha^{-1}	4.94 (24.00)	5.46 (29.33)	6.01 (35.67)	302	36.7	78.9
T_4 - Clodinafop 50 g ha^{-1}	5.55 (30.33)	6.04 (36.00)	6.52 (42.00)	353	37.0	75.3
T_5 - Sulfosulfuron 30 g ha^{-1}	4.53 (20.00)	5.05 (25.00)	5.64 (31.33)	243	29.7	83.0
T_6 - Carfentrazone 25 g ha^{-1}	6.18 (37.67)	6.54 (42.33)	7.24 (52.00)	410	37.7	71.4
T_7 - Pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1}	2.90 (8.00)	3.53 (12.00)	4.14 (16.67)	177	11.3	87.6
T_8 - Pre-mix clodinafop + metsulfuron 60 + 4 g ha^{-1}	3.67 (13.00)	4.34 (18.33)	4.84 (23.00)	203	13.5	85.8
T_9 - Tank-mix clodinafop + sulfosulfuron 25 + 15	4.17 (17.00)	4.80 (22.67)	5.33 (28.00)	223	23.8	84.4
T_{10} -HW at 15 and 30 DAS	2.34 (5.00)	2.97 (8.33)	3.67 (13.00)	131	5.4	90.8
T_{11} -Weed free control	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0	-	100.0
T_{12} -Unweeded check	8.40 (70.00)	8.93 (79.33)	9.28 (85.67)	1434	56.3	-
LSD(0.05)	**0.39**	**0.32**	**0.34**	**58**	**-**	**-**

Notes:
[#]DAS, days after sowing, [¶]Hand weeding
**Pendimethalin 900 g/ha was applied as pre-emergence in the treatments T_1 to T_9*
***Values given in parentheses are the means of original values*

Echinocloa colona L. (11.55%), *Asphodelus tenuifolius* L. (2.34%) and *Dactyloctenium aegyptium* (1.56%) and dicot weeds *viz.*, *Digera arvensis* (18.68%), *Amaranthus viridis* L. (13.90%), *Chenopodium album* L. (8.82%), *Euphorbia hirta* L. (3.22%), *Portulaca oleracea* L. (2.27%), *Physalis minima* L. (2.08%), *Phyllanthus niruri* (1.95%), *Indigofera glandulosa* L. (1.78%) and *Launaea nudicaulis* L. (1.43%) and sedge weed *Cyperus rotundus* L. (14.18%).

At 60 DAS, besides the weed free treatment, HW at 15 and 30 DAS recorded significantly the lowest intensity of total weed (5.00/m^2), which closely followed by the treatment pendimethalin 900 g ha^{-1} as pre-emergence *fb* HW at 30 DAS and pendimethalin 900 g ha^{-1}as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1}. In case of total weed intensity at 90 DAS and harvest, next to the weed free treatment, HW at 15 and 30 DAS registered significantly the lowest number of total weeds (13.00/m^2), but it remained statistically at par with pendimethalin 900 g ha^{-1}as pre-emergence *fb* HW at 30 DAS. Significantly the highest number of total weeds at all dates of observation was observed under the unweeded check.

There were conspicuous differences in dry weight of weeds against different weed management treatments at harvest. Next to the weed free treatment, significantly the lowest dry weight of weeds (131 kg ha^{-1}) was recorded under HW at 15 and 30 DAS, which remained statistically at par with pendimethalin 900 g ha^{-1} as pre-emergence *fb* HW at 30 DAS and pendimethalin 900 g ha^{-1}as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1}. While, the highest dry weight

Table 2: Effect of weed control treatments on yield attributes and yield of wheat

Treatments	Effective tillers m^{-1} row length	Length of spike (cm)	No. of spikelets $spike^{-1}$	No. of grains $spike^{-1}$	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1 - HW¶ at 30 DAS#	32.47	7.63	14.27	29.28	3.9	5.7
T_2 - Metsulfuron 4 g ha^{-1}	29.60	7.54	12.60	24.30	2.7	4.5
T_3 - Isoproturon 500 g ha^{-1}	29.33	7.10	12.47	23.08	2.6	4.5
T_4 - Clodinafop 50 g ha^{-1}	28.00	6.43	11.93	22.97	2.6	4.4
T_5 - Sulfosulfuron 30 g ha^{-1}	30.33	7.18	12.73	25.44	2.9	5.2
T_6 - Carfentrazone 25 g ha^{-1}	27.67	6.13	11.93	21.92	2.5	4.3
T_7 - Pre-mix sulfosulfuron + metsulfuron 30+2 g ha^{-1}	32.00	7.51	14.07	28.76	3.8	5.6
T_8 - Pre-mix clodinafop + metsulfuron 60+4 g ha^{-1}	31.33	7.25	13.60	27.71	3.7	5.5
T_9 - Tank-mix clodinafop+ sulfosulfuron 25+15	30.67	7.19	13.13	26.74	3.1	5.3
T_{10} - HW at 15 and 30 DAS	33.00	7.92	14.40	31.44	3.9	5.7
T_{11} - Weed free control	34.00	8.04	15.07	32.17	4.1	6.2
T_{12} - Unweeded check	25.00	5.71	10.13	19.07	1.8	3.5
LSD (0.05)	**4.66**	**1.01**	**1.56**	**3.66**	**0.5**	**0.9**

Notes:
#DAS, days after sowing, ¶Hand weeding
** Pendimethalin 900 g/ha was applied as pre-emergence in the treatments T_1 to T_9*

of weeds (1434 kg ha^{-1}) was recorded under unweeded check.

The highest WI (56.3%) was recorded under the unweeded check, which indicates that the unrestricted weed growth reduced the grain yield of wheat by 56.3 per cent. Among rest of the treatments, the lowest WI of 5.4 per cent was recorded under the treatment comprising HW at 15 and 30 DAS, closely followed by pendimethalin 900 g ha^{-1}as pre-emergence *fb* HW at 30 DAS, pendimethalin 900 g ha^{-1}as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1}.

The 100% WCE was observed under the weed free treatment. Among the other weed management treatments, the highest WCE (90.8%) was registered with HW at 15 and 30 DAS, closely followed by pendimethalin 900 g ha^{-1}as pre-emergence *fb* HW at 30 DAS, pendimethalin 900 g ha^{-1} as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1} and pendimethalin 900 g/ha as pre-emergence *fb* pre-mix clodinafop + metsulfuron 60 + 4 g ha^{-1} having WCE of 89.1, 87.6 and 85.8 per cent, respectively. The lowest WCE (71.4%) was observed under pendimethalin 900 g ha^{-1}as pre-emergence *fb* carfentrazone 25 g ha^{-1}. This might be due to reduction of densities of identified weed species and thereby reducing crop-weed competition under those treatments. Whereas, the treatments pendimethalin 900 g ha^{-1} as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1} and pendimethalin 900 g ha^{-1} as pre-emergence *fb* pre-mix clodinafop + metsulfuron 60 + 4 g ha^{-1}also reduced crop-weed competition at tillering and grain formation stage. The combined effect on lower dry weight of weeds and excellent weed control efficiency under these treatments might have been responsible for higher grain yield of wheat. Previous studies also reported the influence of herbicides on the grain yield of wheat (Barui *et al.*, 2006); Khokhar and Charak, 2011) .

Effect on crop

Significantly the higher yield attributes *viz*., number of effective tillers per m row length (34.00), length of spike (8.04 cm), number of spikelets/spike (15.07), and number of grains/spike (32.17) were registered under weed free treatment, which remained statistically at par with HW at 15 and 30 DAS, pendimethalin 900 g ha^{-1} as pre-emergence *fb* HW at 30 DAS, pendimethalin 900 g ha^{-1} as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g $ha^{-1}$and pendimethalin 900 g ha^{-1} as pre-emergence *fb* pre-mix clodinafop + metsulfuron 60 + 4 g ha^{-1} in most of the cases. However, significantly minimum value of these yield attributes was recorded under the unweeded check in all the cases.

Increased values in these yield attributes might have been on account of the overall improvement in vegetative growth which favourably influenced the tillering, flowering and fruiting and ultimately resulted into increased spikelets spike^{-1}, grain weight spike^{-1} and test weight (Malik *et al.,* 2007); Vyavahare and Bhilare, 2014).

The grain yield was numerically higher in weed free situation (4.1 t ha^{-1}), but it remained statistically at par with HW at 15 and 30 DAS, pendimethalin 900 g ha^{-1}as pre-emergence *fb* HW at 30 DAS, pendimethalin 900 g ha^{-1} as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1}and pendimethalin 900 g ha^{-1} as pre-emergence *fb* pre-mix clodinafop + metsulfuron 60 + 4 g ha^{-1}, accounting 129.0, 116.5, 115.0, 113.5 and 109.1 per cent increased yield over unweeded check, respectively. On the contrary, the treatment unweeded check gave significantly the lowest grain yield (1.8 t ha^{-1}). The highest straw yield (6.2 t ha^{-1}) was obtained with the weed free treatment, which was found statistically at par with HW at 15 and 30 DAS, pendimethalin 900 g ha^{-1}as pre-emergence *fb* HW at 30 DAS, pendimethalin 900 g ha^{-1}as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1}, pendimethalin 900 g ha^{-1} as pre-emergence *fb* pre-mix clodinafop + metsulfuron 60 + 4 g ha^{-1} , pendimethalin 900g/ha as pre-emergence *fb* tank-mix clodinafop + sulfosulfuron 25 + 15 g ha^{-1} and pendimethalin 900 g ha^{-1}as pre-emergence *fb*sulfosulfuron 30 g ha^{-1}. However, significantly the lowest straw yield (3.5 t ha^{-1}) was registered with the unweeded check. Sulfosulfuron and clodinafop proved effective against grassy weeds, while metsulfuron-methyl controlled the broad-leaf weeds significantly compared to the weedy control and the other herbicide treatments, thereby resulting in significant increase of wheat yield under the treatment Pendimethalin 900 g ha^{-1}as pre-emergence *fb* pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1}at 30 DAS and Pendimethalin 900 g/ha as pre-emergence *fb* pre-mix clodinafop + metsulfuron 60 + 4 g ha^{-1}at 30 DAS. The results are in conformity with those of Kumari *et al.* (2013) and Pal *et al.* (2015).

Significantly the lowest grain and straw yields were recorded under the unweeded check, which might be due to deprived growth and development of the crop owing to severe crop-weed competition for resources.

Results of present one-year study showed that effective control of complex weed flora with profitable production of wheat on calcareous clayey soil of south Saurashtra agro-climatic zone can be obtained by application of pendimethalin 900 g ha^{-1}as pre-emergence *fb* either pre-mix sulfosulfuron + metsulfuron 30 + 2 g ha^{-1}or clodinafop +metsulfuron 60 + 4 g ha^{-1}as post-emergence at 30 DAS.

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