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Efficacy of Some Post-emergence Herbicides and their Mixtures Against Complex Weed Flora in Wheat

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Abstract

A field experiment was conducted during *rabi* season of 2015–16 at Junagadh (Gujarat) to evaluate efficacy of some post-emergence herbicides (metsulfuron, isoproturon, clodinafop, fenoxaprop) and their mixtures (sulfosulfuron+metsulfuron, clodinafop+metsulfuron, isoproturon+metsulfuron, isoproturon+fenoxaprop, isoproturon+clodinafop) against complex weed flora in wheat. The dominant weed flora noticed in the experimental field were *Echinochloa colona, Cynodon dactylon*, *Brachiaria* spp. and *Dactyloctenium aegyptium* among the monocots; *Amaranthus viridis*, *Chenopodium album*, *Digera arvensis*, *Melilotus indica*, *Portulaca oleracea*, *Convolvulus arvensis, Euphorbia hirta* and *Phyllanthus niruri* among the dicot weeds and *Cyperus rotundus* as sedge weed. The results revealed that hand weeding (HW) at 15 and 30 DAS, HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron (25 g ha^{-1}) at 30 DAS, and HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron (32 g ha^{-1}) at 30 DAS were found superior treatments next to the weed free check in controlling weeds and improving growth and yield attributes and ultimately grain and straw yields of wheat. It is suggested that pre-mix sulfosulfuron + metsulfuron or clodinafop+metsulfuron could be used to control broad spectrum of weeds in wheat. The herbicide mix could be helpful in reducing herbicide residue in soil and prevent or delay the development of herbicide resistance weeds.

Keywords: Post-emergence, herbicides mixture, weeds, wheat, sulfosulfuron, metsulfuron, clodinafop

1. Introduction

Wheat is infested by multifarious weed flora comprising both grassy as well as broad-leaved weeds causing yield reduction of 15–40% depending upon type and intensity of their infestation (Katara et al., 2012; Singh et al*.,* 2012; Kumar et al., 2013). Weed competition is intense during first 30-40 days after sowing the wheat crop. Herbicides continue to be the most powerful, economically effective and reliable way to control weeds in wheat. Pendimethalin 900 g ha^{-1} as pre-emergence is effective to control grasses and broad-leaved weeds. Post-emergent herbicides *viz*., 2,4-D and metsulfuron are recommended for effective weed control in wheat, but residues of these herbicides in soil restrict choice of succeeding crops. Thus, it became important to evaluate new herbicide molecules for management of weeds in wheat. Since, no single herbicide controls both narrow and broad-leaved weeds, therefore, mixing of herbicideshave shown great promise in controlling complex weed flora of wheat. Several new herbicides *viz*., clodinafop, fenoxaprop, sulfosulfuron, carfentrazone, diclofop, pinoxaden and pre-mix sulfosulfuron+metsulfuron, clodinafop+metsulfuron, carfentrazone+sulfosulfuron, clodinafop+metribuzin, fenoxaprop+metribuzin and metsulfuron+carfentrazone have been found very effective in controlling weeds without any residual effect on succeeding crops as well as to prevent development of herbicide resistant weeds in wheat (Chopra et al., 2015; Sharma et al., 2015; Pal et al., 2015).

2. Materials and Methods

A field experiment was conducted at Weed Control Research Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh (Gujarat) during *Rabi* season of 2015–16. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction as well as low in available nitrogen, available phosphorus and medium in available potash. The experiment comprising of 12 treatments *viz*., T_1: HW at 15 DAS *fb* metsulfuron 4 g ha^{-1} at 30 DAS, T_2: HW at 15 DAS *fb* isoproturon 500 g ha^{-1} at 30 DAS, T_3: HW at 15 DAS *fb* clodinafop 60 g ha^{-1} at 30 DAS, T_4: HW at 15 DAS *fb* fenoxaprop 90 g ha^{-1} at 30 DAS, T_5: HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron 25 g ha^{-1} at 30 DAS, T_6: HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron 32 g ha^{-1} at 30 DAS, T_7: HW at 15 DAS *fb* tank-mix isoproturon 250 g ha^{-1} + metsulfuron 2 g ha^{-1} at 30 DAS, T_8: HW at 15 DAS *fb* tank-mix isoproturon 250 g ha^{-1}+fenoxaprop 45 g ha^{-1} at 30 DAS, T_9: HW at 15 DAS

fb tank-mix isoproturon 250 g ha^{-1}+clodinafop 30 g ha^{-1} at 30 DAS, T_{10}: HW at 15 and 30 DAS, T_{11}: Weed-free check, and T_{12}: Weedy check was laid out in randomized block design with three replications. The gross and net plot size were 5.0x2.7 m^2 and 4.0x1.8 m^2, respectively. The wheat variety 'GW-366' was sown by tractor operated automatic seed drill at row spacing of 22.5 cm using seed rate of 120 kg ha^{-1}. A fertilizer dose of 60-60-60 kg N-P_2O_5-K_2O ha^{-1} through Ammonium sulphate, Diammonium phosphate and Muriate of potash was applied before sowing as basal. Top dressing of 60 kg N ha^{-1} in form of Urea was applied at 25 days after sowing. The post-emergence spray was done at 30 DAS using knapsack sprayer with flood jet nozzle. The spray volume herbicide application was 500 L ha^{-1}. The crop was raised as per the recommended package of practices. Growth and yield attributing characters *viz*., plant height, no. of effective tillers m^{-1} row length, no. of spikelets $spike^{-1}$, no. of grains $spike^{-1}$ and 100-seed weight were recorded at harvest. The crop was harvested from net plot at maturity. The grains were separated from plants by thresher and grain and straw yields were recorded for each plot. Dry weight of weeds was recorded at harvest. Weed index (WI) and weed control efficiency (WCE) were worked out using following formulae suggested by Gill and Kumar (1969); Kondap and Upadhyay (1985).

$$WI=\frac{Y_{WF}-Y_T}{Y_{WF}}\times 100$$

Where; Y_{WF} and Y_T are the yield from weed-free plot and yield from treated plot, respectively.

$$WCE\ (\%)=\frac{DW_c-DW_T}{DW_c}\times 100$$

Where; DW_C = Dry matter accumulation of weeds in unweeded control, DW_T=Dry matter accumulation of weeds in treated plot.

3. Results and Discussion

The major weed flora noticed were *Echinochloa colona, Cynodon dactylon*, *Brachiaria* spp. and *Dactyloctenium aegyptium* among the monocots; *Amaranthus viridis*, *Chenopodium album*, *Digera arvensis*, *Melilotus indica*, *Portulaca oleracea*, *Convolvulus arvensis, Euphorbia hirta* and *Phyllanthus niruri* among the dicot weeds and *Cyperus rotundus* as sedge weed.

3.1. Effect on crop

Data presented in Table 1 showed growth and yield attributes *viz*., highest plant height, effective tillers m^{-1} row length, spikelets $spike^{-1}$, grains $spike^{-1}$ and 100-seed weight were significantly influenced by different treatments.

Table 1: Effect of weed management on growth and yield attributes of wheat

Treatment	Plant height (cm)	Effective tillers/m row length	Spikelets $spike^{-1}$	Grains $spike^{-1}$	100-seed weight (g)
HW *fb* metsulfuron	81.92	61.83	12.02	27.38	42.76
HW *fb* isoproturon	81.53	60.33	11.82	26.93	42.48
HW *fb* clodinafop	80.03	57.42	11.04	25.83	41.43
HW *fb* fenoxaprop	77.78	54.42	10.41	24.90	40.47
HW *fb* sulfosulfuron+metsulfuron	86.33	70.33	13.74	28.86	44.28
HW *fb* clodinafop+metsulfuron	85.17	68.58	13.03	28.11	43.89
HW *fb* isoproturon+metsulfuron	82.97	63.25	12.34	27.82	43.65
HW *fb* isoproturon+fenoxaprop	79.43	55.83	10.48	25.47	41.07
HW *fb* isoproturon+clodinafop	80.97	59.38	11.21	26.66	41.88
HW twice	88.06	71.32	13.86	29.24	44.47
Weed-free check	89.17	72.73	14.52	29.41	44.73
Weedy check	70.53	51.77	9.11	21.18	37.16
SEm±	1.61	1.46	0.51	0.78	0.52
CD (*p*=0.05)	4.73	4.307	1.50	2.30	1.53

Significantly the highest plant height (89.17 cm) was recorded under the weed-free check, however it remained statistically at par with HW at 15 and 30 DAS (88.06 cm), HW at 15 DAS *fb* pre-mix sulfosulfuron + metsulfuron 25 g ha^{-1} at 30 DAS (86.33 cm) and HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron g ha^{-1} at 30 DAS (85.17 cm). Whereas, significantly the lowest plant height (70.53 cm) was registered under the weedy check.

The weed free plot has significantly the highest number of effective tillers m^{-1} row length (72.73), however it remained statistically comparable to HW at 15 and 30 DAS (71.32), HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron 25

g ha^{-1} at 30 DAS (70.33) and HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron 32 g ha^{-1} at 30 DAS (68.58). The weedy check has significantly the lowest number of effective tillers m^{-1} row length (51.77).

Effective control of weeds through manual weeding in the weed free andHW at 15 and 30 DAS as well as combination of manual weeding with herbicide mix in under the treatments HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron 25 g ha^{-1} at 30 DAS, and HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron 32 g ha^{-1} at 30 DAS caused less crop-weed competition throughout growth period of the crop, less count and dry weight of weeds, which might have resulted in better availability of space, sunlight, moisture and nutrients to the crop in absence of weeds. Thus, increased water and nutrient uptake, which might have accelerated photosynthetic rate, thereby increasing the supply of carbohydrates, resulted in cell division, multiplication and elongation leading to increase in growth character. These results were in conformity with Katara et al. (2012); Pisal and Sagarka (2013); Singh et al. (2013).

Number of spikelets $spike^{-1}$ was significantly the highest (14.52) under the weed free treatment, but it was found statistically equivalent to HW at 15 and 30 DAS (13.86), HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron 25 g ha^{-1} at 30 DAS (13.74) and HW at 15 DAS *fb* pre-mix clodinafop + metsulfuron 32 g ha^{-1} at 30 DAS (13.03). Obviously, the weedy check registered significantly the lowest number of spikelets $spike^{-1}$ (9.11).

Significantly the highest number of grains $spike^{-1}$ (29.41) was observed under the weed free plot, however it did not differ significantly from HW at 15 and 30 DAS (29.24), HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron 25 g ha^{-1} at 30 DAS (28.86) and HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron 32 g ha^{-1} at 30 DAS (28.11). Evidently, the weedy check recorded significantly the lowest no. of grains $spike^{-1}$ (9.11).

The weed free treatment recorded significantly the highest test weight (44.73 g), which remained statistically at par with HW at 15 and 30 DAS (44.47 g), HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron 25 g ha^{-1} at 30 DAS (44.28 g), HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron 32 g ha^{-1} at 30 DAS (43.89 g) and HW at 15 DAS *fb*tank-mix isoproturon 250 g ha^{-1} + metsulfuron 2 g ha^{-1} at 30 DAS (43.65 g). Significantly the lowest test weight was noted with the weedy check (37.16 g).

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 effective tillers m^{-1} row length, spikelets $spike^{-1}$, grains $spike^{-1}$ and test weight. The results are parallel with those of Vyavahare (2012); Kumari et al. (2013); Punia et al. (2013); Singh et al. (2015).

The data furnished in Table 2 showed the weed-free check produced significantly the highest grain yield of 3873 kg ha^{-1} and straw yield of 5301 kg ha^{-1}. The next superior treatments in this regard were HW at 15 and 30 DAS, HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron 25 g ha^{-1} at 30 DAS, and HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron 32 g ha^{-1} at 30 DAS by registering grain yield of 3788, 3632 and 3511 kg ha^{-1}, and straw yield of 5192, 5091 and 4913 kg ha^{-1}, respectively. These treatments increased seed yield by 95, 91, 83 and 77%, and straw yield by 84, 80, 77 and 71% over the weedy check, respectively. Removal of weeds by hand weeding in initial stage and supplemented with herbicide application suppressed weeds, which in turn provided better weed-free environment

Table 2: Effect of weed management on crop yield and weed parameters

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Weed dry weight (kg ha^{-1})	Weed index (%)	Weed control efficiency (%)
HW *fb* metsulfuron	3298	4241	580	14.85	66.99
HW *fb* isoproturon	3129	4196	613	19.21	65.11
HW *fb* clodinafop	2948	3965	944	23.88	46.27
HW *fb* fenoxaprop	2141	3042	1219	44.72	30.62
HW *fb* sulfosulfuron+metsulfuron	3632	5091	274	6.22	84.41
HW *fb* clodinafop+metsulfuron	3511	4913	328	9.35	81.33
HW *fb* isoproturon+metsulfuron	3299	4264	425	14.82	75.81
HW *fb* isoproturon+fenoxaprop	2770	3826	1086	28.48	38.19
HW *fb* isoproturon+clodinafop	3110	4011	859	19.70	51.11
HW twice	3788	5192	131	2.19	92.54
Weed-free check	3873	5301	30	0.00	98.29
Weedy check	1987	2881	1757	48.70	0.00
SEm±	138	209	46		
CD (*p*=0.05)	404	614	136		

to the crop during critical period for growth and development. These results are in conformity with findings of Malik et al. (2012), Kaur et al. (2015), Pal et al. (2015); Singh et al. (2015).

3.2. Effect on weeds

The data (Table 2) indicated that the weed-free recorded significantly the lowest dry weight of weeds (30 kg ha^{-1}), followed by HW at 15 and 30 DAS, HW at 15 DAS *fb* pre-mix sulfosulfuron+metsulfuron 25 g ha^{-1} at 30 DAS, and HW at 15 DAS *fb* pre-mix clodinafop+metsulfuron 32 g ha^{-1} at 30 DAS having weed dry weight of 30, 131, 274 and 328 kg ha^{-1}, WI of 0.00, 2.19, 6.22 and 9.35%, and WCE of 98.29, 92.54, 84.41 and 81.33%, respectively. Efficient control of weeds under these treatments have been reflected in lower dry weight of weeds and evidently showed excellent weed indices. The results corroborate the findings of Yadav et al. (2011); Singh et al. (2013); Tiwari et al. (2015); Chaudhary et al. (2016).

4. Conclusion

Effective control of complex weed flora in wheat along with higher yield could be achieved by hand weedingtwice (at 15 and 30 DAS) or HW (at 15 DAS) *fb* either pre-mix sulfosulfuron+metsulfuron (25 g ha^{-1}) or clodinafop+metsulfuron (32 g ha^{-1}) at 30 DAS.

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