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Response of different combinations of herbicides on yield and economics of wheat

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Abstract
A field experiment was conducted at Agronomy Farm, College of Agriculture, Nagpur during *rabi* season of 2020-21 to evaluate the effect of different combinations of herbicides on weed control yield and economics of wheat (*Triticum aestivum* L.) on clayey and slightly alkaline soil. The experiment was laid out in randomized block design with ten treatments replicated thrice. Results reveal that among all herbicidal treatments, combinations of post emergence application of clodinafop propargyl + metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} at 35 DAS was found to be the most effective for higher weed control efficiency (88.67%), number of effective tillers per meter row length (139.40), spike length (7.92 cm), number of grains per spike (38.11), grain (28.90 q ha^{-1}) and straw yield (33.86 q ha^{-1}) of wheat which resulted in maximum harvest index (46.04%), net monetory returns (56743 ₹ ha^{-1}) and B:C ratio (3.05) followed by post emergence application of sulfosulfuron + metsulfuron methyl @ 0.03 +0.002 kg a.i. ha^{-1} at 35 DAS with 54631 ₹ ha^{-1} net monetory returns and 2.94 B:C ratio.

Keywords: Weed, yield, clodinafop propargyl, metsulfuron methyl

Introduction
Wheat is called as “king of cereals”. Wheat is the backbone of food security in India. It is utilized for bread, cakes, cookies, noodles. Yield reduction due to weeds in wheat ranging from 15-50%, depending upon the weed density and type of weed flora (Jat *et al.* 2003) [4]. Wheat is infested with grassy as well as broad-leaved weeds, which requires a variety of herbicides to control mixed population of weeds. When there is complex weed flora (both grassy and broad-leaved) infestation in wheat crop, the efficacy achieved through alone application of herbicide belonging to single group is limited because of narrow spectrum of weed control. The continuous dependence on a single herbicide for a long time, besides resistance development, also leads to a shift in the weed flora (Chancellor, 1979) [2]. The present situation of labour shortage and increase in wages has only worsened the situation. Under such situations, herbicides are far cheaper and more readily available resource than labour for timely weed control. History shows that in industrializing countries in the past, the same phenomenon has occurred as workers have left agriculture, herbicides have been adopted to control weeds. Therefore, it is inevitable that herbicide use will increase.

Materials and Methods
A field experiment was conducted at Agronomy Section Farm, Collage of Agriculture, Nagpur (Maharashtra) during *rabi* season of 2020-21. Nagpur is in Central Vidarbha Zone of Maharashtra. The ten treatments comprised of pre-emergence application of pendimethalin @ 1 kg a.i. ha^{-1}, metribuzin @ 0.21 kg a.i. ha^{-1}, pendimethalin + metribuzin @ 1.0 + 0.175 kg a.i. ha^{-1} and application of sulfosulfuron @ 0.025 kg a.i. ha^{-1}, clodinafop @ 0.06 kg a.i. ha^{-1}, metsulfuron methyl @ 0.004 kg a.i. ha^{-1}, sulfosulfuron + metsulfuron methyl @ 0.03 + 0.002 kg a.i. ha^{-1}, clodinafop propargyl + metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} at 35 DAS as post emergence application, hand weeding twice at 20 and 40 DAS and unweeded control. Spraying was done with the help of manually operated knapsack sprayer fitted with flat fan nozzle using 500 litres of water per hectare. Monocot and dicot weed count (no./m^2) were recorded from three places selected at random in each plot at 30 days intervals. A quadrate of (0.5 x 0.5m) size was used for recording the weed density and weed dry weight. The weeds within the quadrate were identified and counted and expressed in (no./m^2). Weed dry matter was recorded from three places selected randomly. After sun drying, weeds were dried in hot air oven at 70±1 ºC for 48 hours to obtain constant weight. Weed control efficiency was also calculated on the basis of dry matter production by weeds.

Results and Discussion

Weed Flora

It was found that in weedy plot, grassy weeds constituted about 39.51%, while broad-leaf weeds 60.48% of the total weed population. Herbicide treatments showed differential influence on weed control in wheat during the year of experimentation. Major weed flora observed on weedy plot comprised *Corchorus aestuans, Chenopodium album, Digera arvensis, Convolvulus arvensis, Celosia argentea, Euphorbia hirta, Euphorbia geniculate, Amaranthus viridis, Parthenium hysterophorus, Cynodon dactylon, Cyperus rotundus, Dinebra arabica, Eragrosis major and Commelia benghalensis*.

Weed control efficiency and weed index

Among the herbicides higher weed control efficiency of 88.67% and lower weed index (3.76%) was observed (Table 1) with the application of clodinafop propargyl + metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} PoE followed by sulfosulfuron + metsulfuron methyl @ 0.03 + 0.002 kg a.i. ha^{-1} with WCE 87.04% and WI 5.59%. The lower weed control efficiency was recorded when herbicides were applied alone. Higher weed control efficiency with clodinafop-propargyl + metsulfuron-methyl (60+4 g/ha) may be attributed to the better weed control resulting in lower dry weight of weeds.

Effect on yield attributes

Among the herbicidal combinations clodinafop propargyl + metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} followed by sulfosulfuron + metsulfuron methyl @ 0.03 + 0.002 kg a.i. ha^{-1} applied as post-emergence recorded higher number of effective tillers m^{-1} row length at harvest (139.40, 136.11), spike length (7.92, 7.80 cm), number of grains spike^{-1} (38.11, 37.10), grain (28.90, 28.35 qt/ha) and straw yield (33.86, 33.25 qt/ha). Herbicide application had significant effect on wheat grain and straw yield (Table 2). This might be due to greater photo-synthesis and translocation of photosynthates besides longer and stronger sink size as reflected by maximum values of yield attributes and finally the yield.

Table 1: Yield attributes of wheat as influenced by different weed management practices

	Treatments	Number of effective tillers m^{-1} row length	Spike length (cm)	Number of grains spike^{-1}	WCE at 60 DAS (%)	WI (%)
T_1	Pendimethalin @ 1 kg a.i. ha^{-1} (pre-emergence)	87.03	5.70	21.90	65.25	32.06
T_2	Sulfosulfuron @ 0.025 kg a.i. ha^{-1} (post emergence at 35 DAS)	122.33	7.10	32.28	79.46	15.08
T_3	Metribuzin @ 0.21 kg a.i. ha^{-1} (pre-emergence)	99.35	6.30	25.83	71.69	25.07
T_4	Clodinafop @ 0.06 kg a.i. ha^{-1} (post emergence at 35 DAS)	119.00	6.95	31.25	78.69	16.08
T_5	Pendimethalin + Metribuzin @ 1.0 + 0.175 kg a.i. ha^{-1} (pre-emergence)	105.30	6.35	27.35	72.85	23.40
T_6	Metsulfuron methyl @ 0.004 kg a.i. ha^{-1} (post emergence at 35 DAS)	124.80	7.19	33.10	81.06	13.25
T_7	Sulfosulfuron + Metsulfuron methyl @ 0.03 + 0.002 kg a.i. ha^{-1} (post emergence at 35 DAS)	136.11	7.80	37.10	87.04	5.59
T_8	Clodinafop propargyl + Metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} (post emergence at 35 DAS)	139.40	7.92	38.11	88.67	3.76
T_9	Hand weeding twice at 20 and 40 DAS.	146.16	8.20	40.02	94.78	0.00
T_{10}	Unweeded control	75.16	5.10	16.33	-	44.72
	SE (m) ±	3.49	0.18	1.28	-	-
	C.D.5%	10.37	0.55	3.82	-	-
	G.M.	115.46	6.86	30.32	71.95	17.90

Effect on yield: The highest grain yield of wheat (30.03 qt/ha) and straw yield (35.03 qt/ha) was recorded in weed free plot due to increased nutrients, water, space and light supply to the wheat crop with zero crop-weed competition. The reason for lower yields in case of clodinafop, sulfosulfuron and metsulfuron alone as compared to clodinafop propargyl + metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} PoE and sulfosulfuron + metsulfuron methyl @ 0.03 + 0.002 kg a.i. ha^{-1} could obviously be due to less control of broad-leaved and grassy weeds, respectively. These results are in conformation with those of Patel *et al*. 2017 and Sahu *et al*. 2018.

Effect on economics: Maximum net monetary returns and B:C ratio (56743 ₹ ha^{-1}, 3.05) was obtained with clodinafop propargyl + metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} applied at 35 DAS followed by sulfosulfuron + metsulfuron methyl @ 0.03 + 0.002 kg a.i. ha^{-1} (54631 ₹ ha^{-1}, 2.94). The unweeded check recorded lowest net return (21914 ₹ ha^{-1}) and B:C ratio (1.81) (Table 2). It can be concluded that post-emergence application of clodinafop propargyl + metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} effectively reduced weed population and its dry weight and increased the grain yield of wheat ultimately gives higher net return and B:C ratio. These results are in conformation with those of Chopra *et al*. 2012 [3] and Pal *et al*. 2016 [5].

Table 2: Yield and economics of wheat as influenced by different weed management practices

	Treatments	Grain (q ha^{-1})	Straw (q ha^{-1})	Total cost of cultivation (₹ ha^{-1})	NMR (₹ ha^{-1})	B:C ratio
T_1	Pendimethalin @ 1 kg a.i. ha^{-1} (pre-emergence)	20.40	24.60	27846	31974	2.14
T_2	Sulfosulfuron @ 0.025 kg a.i. ha^{-1} (post emergence at 35 DAS)	25.50	30.11	27976	46543	2.66
T_3	Metribuzin @ 0.21 kg a.i. ha^{-1} (pre-emergence)	22.50	27.00	27946	37979	2.35
T_4	Clodinafop @ 0.06 kg a.i. ha^{-1} (post emergence at 35 DAS)	25.20	29.80	27546	46114	2.67
T_5	Pendimethalin + Metribuzin @ 1.0 + 0.175 kg a.i. ha^{-1} (pre-emergence)	23.00	27.55	28406	38964	2.37
T_6	Metsulfuron methyl @ 0.004 kg a.i. ha^{-1} (post emergence at 35 DAS)	26.05	30.70	27456	48647	2.77
T_7	Sulfosulfuron + Metsulfuron methyl @ 0.03 + 0.002 kg a.i. ha^{-1} (post emergence at 35 DAS)	28.35	33.25	28126	54631	2.94
T_8	Clodinafop propargyl + Metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} (post emergence at 35 DAS)	28.90	33.86	27606	56743	3.05
T_9	Hand weeding twice at 20 and 40 DAS.	30.03	35.03	35396	52189	2.47
T_{10}	Unweeded control	16.60	20.60	26996	21914	1.81
	SE (m) ±	0.69	0.72	-	1936	-
	C.D.5%	2.07	2.15	-	5752	-
	G.M.	24.65	29.25	28541	43570	2.52

Conclusion

Based on experimental findings, it can be concluded that among the herbicides, post-emergence application of clodinafop propargyl + metsulfuron methyl @ 0.06 + 0.004 kg a.i. ha^{-1} observed higher the number of effective tillers m^{-1} row length, spike length, number of grains spike^{-1}, weed control efficiency, grain yield and straw yield per hectare and lower weed index also maximum monetary returns, B:C ratio of wheat crop recorded and was comparable with application of sulfosulfuron + metsulfuron methyl @ 0.03 +0.002 kg a.i. ha^{-1}.

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