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Short communication

Herbicide combinations for broad spectrum weed control in wheat

O.P. Meena, V. Nepalia*, Dilip Singh, Arvind Verma and Roshan Choudhary
Department of Agronomy, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology Udaipur, Rajasthan 313 001

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Weed is one of the major biotic constraints in wheat production as they compete with crop for nutrients, moisture, light and space (Chhokar *et al.* 2012). They possess many growth characteristics and adaptations which enable them to successfully exploit the numerous ecological niches. Weeds suppress the crop and result in reduction of yield. Weed control cost is a major segment of input cost in crop production and herbicides provide a better opportunity to control weeds in close row crops like wheat where manual or mechanical weeding is not possible (Yaduraju and Mishra 2002). Apart from an ineffective control measure against mimicry weeds like *Phalaris minor* and *Avena ludoviciana*, manual weeding also involves high cost (Chhokar *et al.* 2012). 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 recourse than labor for hand weeding. When there is complex weed flora, infestation in wheat crop, the efficacy achieved by one herbicide belonging to single group is limited because of narrow spectrum of weed control. In such situations, mix or sequential application of herbicides with different selectivity can widen the range of weed control, save time, application cost and reduce impact of herbicides on environment, resulting in biological activity higher than their individual applications (Sharma *et al*. 2015). Herbicide efficacy can be increased by tank mixing or ready-mix (RM) formulations, if compatible or by their sequential application for effective control of weed flora in wheat. Compatibility of herbicides depends on mixture partners (Yadav *et al*. 2009). Recent investigations have vouched the importance of herbicide combinations in enhancing wheat productivity through wide spectrum weed.

An experiment was carried out at Agronomy Farm, Maharana Pratap University of Agriculture and Technology, Udaipur during *Rabi* season (winter) of 2015-2016. Soil of the experimental site was clay loam in texture and alkaline in reaction (pH-8.2). The experiment consisted of thirteen treatments (pendimethalin at 750 g/ha, sulfosulfuron at 25 g/ha, metribuzin at 210 g/ha, clodinafop at 60 g/ha, pendimethalin *fb* sulfosulfuron 1000 g + 18 g/ha, pendimethalin + metribuzin 1000 g + 175 g/ha, sulfosulfuron + metsulfuron at 30 g + 2 g/ha (RM), pinoxaden + metsulfuron 60 g + 4 g/ha, mesosulfuron + iodosulfuron at 12 g + 2.4 g/ha (RM), clodinafop + metsulfuron at 60 g+ 4 g/ha (RM), one hand weeding at 30 DAS; two hand weedings at 30 and 45 DAS, weedy check) were tested in a randomized block design in three replications. Wheat variety '*Raj.-4037*' was sown at 22.5 cm row distance using 100 k g/ha seed rate. The crop was supplied with 120 kg N/ha, half of which was drilled in crop rows at sowing while remaining half was top dressed in two equal splits at the time of first and second irrigation. The individual weed species were counted at 45, 60 DAS and harvest. This was done by placing 0.25 m^2 quadrate at two randomly selected spots in each plot, averaged and finally weed count was expressed as number/m^2. Separate counts were recorded for major broad-leaf weeds and grassy weeds. The count data were subjected to square root transformation $\sqrt{X+0.5}$ to normalize their distribution. After recording counts these samples were first sun dried and then oven dried at 70° C till constant weight was achieved. The final dry weight of broad-leaf and grassy weeds was recorded and expressed in kg/ha. The NPK uptake by weeds was estimated at harvest by multiplying the respective contents with weed dry matter. In case of crop, the NPK uptake by grain and straw were estimated by multiplying content with their respective yield. The two were then added to derive total NPK uptake by wheat crop.

Highest number of weeds at 45 DAS was recorded under weedy check. Among herbicide treatments, pendimethalin + metribuzin, metribuzin alone and pendimethalin *fb* sulfosulfuron resulted in

***Corresponding author:** vnepalia@gmail.com

perceptible reduction in total weed density at this stage. Their results were at par but significantly superior over other treatments, while at 60 DAS, minimum density of total weed was recorded under the effect of sulfosulfuron + metsulfuron (9.99/m^2). Mesosulfuron + iodosulfuron (14.00/m^2), clodinafop + metsulfuron (16.99/m^2) trailed behind it significantly. Compared to weedy check, reduction (57.8 to 96.3%) in total weed density at harvest was observed by exercising various options. Though the hand weeding treatments accounted minimum density of total weeds but good control of weed was registered by sulfosulfuron + metsulfuron followed by mesosulfuron + iodosulfuron, clodinafop + metsulfuron, pinoxaden + metsulfuron and pendimethalin *fb* sulfosulfuron. The data explicitly indicated that weed control through sulfosulfuron + metsulfuron herbicide mixtures gave highest weed control efficiency (79.3, 80.9 and 87.9%) at 45 DAS, 60 DAS and at harvest, respectively (Table 1).

Wide ranging decline in total weed dry matter at 45 DAS were noticed by applying various weed control treatments relative to a weedy wheat crop (Table 1). All the herbicide mixtures and sequential application were significantly superior over alone applied herbicides in reducing dry matter. Sulfosulfuron + metsulfuron brought about 79.9% reduction in dry matter. However, it was at par with pendimethalin *fb* sulfosulfuron and pendimethalin + metribuzin. Significant reduction in total weed dry matter at 60 DAS observed by applying various weed control options under study against weedy check. The trend of significance indicated that sulfosulfuron + metsulfuron with 80.9% reduction in dry matter stood first in the order in significance and outplayed all the other treatments. At harvest, least weed dry matter was observed under sulfosulfuron + metsulfuron (19.22 g/m^2) followed by mesosulfuron + iodosulfuron (22.53 g/m^2).

Marked increase in grain yield of wheat was recorded by weed control, though magnitude of yield differed with treatments. Minimum yield was recorded by one hand weeding which was at par to two hand weedings but inferior to all herbicidal weed control treatments. Two hand weedings was also surmounted by herbicidal weed control except metribuzin. Collective application of herbicides either as pre-mix, tank mix or sequentially resulted in significantly higher grain yield of wheat over singly applied herbicides. Highest yield (6.02 t/ha) was obtained by controlling weeds through sulfosulfuron + metsulfuron followed by mesosulfuron + iodosulfuron (5.80 t/ha). These two treatments recorded 67.6 and 61.3% yield enhancement over weedy check and were at par to each other. The third treatment in the order of merit was clodinafop + metsulfuron which brought 54.6% increase and it was at par with mesosulfuron + iodosulfuron. Application of of pinoxaden + metsulfuron, pendimethalin + metribuzin and sequential application of pendimethalin *fb* sulfosulfuron were next in the order of significance (Table 2).

In contrast to weedy check, all the weed control treatments exhibited significant increase of varying extent in nutrient uptake by wheat crop. The maximum nitrogen (164.62 kg/ha), phosphorus (35.46 kg/ha) and potassium (127.1 kg/ha) uptake were registered by applying sulfosulfuron + mesulfuron, as means for control complex weed flora in wheat crop, (Table 2).

Table 1. Effect of treatments on weed density and weed dry matter

Treatment	Weed density* (no./m^2)			Weed dry matter (g/m^2)		
	45 DAS	60 DAS	At harvest	45 DAS	60 DAS	At harvest
Pendimethalin (750 g/ha)**	5.30 (27.7)	6.23 (38.3)	6.51 (42.0)	36.80	71.61	79.73
Sulfosulfuron (25 g/ha)	7.31(53.0)	4.91 (23.7)	5.01 (24.7)	27.82	55.76	49.85
Metribuzin (210 g/ha)	4.25 (17.7)	5.84 (33.7)	6.09 (36.7)	36.28	73.01	77.77
Clodinafop (60 g/ha)	8.55 (72.7)	5.42 (29.0)	5.72 (32.3)	28.67	57.11	59.23
Pendimethalin *fb* sulfosulfuron (1000+18 g/ha)	4.21 (17.3)	4.72 (22.0)	4.62 (21.0)	20.31	44.41	45.27
Pendimethalin + metribuzin (1000+175 g/ha)	4.05 (16.0)	5.51 (30.0)	5.66 (31.7)	20.82	50.63	52.08
Sulfosulfuron + metsulfuron (RM) (30+2 g/ha)	7.03 (49.0)	3.22 (10.0)	2.78 (7.3)	18.82	28.75	19.22
Pinoxaden + metsulfuron (60+4 g/ha)	7.77 (60.0)	4.83 (23.0)	4.41 (19.0)	25.45	36.76	28.11
Mesosulfuron + iodosulfuron (RM) (12+2.4 g/ha)	7.38 (53.7)	3.80 (14.0)	3.32 (10.7)	21.20	33.12	22.53
Clodinafop + metsulfuron (RM) (60+4 g/ha)	7.62 (57.7)	4.18 (17.0)	3.91 (15.0)	23.36	35.05	25.29
One hand weeding (30 DAS)	7.37 (52.3)	8.97 (80.0)	9.13 (83.0)	39.88	80.56	96.93
Two hand weedings (30 and 45 DAS)	7.37 (52.3)	8.27 (68.0)	8.61 (73.7)	39.88	71.56	80.84
Weedy check	10.18 (103.3)	13.34 (177.7)	14.04 (196.7)	91.60	150.89	160.9
LSD (P=0.05)	0.53	0.48	0.44	2.33	3.70	3.65

Figures in parentheses are original weed count with transformed values at $\sqrt{x+0.5}$; **Through Stomp Xtra 38.7 % CS; RM= Ready mix

Table 2. Effect of treatments on grain yield and nutrient uptake by weeds and crop

Treatment	Grain yield (t/ha)	Net returns (x10^3 `/ha)	Nutrient uptake (kg/ha)					
			By weeds			By crop		
			N	P	K	N	P	K
Pendimethalin (750 g/ha)**	4.71	60.65	1.40	0.35	2.31	127.3	25.6	104.6
Sulfosulfuron (25 g/ha)	4.84	63.72	0.97	0.28	1.65	131.9	26.8	106.8
Metribuzin (210 g/ha)	4.50	57.03	1.26	0.33	2.48	121.9	24.6	104.4
Clodinafop (60 g/ha)	4.74	61.55	0.98	0.37	2.56	129.7	27.2	109.2
Pendimethalin *fb* sulfosulfuron (1000+18 g/ha)	5.28	72.17	0.39	0.27	1.30	142.8	30.4	117.9
Pendimethalin + metribuzin (1000+175 g/ha)	5.33	72.64	0.60	0.28	1.48	143.6	30.4	117.2
Sulfosulfuron + metsulfuron (RM) (30+2 g/ha)	6.02	85.57	0.20	0.16	0.42	164.6	35.5	127.1
Pinoxaden + metsulfuron (60+4 g/ha)	5.40	74.25	0.56	0.26	0.78	146.1	31.5	120.8
Mesosulfuron + iodosulfuron (RM) (12+2.4 g/ha)	5.80	81.26	0.23	0.21	0.46	160.2	33.3	123.8
Clodinafop + metsulfuron (RM) (60+4 g/ha)	5.56	76.94	0.26	0.23	0.63	151.5	32.3	123.0
One hand weeding (30 DAS)	4.07	49.01	4.45	1.37	4.18	106.9	22.2	94.1
Two hand weedings (30 and 45 DAS)	4.29	5369	3.58	0.43	2.26	116.0	24.7	101.3
Weedy check	3.59	39.44	6.04	2.06	5.97	92.6	19.3	81.6
LSD (P=0.05)	0.34	6.38	0.04	0.13	0.03	2.45	0.56	2.13

**Through Stomp Xtra 38.7 % CS

Highest NPK uptake was recorded under weedy check but the weed control treatments tended to reduce it significantly. Least uptake was exhibited by sulfosulfuron + metsulfuron, which was followed by mesosulfuron + iodosulfuron but the two were at par, (Table 2). It was significantly superior over rest of the weed control treatments. Similar results on inverse relationship between NPK uptake by weeds and crop under the influence of weed control and concomitant yield enhancement of wheat crop have been documented by Singh *et al.* (2012).

Economical viability of treatments in term of net returns indicated that sulfosulfuron + metsulfuron (RM) and mesosulfuron + iodosulfuron (RM) were the lead herbicide mixtures; which accounted for net returns worth of ` 85566 and ` 81265, respectively. These two treatments gave at par results which significantly surpassed others.

SUMMARY

Field trial was conducted during *Rabi* 2015-2016 at Udaipur to find out an appropriate herbicidal recommendation to augment wheat productivity. The experiment consisted of thirteen treatments (pendimethalin 750 g/ha, sulfosulfuron 25 g/ha, metribuzin 210 g/ha, clodinafop 60 g/ha, pendimethalin *fb* sulfosulfuron at 1000 + 18 g/ha, pendimethalin + metribuzin at 1000 + 175 g/ha, sulfosulfuron + metsulfuron 30 + 2 g/ha, pinoxaden + metsulfuron 60+4 g/ha, mesosulfuron + iodosulfuron at 12 + 2.4 g/ha, clodinafop + metsulfuron at 60 + 4 g/ha, one hand weeding at 30 DAS, two hand weedings at 30 and 45 DAS, weedy check) were tested in a randomized block design in three replications. The results revealed that the mixed population of weeds comprising broad-leaf and grassy was significantly controlled by applying the herbicide mixtures than their alone applications. The sulfosulfuron + metsulfuron mixture resulted in minimum density and dry matter of weeds and NPK uptake by them. The simultaneous increase in NPK uptake by crop by applying this treatment resulted in significantly higher wheat grain yield and nets returns, though the yield and net returns were at par to that of mesosulfuron + iodosulfuron.

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