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# Assess the effect of different combinations of herbicides on weed population and economic feasibility of treatments in late sown wheat crop

**Sonali Singh, AK Singh, Atul Yadav, Shivam and Harikesh**

**Abstract**
The present investigation was conducted with objective to assess the effect of herbicides on weed density, physiology and economics. The experiment was laid out in randomized block design with three replications. The experiment was comprised ten treatments *viz*., $T_1$ Pendimethalin @ 0.75kg/ha, $T_2$ Metribuzin @200g/ha, $T_3$ Clodinofop propargyl @ 400g/ha, $T_4$ Sulfosulfuron methyl @ 25g/ha, $T_5$ Metsulfuron @ 0.24g/ha, $T_6$ Sulfosulfuron + metribuzin @1.14g/ha, $T_7$ Sulfosulfuron + metsulfuron @0.096g/ha, $T_8$ Isopruturon +2,4-D @ 6g/ha, $T_9$ Weed check, $T_{10}$ Weed free. The present investigation revealed that the major weed flora observed in the experiment were grassy weeds *viz., Phalaris minor, Cynodon dactylon, Avena fatua* and Broad leaf weeds *viz*., C*henopodium album, Anagallis arvensis, Convolvulus arvensis, Melilotus alba, Rumex spp.* and sedges *Cyperus rotundus.* Among herbicides, post emergence application of Sulfosulfuron+ Metsulfuron@ 0.096 g $ha^{-1}$ proved its superiority over other herbicides followed by post emergence application of Isopruturon +2,4-D@ 6 g $ha^{-1}$ for reducing number and dry weight of weeds at all the stages of crop growth. Application of Metribuzin @ 200 g $ha^{-1}$registered highest dry matter accumulation over other herbicides followed by Pendimethalin @ 0.75kg/ha at all the growth stages of crop growth. Post emergence application of Sulfosulfuron+ Metsulfuron@ 0.096 g $ha^{-1}$ registered highest weed control efficiency of 82.27% followed by post emergence application of Isopruturon +2,4-D@ 6 g $ha^{-1}$ (79.11%). Weed infestation exhibited 31.16% loss in grain yield, which were minimized by post emergence application of Sulfosulfuron+ Metsulfuron @ 0.096 g $ha^{-1}$ which recorded lowest value of weed index (2.809%) followed by post emergence application of post emergence application of Isopruturon +2,4-D@ 6 g $ha^{-1}$ (5.36%).

**Key words:** wheat, herbicides, weed control efficacy

## Introduction
Wheat (*Triticum aestivum* L.) "King of cereals" belongs to family *poacea*. It is primarily grown in temperate regions and also at higher altitude under tropical climatic areas in winter season. It is the single most important cereal crop. It has been considered as integral component of the food security system of the several nations. It is eaten in various forms more than one thousand million humans being in the world. In the terms of production wheat occupies the prime position among the food crop in the world. Wheat is the world's leading cereal crop, cultivated over an area of 215 m ha with the production of 726 million tons (USDA Report 2015) [10] of grains. Wheat is grown in 122 countries. Major wheat producing countries are China, India, USA, Canada and Australia. China is the world largest producer of wheat around 126 million tons. India is the 2nd largest producer of wheat around 95 million tons.

The prominent weeds noted in wheat fields are *Phalaris minor, Chenopodium album, Anagallis arvensis, Avenafatua, Convolvulus arvensis, Lathyrusaphaca, Cyperus rotundus* and *Cynodon dactylon* etc. which alone cause 33 per cent reduction in wheat yield. Rice-wheat is one of the most important cropping systems in northern part of the country. The *Phalaris minor* is one of the very serious problems in wheat in this cropping system and sometimes almost 65 per cent crop losses have been reported, (Chhokar *et al*.,2008) [2] some broad leaved weeds are also causing a threat but their control is comparatively easier and effective but control of *Phalaris minor* has become a serious challenge. Some of the resistant types of the *Phalaris minor* were reported against isoproturon in 1990s from Haryana and western U.P. and later on some new herbicides molecules eg. Sulfosulfuron, Clodinafop, Isoproturon and fenoxapropmethyl were registered and recommended to control the *Phalaris minor* in wheat since Walia and Brar (2006) [11]. After 2010 these herbicides have also been proved ineffective to control this weed. Likewise, due to the repeated application of grassy weed killer molecules, infestation of broad leaved weeds becoming a serious problem in the wheat fields. Under such circumstances, there is an urgent need to find out some other molecules which may be quite effective against not only to grassy weeds but also take care of broad leaves weed. In the present investigation, some of the new herbicides molecules (combinations) having its very high potency at lower doses to kill grassy along with broad leaved weeds have been developed as ready mixed. These molecules may be proved more effective to control various weed species as well as relatively safer for environmental pollution point of view.

## Materials and Methods

### Experimental details

The treatments were allocated to different plot at random in all the three replications using the random tables. The lay out plan of present investigation is given in Fig.3.2,

### Details of treatments with their symbols

| S. No. | Details of treatments | Symbols |
|---|---|---|
| 1 | Pendimethalin 0.75g/ha | $T_1$ |
| 2 | Metribuzin 200g/ha | $T_2$ |
| 3 | Clodinafop propargyl 400gha$^{-1}$ | $T_3$ |
| 4 | Sulfosulfuron 25gha$^{-1}$ | $T_4$ |
| 5 | Metsulfuron 0.24 g ha$^{-1}$ | $T_5$ |
| 6 | Sulfosulfuron+Metribuzin(0.15+1.26)=1.41g ha$^{-1}$ | $T_6$ |
| 7 | Sulfosulfuron+Metsulfuron(0.09+0.006)=0.096g.ha$^{-1}$ | $T_7$ |
| 8 | Isoproturon+2,4-D(4+2)= 6gha$^{-1}$ | $T_8$ |
| 9 | Weed check | $T_9$ |
| 10 | Weedy free | $T_{10}$ |

## Result and Discussion

### Studies on weeds

Divergent weed flora like *Phalaris minor, Cynodon dactylon, Avena fatua* of grassy weeds, *Chenopodium album, Angallis arvensis, Convolvulus arvensis, Rumex spp., Melilotus indica, Vicia hirsuta* and *Lathyrus aphaca* of broad leaf weed and *Cyperus rotundus* of sedges were noted (Table-1). Similar weed flora of wheat crop under normal as well as late sown condition have also reported by Wani *et al.* (2005) [13], Kumar *et al.* (2006) [3-5], Singh *et al.* (2006) [5] and Rahaman and Mukherjee, (2009) [4].

**Table 1:** Weed flora of experimental crop

| | Weed species | Common name | Family | Habitat |
|---|---|---|---|---|
| **A- Grasses** | | | | |
| 1. | *Phalaris minor* | Canary grass | Poaceae | Annual |
| 2. | *Avena fatua* | Wild oat | Poaceae | Annual |
| 3. | *Cynodon dactylon* | Bermuda grass | Poaceae | Annual |
| **B- Sedges** | | | | |
| 1. | *Cyperus rotundus* | Nut sedge | Cyperaceae | Perennial |
| **C- Broad leaf weeds** | | | | |
| 1. | *Chenopodium album* L. | Lambis quarter | Chaenopodiaceae | Annual |
| 2. | *Anagallis arvensis* L. | Blue pimpernal | Primulaceae | Annual |
| 3. | *Convonvulus arvensis* L. | Field binder | Convonvulaceae | Annual |
| 4. | *Melilotus alba* Medikus | Sweet clover | Leguminaceae | Annual |
| 5. | *Coronopus spp.* | Lesser swine-cress | Brassicaceae | Annual |
| 6. | *Rumex spp.* | Dock | Polygonaceae | Perennial |

### Weed density (m$^{-2}$)

By and large, all the herbicidal treatments reduced the weed population significantly over un-weeded control at 60$^{th}$, 90$^{th}$ day and harvest stages of crop growth. Next to weed free, post emergence application has Sulfosulfuron+ Metsulfuron@ 0.096gha$^{-1}$ been found most effective to control the weeds as compared to other herbicide at all the stages. Post emergence application of Sulfosulfuron+Metsulfuron@0.096gha$^{-1}$ was found at par with most effective to control the weeds followed by post emergence application of Isopruturon +2,4-D@6gha$^{-1}$ and both were significantly superior than weedy check (Table-2). Effective weed control in wheat by the use of isoproturon and 2, 4-D has also been observed by Wani *et al.* (2005) [13].

**Table 2:** Effect of various weed control treatments on weed density at different growth stages

| Treatments | | Weed density (No. m$^{-2}$) | | | |
|---|---|---|---|---|---|
| | | 30 DAS | 60 DAS | 90 DAS | At Harvest |
| $T_1$ | Pendimethalin @ 0.75kg ha$^{-1}$ | 11.05 (121.90) | 6.00 (35.50) | 7.87 (61.70) | 6.65 (43.80) |
| $T_2$ | Metribuzin @ 200g ha$^{-1}$ | 10.90 (118.60) | 6.39 (40.40) | 10.30 (105.8) | 8.33 (69.10) |
| $T_3$ | Clodinafop propargyl@400g ha$^{-1}$ | 10.84 (117.40) | 3.90 (14.70) | 6.49 (41.60) | 5.17 (26.30) |
| $T_4$ | Sulfosulfuron methyl @25g ha$^{-1}$ | 11.10 (123.00) | 4.40 (18.90) | 7.39 (54.30) | 5.97 (35.20) |
| $T_5$ | Metsulfuron@0.24 g ha$^{-1}$ | 10.90 (118.50) | 4.71 (21.70) | 7.13 (50.50) | 5.72 (32.30) |
| $T_6$ | Sulfosulfuron+ Metribuzin@1.41 g ha$^{-1}$ | 11.13 (123.80) | 4.62 (20.90) | 6.78 (45.60) | 5.38 (28.50) |
| $T_7$ | Sulfosulfuron+ Metsulfuron@ 0.096 g ha$^{-1}$ | 11.03 (121.40) | 3.14 (9.40) | 5.70 (32.10) | 3.56 (12.20) |
| $T_8$ | Isopruturon +2,4-D@ 6 g ha$^{-1}$ | 10.86 (117.50) | 3.59 (12.40) | 6.03 (36.00) | 4.63 (21.00) |
| $T_9$ | Weed check | 11.03 (121.60) | 13.38 (178.80) | 13.96 (194.80) | 13.93 (194.0) |
| $T_{10}$ Weed free | | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| SEm ± | | 0.37 | 0.21 | 0.28 | 0.24 |
| CD at 5% | | N.S | 0.62 | 0.83 | 0.71 |

* The value in parentheses are original value.

** Value transformed by $\sqrt{x+1}$

**Dry matter of weed (gm$^{-2}$)**

Synonymous to weed density, weed dry weight was also reduced significantly by the different weed management practices as compared to un-weeded control at all the stages of crop growth. The weed dry weight recorded at harvest stage was lower than 90$^{th}$ day stage due to senescence of weed plants with the advancement of age. Post emergence application of Sulfosulfuron +Metsulfuron@ 0.096g ha$^{-1}$ was most effective to reduce the weed dry weight g m$^{-2}$ which remained at par with Post emergence application of Isopruturon +2,4-D@6gha$^{-1}$ and weed free. Reduced weed density under these treatments have resulted in reduced weed dry weight. Similar findings were also reported by Wani *et al.* (2005) [13], Chhipa *et al.* (2005) [1], and Malik *et al.* (2006) [3].

**Table 3:** Effect of weed control treatments on Dry matter accumulation of weed flora at different growth stages.

| Treatments | | 30 DAS | 60 DAS | 90 DAS | Harvest stage |
|---|---|---|---|---|---|
| $T_1$ | Pendimethalin @ 0.75kg ha$^{-1}$ | 3.88 (14.58) | 4.82 (22.75) | 7.54 (56.40) | 6.01 (35.60) |
| $T_2$ | Metribuzin @ 200g ha$^{-1}$ | 3.93 (15.00) | 8.61 (66.30) | 13.67 (187.0) | 12.45 (155.0) |
| $T_3$ | Clodinafop propargyl@400g ha$^{-1}$ | 3.57 (12.25) | 3.66 (12.95) | 5.78 (33.00) | 4.41 (18.96) |
| $T_4$ | Sulfosulfuron methyl @25g ha$^{-1}$ | 3.87 (14.50) | 3.31 (10.50) | 5.95 (34.90) | 5.53 (30.20) |
| $T_5$ | Metsulfuron@ 0.24 g ha$^{-1}$ | 3.77 (13.75) | 4.52 (20.00) | 6.54 (42.40) | 5.07 (25.30) |
| $T_6$ | Sulfosulfuron+ Metribuzin @ 1.41 g ha$^{-1}$ | 3.66 (12.95) | 4.13 (16.60) | 5.98 (35.30) | 4.65 (21.20) |
| $T_7$ | Sulfosulfuron+Metsulfuron @ 0.096 g ha$^{-1}$ | 4.09 (16.30) | 2.26 (4.60) | 5.04 (25.00) | 3.09 (9.10) |
| $T_8$ | Isopruturon +2,4-D @ 6 g ha$^{-1}$ | 3.74 (13.55) | 2.45 (5.50) | 5.42 (29.00) | 3.64 (12.75) |
| $T_9$ | Weed check | 3.92 (14.90) | 10.54 (110.8) | 17.92 (321.3) | 17.43 (303.95) |
| $T_{10}$ | Weed free | 0.71 (0.0) | 0.71 (0.00) | 0.71 (0.00) | 0.71 (0.00) |
| SEm ± | | 0.13 | 0.18 | 0.32 | 0.26 |
| CD at 5% | | N.S | 0.55 | 0.95 | 0.77 |

**Weed control efficiency**

The spectrum of weeds has a bearing on the efficiency of the management practices adopted (Table-4). Post emergence application of Sulfosulfuron+Metsulfuron@0.096gha$^{-1}$ provided the highest weed control efficiency (82.27%) followed by Post emergence application of Isopruturon +2,4-D@6gha$^{-1}$ (79.11%). This was mainly due to lowest weed dry weight under the effects of above treatment. Chhipa *et al.* (2005) [1], Wallia *et al.* (2011), Chopra *et al*. (2015) [7] have also reported increase in weed control efficiency with use of herbicides in wheat.

**Weed index**

Weed index is the measure of reduction in yield caused by weed infestation and directly related with weed density and weed dry matter (Table-4). Post emergence application of Sulfosulfuron+Metsulfuron@0.096gha$^{-1}$ recorded lowest weed index of 2.809 followed by post emergence application of Isopruturon +2,4-D@6gha$^{-1}$ of 5.36 as compared to weed index of 31.16 noted with weedy check. This was mainly due to lesser crop weed competition in herbicidal treatment as compared to weedy check within term resulted higher yield vice-versa reduce weed index. The results are in agreement with Chhipa *et al.* (2005) [1].

**Table 4:** Effect of various weed control treatments on weed control efficiency and weed index.

| Treatment | | W.C.E. (%) | W.I. (%) |
|---|---|---|---|
| $T_1$ | Pendimethalin @ 0.75kg ha$^{-1}$ | 65.51 | 13.53 |
| $T_2$ | Metribuzin @ 200g ha$^{-1}$ | 28.57 | 20.17 |
| $T_3$ | Clodinafop propargyl@400g ha$^{-1}$ | 74.69 | 6.130 |
| $T_4$ | Sulfosulfuron methyl @25g ha$^{-1}$ | 68.27 | 11.74 |
| $T_5$ | Metsulfuron@0.24 g ha$^{-1}$ | 70.91 | 9.323 |
| $T_6$ | Sulfosulfuron+ Metribuzin@1.41 g ha$^{-1}$ | 73.32 | 6.5 |
| $T_7$ | Sulfosulfuron+Metsulfuron@0.096g ha$^{-1}$ | 82.27 | 2.809 |
| $T_8$ | Isopruturon +2,4-D@ 6 g ha$^{-1}$ | 79.11 | 5.36 |
| $T_9$ | Weed check | 0.00 | 31.16 |
| $T_{10}$ | Weed free | 100 | 0.00 |

**Economics**

The highest cost of cultivation of Rs 25765 ha$^{-1}$ was incurred under weed free against the lowest cost of cultivation of Rs.23720 ha$^{-1}$ of weedy check (Table-5). All the treatments higher gross return, net return and benefit cost ratio over weedy check. The maximum gross income of Rs. 69980 ha$^{-1}$ was obtained with weed free closely followed by Sulfosulfururon + metsulfuron@ 0.096gha$^{-1}$ (Rs.68110 ha$^{-1}$) against lowest gross income of Rs. 48590 ha$^{-1}$ of weedy check. Weed free recorded the highest net return of Rs. 44215ha$^{-1}$ closely followed by post emergence application of Sulfosulfururon + metsulfuron @0.096g ha$^{-1}$ (Rs. 42930 ha$^{-1)}$ and against lowest net return of Rs. 24870 ha$^{-1}$ noted with weedy check. Weed free as well as Sulfosulfururon+metsulfuron@0.096gha$^{-1}$ treatments also recorded highest benefit cost ratio of 1.72, 1.70 as compared to weedy check of 1.04.

The weed free was not found to be economical in comparison to other herbicidal treatments because of its high labors expenditure involved in keeping the plots free of weeds. The better net return and net return per rupee investment was mainly due to higher grain and straw yield to greater extent as compare to lesser increase in cost of cultivation with these treatments. The results are in agreement with Verma *et al.* (2008) [2], Singh *et al.* (2013) [6] and Sharma *et al*. (2015) [7].

**Table 5:** Effect of various weed control treatments on Economics.

| Treatments | Total cost of cultivation (Rs ha$^{-1}$) | | Gross return (Rs ha$^{-1}$) | Net return (Rs ha$^{-1}$) | B-C ratio |
|---|---|---|---|---|---|
| $T_1$ | Pendimethalin @ 0.75kg ha$^{-1}$ | 24020 | 60420 | 36400 | 1.51 |
| $T_2$ | Metribuzin @ 200g ha$^{-1}$ | 24066 | 56200 | 32134 | 1.34 |
| $T_3$ | Clodinafop propargyl @400g ha$^{-1}$ | 24970 | 66000 | 41030 | 1.64 |
| $T_4$ | Sulfosulfuron methyl@25g ha$^{-1}$ | 24570 | 62085 | 37515 | 1.52 |
| $T_5$ | Metsulfuron 0.24 g ha$^{-1}$ | 24330 | 63687 | 39357 | 1.61 |
| $T_6$ | Sulfosulfuron+Metribuzin@1.41 g ha$^{-1}$ | 24916 | 65432 | 40516 | 1.63 |
| $T_7$ | Sulfosulfururon+metsulfuron@0.096gha$^{-1}$ | 25180 | 68110 | 42930 | 1.70 |
| $T_8$ | Isoproturon+2,4-D @6g/ha | 24950 | 66285 | 41335 | 1.66 |
| $T_9$ | Weedy check | 23720 | 48590 | 24870 | 1.04 |
| $T_{10}$ | Weed free | 25765 | 69980 | 44215 | 1.72 |

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