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Bio-efficacy of pre- & post-emergence herbicides in controlling three problematic weed species of wheat & pea crops in winter season

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Abstract
The investigation was conducted during the winter season of 2014-15 to study the herbicidal efficacy of different herbicides on three problematic weed species of winter season *viz., Phalaris minor, Medicago denticulata* and *Anagallis arvensis.* The field experiment was conducted at Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar. Wheat (UP-2526) & pea (P-25) were also grown to determine the phytotoxic effects of these herbicides, if any, on the associated crops of these weeds. The treatments consisted of clodinafop @ 60 g/ha, clodinafop+ mesosulfuron methyl @ 60 g+4.0 g/ha, sulfosulfuron @ 25g/ha, metribuzin @ 250 g/ha, pendimethalin @ 1 kg/ha and trifluralin @ 1 kg/ha. This experiment was laid out in a randomized block design with three replications. Among the herbicides tested in the present study, The pre-emergnce herbicides pendimethalin and trifluralin effectively controlled the germination of *P. minor* and *A. arvensis*. Among post emergence herbicides, ready mix of Clodinafop + MSM successfully controlled all the three weeds. Application of clodinafop alone seems to be effective against only *P. minor* whereas, sulfosulfuron and metribuzin were effective against the broad-leaved weeds. Phytotoxicity effect was observed in wheat in trifluralin treatment whereas pea exhibited toxicity symptoms in ready mix of Clodinafop + Metsulfuron methyl (MSM) and sulfosulfuron treatments.

Keywords: bioefficacy, herbicides, phytotoxicity, treatments, weeds control

Introduction
The concept of weeds as unwanted plant was born when man started to grow plants deliberately for food and other purposes. There are about 30,000 species of weeds in the world, of which 50 to 200 usually cause appreciable damage to the major food crops. Weeds belong to all plant families, but certain families particularly Asteraceae, Poaceae, Brassicaceae and Fabaceae constitute the worldwide major weed flora. It was estimated that 250 weed species are common in agricultural crops throughout the world (Marwat *et al.,* 2012) [5]. Over the past 40 years, modern herbicides make a significant contribution to the high productivity of global agriculture by effectively controlling weeds and substituting for destructive soil cultivation. The success of any herbicide depends on both its method of application and its mode of action (Powles and Yu, 2010) [8]. Some of the herbicides are effective against grasses while some are against broad leaved weeds. Combination of grassy and broad leaf herbicides was better than their separate application for weed control in wheat (Cheema and Akhtar, 2005) [3].
Wheat crop usually suffers from stress created by weeds (Anderson, 1983) along with the interference caused by releasing toxic substances into the rhizosphere of the crop plants. To properly address the weed problem in wheat, there is a dire need of developing a package of weed control technology for the wheat growers (Amare, 2014). Global yield reduction in wheat due to weeds is 13.1% (Oerke *et al.,* 1994) [6] or even more. The losses in wheat yield have been reported from 10-50%depending upon the intensity of infestation of weeds (Walia *et al.,* 1990) [10]. Pea crop which is an important pulse crop and vegetable as well suffers of about 81% loss in its yield due to weed infestation. The critical period for crop-weed competition in pea varies from 40–60 days after sowing (Rana *et al.,* 2013) [9]. In the present study, the efforts have been made to find out the bio-efficacy of some pre- and post-emergence herbicides in controlling three problematic weed species of winter season.

Materials and Methods

To study the bio-efficacy of some pre- and post-emergence herbicides in controlling three problematic weed species (*Phalaris minor*, *Medicago denticulata* and *Anagallis arvensis*) of winter season for weed management and their toxic effects, if any, on associated crops *viz*, wheat (UP-2526) & pea (P-25), a field experiment was conducted during *Rabi* season of 2014-15 at Norman E. Borlaug Crop Research Centre, G. B. Pant University of Agriculture and Technology, Pantnagar. Pantnagar lies in the Tarai region to the South of foot hills of the Shivalik Himalayas at 29ºN latitude and 79.3ºE longitude and at an altitude of 243.83m above mean sea level. The experiment consisted of seven treatments including control and it was laid out in a randomized block design with three replications. The treatments were as follows: clodinafop @ 60 g/ha, clodinafop+ mesosulfuron methyl @ 60 g+4.0 g/ha, sulfosulfuron @ 25g/ha, metribuzein @ 250 g/ha, pendimethalin @ 1 kg/ha and trifluralin @ 1 kg/ha. There were two pre-emergence herbicides, trifluralin and pendimethalin and rest of the treatments were post-emergence. The post-emergence herbicides were applied at 37 days after sowing. The biomass (g/m^2) of weeds was recorded at 40 days after spraying and at harvest whereas the weed counts for percent mortality of weeds and phytotoxic effects of herbicides on associated crops were observed after the application of herbicides at their recommended doses. The data on weed biomass was statistically analyzed at 5% level of significance.

Results and Discussion

Mortality of weeds (%) treated with different herbicides

The mortality of weeds in different herbicide treatments is presented in Table 1. The data on weed mortality (%) showed that pre-emergence herbicides, trifluralin @ 1kg/ha and pendimethalin @ 1kg/ha inhibited the germination of *P. minor* and *A. arvensis*. Trifluralin @ 1kg/ha, pendimethalin @ 1kg/ha and *c*lodinofop-propargyl @ 60g/ha were found ineffective to control *M. denticulata*. The data showed that *P. minor*, *M. denticulata* and *A. arvensis* were effectively controlled by the ready mix of clodinafop propargyl + metsulfuron methyl. The broad leaves weed (*M. denticulata* and *A. arvensis*) were completely controlled (100% mortality) by clodinofop propargyl + metsulfuron methyl @ 60g/ha+4g/ha, sulfosulfuron @ 25g/ha and metribuzin @ 250g/ha.

Table 1: Effect of different herbicides on mortality (%) of weed species under study

	Grasses	**(BLWs)**	
Treatments	***P. minor***	***M. denticulata***	***A. arvensis***
T1 (Trifluralin @ 1kg/ha)	No germination	0	No germination
T2 (Pendimethalin @ 1kg/ha)	No germination	0	No germination
T3 (Clodinofop-propargyl @ 60g/ha)	100	0	0
T4 (Total @ Clodinofop-propargyl + Metsulfuron methyl @ 60g/ha+4g/ha)	100	100	100
T5 (Sulfosulfuron @ 25g/ha)	0	100	100
T6 (Metribuzin @ 250g/ha)	100	100	100
T7 (Control)	0	0	0

Effect of herbicides on weed dry weight

The mean data on weed biomass (g/m^2) under different treatments is presented in the table 2. The biomass of weeds was significantly affected by application of various pre-emergance and post-emergence herbicides. The biomass of weed species was recorded at 40 DAS and at harvest. At 40 DAS, all the treatments were found effective to control *P. minor* except sulfosulfuron @ 25g/ha. The biomass and infestation of *P. minor* was highest under control (untreated) as compared to other treatments at 40 DAS ($386.6 g/m^2$) and at harvest ($1085.3 g/m^2$). *M. denticulata* was successfully controlled by clodinafop+ metsulfuron methyl, sulfosulfuron and metribuzin. The biomass was found maximum under trifluralin @ 1kg/ha ($154.6 g/m^2$) at 40 DAS and clodinofop-propargyl @ 60g/ha ($892 g/m^2$) at harvest.

Table 2: Effect of herbicides on biomass of weed species (g/m^2) at 40 DAS and at harvest

Treatments	***P. minor***		***M. denticulata***		***A. arvensis***	
	40 DAS	**Harvest**	**40 DAS**	**Harvest**	**40 DAS**	**Harvest**
T1(Trifluralin @ 1kg/ha)	0	0	154.6	630.6	0	0
T2(Pendimethalin @ 1kg/ha)	0	687.3	147.1	505.3	0	0
T3(Clodinofop-propargyl @ 60g/ha)	0	0	93.7	892.0	4.96	118.6
T4(Clodinofop propargyl + msm @ 60g/ha+4g/ha)	0	0	0	0	0	0
T5(Sulfosulfuron @ 25g/ha)	94.6	310.0	0	0	0	0
T6(Metribuzin @ 250g/ha)	0	841.3	0	0	0	0
T7(Control)	386.6	1085.3	129.3	694.0	15.8	73.3
S.Em(±)	5.28	26.8	15.5	11.6	2.24	3.28
CD (P=0.05)	16.4	82.8	47.4	36	6.96	10

DAS= Days after sowing, msm= metsulfuron methyl

The results indicated that among the different weed management practices, the application of pre-emergnce herbicides pendimethalin and trifluralin effectively controlled the germination of *P. minor* and *A. arvensis*. Readymix of clodinofop-propargyl+ metsulfuron methyl @ 60g/ha+4g/ha, sulfosulfuron @ 25g/ha and metribuzin @ 250g/ha were also effective to control *A. arvensis* whereas clodinofop-propargyl was found ineffective against this weed.

Toxicity of herbicides to crops

A visible injury symptom was observed in wheat and pea under some herbicide treatments and it is presented in the table 3. There was poor germination in wheat under trifluralin treatment while rest of the treatments did not show any phytotoxic effect on wheat. Pea exhibited toxicity symptoms in ready mix of clodinafop+metsulfuron methyl and sulfosulfuron treatments. The symptoms included chlorosis,

necrosis and leaf burn which lead to complete death of the plant tissues. Pea was unaffected under trifluralin and pendimethalin treatment and did not show any phytotoxicity. In clodinafop-propargyl treatment, the injury appeared as patches on the leaf surface that were lightly bleached & lighter in colour whereas sulfosulfuron caused distinct small to medium white linear splotches, well defined by a necrotic contour. The lower leaves of pea got damaged by metribuzin.

Table 3: Toxicity symptoms in crops treated with different herbicides

Treatment	Wheat	Pea
T1(Trifluralin @ 1kg/ha)	Affected, Poor germination	Not affected
T2(Pendimethalin @ 1kg/ha)	Not affected	Not affected
T3(Clodinofop-propargyl @ 60g/ha)	Not affected	Less affected
T4(Total @ Clodinofop-propargyl + Metsulfuron methyl @ 60g/ha+4g/ha)	Not affected	100% mortality
T5(Sulfosulfuron @ 25g/ha)	Not affected	100% mortality
T6(Metribuzin @ 250g/ha)	Not affected	Lower leaves dead
T7(Control)	-	-

Effect of herbicides on crop dry weight

The effect of herbicides on crop dry weight under different treatments is presented in the table 4. At 40 days after spraying, maximum biomass of wheat was recorded under clodinofop-propargyl @ 60g/ha treatment followed by metribuzin @ 250g/ha and sulfosulfuron @ 25g/ha whereas trifluralin @ 1kg/ha treatment attained the minimum biomass of wheat at 40 days after spraying and as well as at harvesting. On the other hand, in case of pea highest biomass was achieved under pendimethalin @ 1Kg/ha treatment at 40DAS whereas clodinofop-propargyl and sulfosulfuron were injurious for pea and not suitable for weed control in pea.

Table 4: Effect of herbicides on biomass (g/m^2) of crops (Wheat and pea) at 40 days after spraying and at harvest

Treatments	*Triticum aestivum*		*Pisum sativum*	
	40 DAS	Harvest	40 DAS	Harvest
T1(Trifluralin @ 1kg/ha)	226.6	670.6	164	1026.6
T2(Pendimethalin @ 1kg/ha)	534.6	1426.6	233.3	720
T3(Clodinofop-propargyl @ 60g/ha)	756.0	1437.3	174.6	653.3
T4(Total @ Clodinofop-propargyl + Metsulfuron methyl @ 60g/ha+4g/ha)	653.3	1618.6	0	0
T5(Sulfosulfuron @ 25g/ha)	729.3	1733.3	0	0
T6(Metribuzin @ 250g/ha)	736.0	1806.6	192	553.3
T7(Control)	452.0	1320	209.3	376
S.Em(±)	24.8	90.4	13.2	45.6
CD (P=0.05)	76.5	278.48	40.8	141.2

Effect of herbicides on chlorophyll content (mg/g FW) of *Triticum aestivum* and *Pisum sativum*

The chlorophyll content of wheat leaves under different treatments is presented in table 5. In wheat, the chlorophyll 'a' and 'b' content was highest under untreated plot (T7 treatment), it was 2.02 mg/g FW and 0.5 mg/g FW respectively**.** Chlorophyll a content was slightly affected in sulfosulfuron treatment (1.30 mg/g FW) but in case of trifluralin, it was recorded minimum as compared to rest of the treatment. Among the herbicide treatments, the chlorophyll content was found highest in (T6 treatment) metribuzin @ 250g/ha *viz.*, chlorophyll a ;1.71mg/g FW, chlorophyll b ;0.45 mg/g FW and total chlorophyll; 2.13 mg/g FW. The data on chlorophyll content of pea leaves is presented in table 6. The chlorophyll 'a'content was highest under pendimethalin (T2 treatment), it was 1.676 mg/g FW while chlorophyll 'b' was maximum in metribuzin (T6 treatment); 0.551 mg/g FW.

Table 5: Effect of herbicides on chlorophyll content of *Triticum aestivum* (mg/g FW)

Treatments	Chl a	Chl b	total Chl
T1(Trifluralin @ 1kg/ha)	1.063	0.232	1.275
T2(Pendimethalin @ 1kg/ha)	1.500	0.369	1.842
T3(Clodinofop-propargyl @ 60g/ha)	1.454	0.351	1.777
T4(Total @ Clodinofop-propargyl + Metsulfuron methyl @ 60g/ha+4g/ha)	1.469	0.341	1.783
T5(Sulfosulfuron @ 25g/ha)	1.306	0.421	1.701
T6(Metribuzin @ 250g/ha)	1.712	0.457	2.137
T7(Control)	2.027	0.529	2.517
Sem	0.102	0.036	0.125
Cd at 5%	0.355	0.123	0.433

Table 6: Effect of herbicides on chlorophyll content of *Pisum sativum* (mg/g FW)

Treatment	Chl a	Chl b	total Chl
T1(Trifluralin @ 1Kg/ha)	1.127	0.305	1.412
T2(Pendimethalin @ 1Kg/ha)	1.676	0.331	1.977
T3(Clodinofop-propargyl @ 60g/ha)	1.270	0.391	1.637
T4(Total @ Clodinofop-propargyl + Metsulfuron methyl @ 60g/ha+4g/ha)	0.673	0.283	0.943
T5(Sulfosulfuron @ 25g/ha)	0.907	0.306	1.196
T6(Metribuzin @ 250g/ha)	1.130	0.551	1.658
T7(Control)	1.297	0.487	1.759
Sem	0.099	0.075	0.165
Cd at 5%	0.342	0.258	0.570

Effect of herbicides on proline content of wheat and pea (µ mol/g FW)

Effect of herbicide on proline content of wheat and pea is presented in Figure 1. Highest proline content was accumulated in (T1 treatment) trifluralin (12.1 µ mol/g FW) and sulfosulfuron (17.7µ mol/g FW) in case of wheat and pea respectively. The proline content in pea was found less in pre-emergence herbicides; pendimethalin and trifluralin as compared to the post-emergence herbicides. Lowest proline content of wheat and pea was recorded under control.

Table 7: Recovery of crops in different pre and post emergence herbicide treatment

Treatments	*Triticum aestivum*	*Pisum sativum*
T1(Trifluralin @ 1kg/ha)	XX	**
T2(Pendimethalin @ 1kg/ha)	**	**
T3(Clodinofop-propargyl @ 60g/ha)	**	20-25
T4(Total @ Clodinofop-propargyl + Metsulfuron methyl @ 60g/ha+4g/ha)	**	-
T5(Sulfosulfuron @ 25g/ha)	**	-
T6(Metribuzin @ 250g/ha)	**	25
T7(Control)	**	**

**=No effect X=Not recovered, -=complete death, XX=Poor germination

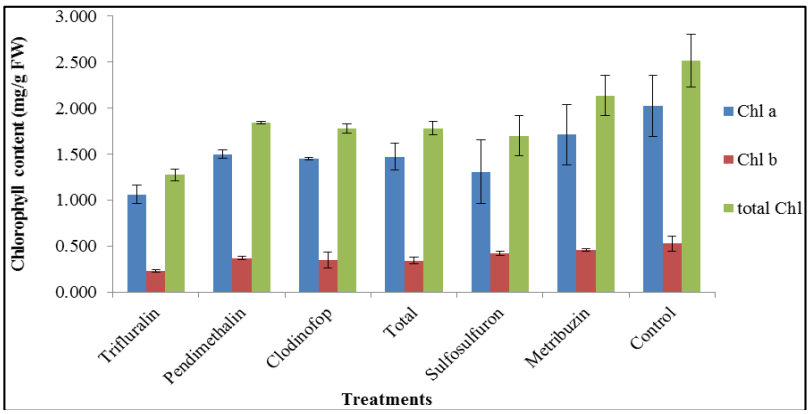

Fig 1: Effect of herbicides on chlorophyll content (mg/g FW) of wheat at 35 days after spraying

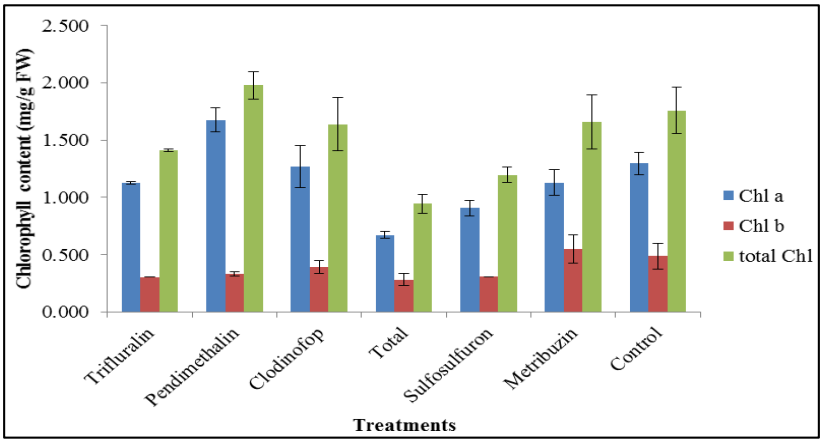

Fig 2: Effect of herbicides on chlorophyll content (mg/g FW) of pea at 35 days after spraying.

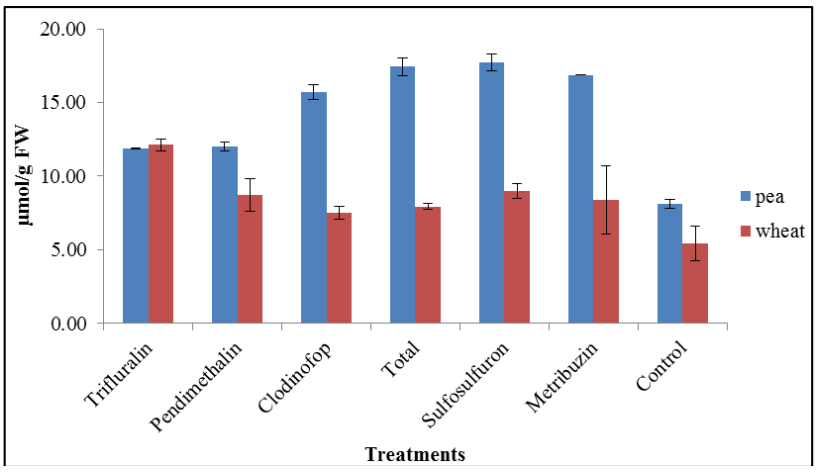

Fig 3: Effect of herbicides on proline content of wheat and pea (µ mol/g FW)

Recovery time of crops treated with different Pre and post emergence herbicides

Recovery of crops in different pre and post emergence herbicide treatment is presented in table 7. In wheat, no toxicity was observed in any of the treatments except trifluralin. Poor germination was found in wheat crop under trifluralin treatment throughout the season. The pea crop was recovered within 20 to 25 days after spraying under clodinofop-propargyl @ 60g/ha and metribuzin @ 250g/ha treatment but no recovery was observed under sulfosulfuron @ 25g/ha and readymix of clodinofop-propargyl + metsulfuron methyl @ 60g/ha+4g/ha treatment.

Summary and Conclusion

Results revealed that the population of *Phalaris minor*, *Medicago denticulata* and *Anagallis arvensis* effectively controlled by all the herbicides as compared to untreated. The results are in conformity with the findings of Kathiresan *et al.* (2004) **[4]**. The efficacy of herbicides on the basis of weed biomass indicated that weed population was significantly less in herbicide treated plots as compare to control. The variability in weeds population in different treatments can be attributed to the fact that some herbicides are more effective for weed control than the others. Among post emergence herbicides, Clodinafop + metsulfuron methyl successfully controlled all the weeds. This combination have been reported to be very effective against complex weed flora in wheat crop with about 95% control of grassy and BLWs. Similar results were reported by Pandey *et al*. (2001) [7]. Metsulfuron methyl kills broadleaf weeds and some annual grasses through foliar and soil activity, which inhibits cell division in shoots and roots. All the herbicides were found safe on wheat crop except trifluralin whereas pea exhibited toxicity symptoms in ready mix of Clodinafop + Metsulfuron methyl and sulfosulfuron treatments.

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Authors' contributions

The first author of the paper Prinsa along with Nitin Kumar (2nd author) were critically involved in the fieldwork regarding the experiment and collected all the data at respective stages. Sudershan Mishra and Babita Joshi addressed the problem of analyzing and formulating the data so that specific results could be drawn out. Dr. S K Guru had major contributions towards developing the draft of the manuscript.

Photo plate 1: Effect of root growth inhibitors, Pendimethalin and trifluralin on weeds and crops

Early and late symptoms of metribuzin on *M. denticulata*

Early and late symptoms of metribuzin on *P. minor.*

Photo plate 2: Effect of metribuzin on *M. denticulata* and *P. minor*

A) Control

Sulfosulfuron

Clodinofop + Metsulfuron methyl

Photo plate 3: Effect of post-emergence herbicides clodinafop-propargyl and readymix of clodinafop and metsulfuron methyl on crops and weeds

References

1. Amare T. Effect of weed management methods on weeds and wheat (*Triticum aestivum* L.) yield, African Journal of agricultural Research. 1990; 9:1914-1920.
2. Anderson WP. Weeds-crop competition. In: Weed Science Principles, 2nd Ed, West Publication Co., St. Paul Minn, USA, 1983, 33-42.
3. Cheema MS, Akhtar M. Efficacy of different post emergence herbicides and their application methods in controlling weeds in wheat, Pak. J Weed Sci. Res. 2005; 11:23-30.
4. Kathiresan RM, Gnanavel I, Jayakan UV, Arulchezlian MP, Anbhazhagon R, Pandmapriya SP. Bioefficiency and phytotoxicity of oxadiagyl in onion (*Allium cepa* var. *aggregatum*), Indian J Weed Sci. 2004; 36:236-238.
5. Marwat SF, Usman K, Khan N, Khan MU, Khan EJ, Khan MA, *et al.* Weeds of wheat crop and their control strategies in Dera Ismail Khan District, Khyber Pakhtun Kh wa, Pakistan, American J Plant Sci. 2012; 4:66-76.
6. Oerke EC, Dehne HW, Schonbeck F, Weber A. Crop Production and Crop Protection: Estimated Losses in Major Food and Cash Crops, Elsevier, Amsterdam, 1994.
7. Pandey J, Singh R, Verma AK. Influence of herbicides on weed management in true potato, Acta Agronomica Hungarica. 2001; 49:183-87.
8. Powles SB, Yu Q. Evolution in Action: Plants resistant to herbicides, Annu. Rev. Plant Biol. 2010; 61:317-47.
9. Rana MC, Nag M, Rana SS, Sharma GD. Influence of post- emergence herbicides on weeds and productivity of garden pea (*Pisum sativum*) under mid hill conditions of Himachal Pradesh, Indian. J Agron. 2013; 58:226-230.
10. Walia US, Brar LS, Mehra SP. Interaction effect of nitrogen levels and weed control measures in wheat. Indian J Weed Sci. 1990; 22:26-33.