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Phytotoxicity effect of different doses of Pendimethalin on wheat and succeeding green gram

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Abstract
A field experiment conducted at Agricultural Research Farm, Department of Agronomy, BHU, Banaras to evaluate the efficacy of herbicide to control of weeds in wheat crop. Weed flora of the experimental field was dominated by various weeds like *Solanum nigrum*, *Anagallis arvensis*, *Chenopodium album*, *Vicia sativa*, *Melilotus indicus*, *Rumex dentatus*, and *Medicago denticulatum*, *Cynodon dactylon*, *Phalaris minor* and *Cyperus rotundus.* In the experimental field weeds were controlled by pre-emergence application of herbicides *viz*, pendimethalin 30% EC @ 600 g ha^{-1}, pendimethalin 30% EC @ 900 g ha^{-1}, pendimethalin 30% EC @ 1200 g ha^{-1}, pendimethalin 30% EC @ 1500 g ha^{-1}, metribuzin 70% WP @ 210 g ha^{-1}and weed free (two hands weeding). All herbicidal treatment compares with Untreated Control (Weedy check). Among all herbicidal treatment pendimethalin 30% EC @ 1200 g ha^{-1} application is effective to control *Phalaris minor*, and Metribuzin have efficacy to control broad-leaf weed effectively and some narrow leaf weed. The highest grain yield observed in hand weeding (5693 kg ha^{-1}) followed by herbicidal treatments, pendimethalin 30% EC @ 1200 g ha^{-1} (5078 kg ha^{-1}). Different dose of pendimethalin cause phytotoxicity in wheat by causing injury and there is no phytotoxicity in succeeding green gram.

Keywords: Field, herbicidal, metribuzin, pendimethalin, weed, wheat

Introduction
Indian mustard (*Brassica juncea* L.) is an important *Rabi* oilseed crop extensively grown as rainfed crop in India. Mustard oil meets the one third of edible oil requirement of the country, to meet these needs the country highly depends on imports of vegetable oil. Import of vegetable oils during July 2019 is up by 26% to 14.12 lakh tones as compared to 11.19 lakh tones in July 2018, according to data compiled by the Solvent Extractors' Association of India (SEA). There is a need to decrease the Import of vegetable oils by expanding the area under oil seed crops. It is important to increase the yields of mustard crop by improving the available germplasm lines, for that we need to know various yield contributing characters and the relationship among them and with the seed yield. In this experiment, we studied correlation or mutual association among different yield contributing characters and the direct and indirect effects also estimated through path coefficient analysis. The inter-relationship between the yield components will be helpful to a breeder to assess the nature, extent and direction of selection pressure on characters.

Material and Methods
Wheat is dominant crop in temperate countries. Wheat is heavily infested with narrow leaf weed and broad leaf weed. Wheat is mainly infested with *Solanum nigrum*, *Anagallis arvensis*, *Chenopodium album*, *Vicia sativa*, *Melilotus indicus*, *Rumex dentatus*, *Medicago denticulatum*, *Cynodon dactylon*, *Phalaris minor* and *Cyperus rotundus.* The yield losses caused by weeds alone account 10 to 80% reduces depending upon weed species, severity and duration of weed infestation in which *Phalaris minor* and *Avena ludoviciana* are major problematic grass weeds causing large scale reductions in wheat grain yield Banerjee *et al.* (2019) [1]. In North-West India, continuous use of isoproturon particularly in rice-wheat cropping system evolved multiple resistance in *Phalaris minor* due to shifting of weed flora which is a major reason for yield loss in wheat crop Kaur *et al.* (2019) [6]. It is more difficult to control weeds when it evolves multiple herbicide resistance to recommended herbicides. In other cases, the herbicide resistance has been reported in *Rumex dentatus* against metsulfuron-methyl Chhokar *et al.* (2017) and in *Avena ludoviciana* against clodinafop Singh *et al.* (2016) [8].

Several herbicides used in crop in which herbicide is effective only one weed species is generally ineffective against other weed species. It is more difficult to control weeds, if it evolved resistance against recommended herbicide. The continuous use of the herbicides *Phalaris minor* evolved resistance against herbicide Dhawan *et al.* (2009) [3]. Continuous use of similar mode of action of herbicide overcome the weed infestation caused threating to sustainability of crop. Repeated use of same herbicide cause herbicide resistance which is very critical problem now days. For reducing weed infestation, used many methods like cultural practices, agronomic practices and chemical method. In chemical method, again and again we introduce new herbicide in market which cause resistance against weed after some time. Now days it is serious topic to discuss that evolution of new herbicide caused herbicide resistance so again we move to old herbicide which is non-hazardous to plant, soil and environment. Pendimethalin used from long time till now because it effectively controls the weeds. The pendimethalin is selective pre- emergence herbicide for annual grass weed control belong to dinitroaniline group of organic herbicide compounds and metribuzin is also selective pre- emergence herbicide control mainly broad leaf weed belonging to triazines group of herbicide compound apply in spring wheat. Under such condition, different doses of pendimethalin and broad-spectrum herbicide like metribuzin evaluated that in what manner control the weeds. Different dose of pendimethalin cause phytotoxicity effect on wheat crop which is visible with naked eyes in different forms of injury which decreases crop yield.

Material and Methods

Field experiment was carried out at Agricultural Research Farm of Banaras Hindu University, Banaras, Uttar Pradesh during *Rabi* season of 2018-2019. The farm is situated at sub-tropical zone of Indo-Gangetic plains on 25^0 18' North latitude and 83^0 03' longitude and at an altitude of 75.70 meter above mean sea level. The soil was sandy clay loam type (Inceptisol), pH is 7.4, low EC (dS m^{-1}) is 0.32low in organic carbon 0.34%, and in available nitrogen 185 kg N/ha, medium in available phosphorus 22.3 kg P_2O_5/ha and potassium178 kg K_2O ha^{-1}. The experiment was laid out in randomized complete block design with three replications having 5.5 x 4.5 m plot sizes. Seven treatments were evaluated in randomized block design with three replications. The treatments comprised of their doses of Pendimethalin 30% EC 600 g ha^{-1}, 900 g ha^{-1}, 1200 g ha^{-1}, 1500 g ha^{-1} and Metribuzin 70% WP as well as two hand weeding at 20 and 40 days after sowing (DAS) and untreated plot. The wheat variety "*HD 2967*" was sown on 6 December 2018 by using seed rate 100 kg ha^{-1} with the help of *kudal* by maintaining 22.5 cm row spacing. The data on weed density was recorded from four randomly selected spots for each plot at 60 days after sowing (DAS) using 0.5 × 0.5 m quadrat. Weed biomass was recorded at 60 days after spray by cutting the weed plants above the ground by randomly placing the four quadrats of 0.5 × 0.5 m and then the samples were oven dried at 70°C until they reached to a constant weight. The pre-emergence herbicides were sprayed on the next day of sowing using 500 litre water/ha using knapsack sprayer fitted with flan-fan nozzle. The objective of an experiment was to evaluate the efficacy of Pendimethalin on weed control. Phytotoxicity symptoms, *viz.* yellowing, necrosis, epinasty, hyponasty and scorching were recorded at t 10, 20, 25 and 30 days after spraying indicated that there was no effect of herbicidal treatments, using rating scale of 0 - 10 where, where, 0 = no effect on plant and 10 = complete death of the plant. The data observation of phytotoxicity recorded at 10, 20, 25 and 30 days after treatment application.

Result and Discussion

Phytotoxicity on wheat

Visible observations were recorded on phytotoxicity parameters *viz.*, leaf injury on tips/surface, wilting, vein clearing, necrosis, epinasty and hyponasty in wheat crop due to the application of pendimethalin 30% EC @ 600, 900, 1200, 1500 g ha^{-1}. The pendimethalin 30% EC @ 1500 g ha^{-1} cause leaf injury and epinasty whereas pendimethalin 30% EC @ 1200 g ha^{-1} cause leaf injury on wheat. There was no phytotoxicity of any of the treatment on the wheat crop. However, some spot injury appeared on leaves tip of wheat after spray of pendimethalin 30% EC @ 1200 g ha^{-1} and 1500 g ha^{-1} this is due to higher dose of pendimethalin. Application of pendimethalin 30% EC @ 1500 g ha^{-1}cause epinasty for temporary period after some time it recover normal condition. Crop phytotoxicity (%) Visible with naked eye phytotoxicity recorded at 10, 20, 25 and 30 days after sowing. Based on 1-10 scale where: 1=0-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100% indicated that there was no phytotoxicity of any of the treatments on the wheat crop. However, some spots/ injury appeared on leaves tip/ surface of wheat after spray of pendimethalin 30% EC @ 1200 and 1500 g ha^{-1}this is due to higher dose of pendimethalin Table (1). pendimethalin 30% EC @ 1500 g ha^{-1}cause epinasty for temporary period after that it recover normal condition. The treatments that recorded below 10% which disappeared within 1-2 weeks, and had no effect on the crop.

Phytotoxicity on succeeding crop (Green gram)

Visible naked eye phytotoxicity recorded at 10, 20, 25 and 30 days after spraying Based on 1-10 scale where: 1=0-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100% indicated that there was no phytotoxicity of any of the treatments on the wheat crop in Table (2). There is no appearance of phytotoxicity on succeeding crop because pendimethalin 30% EC is not so much harmful for the crop.

Table 1: Pytotoxicity evaluation of treatments on wheat crop

Treatment	g a.i	Formulation dose/ ha	Phytotoxicity parameters observed (Mean observations recorded at 10, 20, 25 and 30 days after treatment application)					
			Leaf injury on tips/ surface*	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
Pendimethalin 30% EC	600	2000 ml	Nil	Nil	Nil	Nil	Nil	Nil
Pendimethalin 30% EC	900	3000 ml	Nil	Nil	Nil	Nil	Nil	Nil
Pendimethalin 30% EC	1200	4000 ml	1	Nil	Nil	Nil	Nil	Nil

Pendimethalin 30% EC	1500	5000 ml	1	Nil	Nil	Nil	1	Nil
Metribuzin 70% WP	210	300 g	Nil	Nil	Nil	Nil	Nil	Nil
HW twice (20 &40 DAS)	-	-	Nil	Nil	Nil	Nil	Nil	Nil
Untreated Control (Weedy check)	-	-	Nil	Nil	Nil	Nil	Nil	Nil

*Based on 1-10 scale where 1=0-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-100%

Table 2: Pytotoxicity evaluation of treatments on green gram crop

Treatment	ga.i	Formulation dose/ ha	Phytotoxicity parameters observed (Mean observations recorded at 10, 20, 25 and 30 days after treatment application)					
			Leaf injury on tips/ surface*	Wilting	Vein clearing	Necrosis	Epinasty	Hyponasty
Pendimethalin 30% EC	600	2000 ml	Nil	Nil	Nil	Nil	Nil	Nil
Pendimethalin 30% EC	900	3000 ml	Nil	Nil	Nil	Nil	Nil	Nil
Pendimethalin 30% EC	1200	4000 ml	Nil	Nil	Nil	Nil	Nil	Nil
Pendimethalin 30% EC	1500	5000 ml	Nil	Nil	Nil	Nil	Nil	Nil
Metribuzin 70% WP	210	300 g	Nil	Nil	Nil	Nil	Nil	Nil
HW twice (20 &40 DAS)	-	-	Nil	Nil	Nil	Nil	Nil	Nil
Untreated Control (Weedy check)	-	-	Nil	Nil	Nil	Nil	Nil	Nil

*Based on 1-10 scale where 1=0-10%, 2=11-20%, 3=21-30%, 4=31-40%, 5=41-50%, 6=51-60%, 7=61-70%, 8=71-80%, 9=81-90%, 10=91-1

Conclusion

With the field analysis, it can be concluded that application of pendimethalin 30% EC @ 1200 g ha^{-1} was effective to control *Phalaris minor* and *Cyperus rotundus* with some broad-leaved weeds. Metribuzin 70% WP @ 210 g ha^{-1}application observed more effective to control broad leaved weed to achieve higher grain yield of wheat. There is no phtotoxicity effect on wheat crop and green gram which is sown after harvesting of wheat crop. Some injury caused due to higher dose of pendimethalin 30% EC is used like pendimethalin 30% EC @ 1200 and 1500 g ha^{-1}.

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