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Effect of various herbicides for weed control in late sown wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted at the Research farm of the Department of Agriculture, Maharishi Markandeshwar University, Mullana, Ambala during Rabi season of 2022. The present investigation entitled "Effect of various herbicides for weed control in late sown wheat (*Triticum aestivum* L.)". Experiment was laid out in randomized block design with three replications. The experiment consisted of eight treatments *viz* Pendimethalin 1000 ml ha^{-1}, Pendimethalin 1000 ml ha^{-1} *fb* Metribuzin 250g ha^{-1}, Clodinafop propargyl 400g ha^{-1}, 2,4-D (amine salt) 750 ml ha^{-1}, Metribuzin 250g ha^{-1}, Sulfosulfuron 35g ha^{-1}, Two Hand weeding (20 and 40 DAS) and weedy check. Result revealed that Pendimethalin 1000 ml ha^{-1} *fb* Metribuzin 250g ha^{-1} was found effective to control weed populations and recorded (47.30 q/ha) the highest grain yield. The highest test weight (40.26g) was recorded in Pendimethalin 1000 ml ha^{-1} *fb* Metribuzin 250g ha^{-1}. The highest weed control efficiency (75.10%), lowest weed dry weight (4.60 g) and minimum weed density (3.53 m^{-2}) at tillering stage was recorded in Pendimethalin 1000 ml ha^{-1} *fb* Metribuzin 250g ha^{-1} among all the treatments.

Keywords: Wheat, weed control, herbicides, yield attributes

Introduction
In the world, the second most dominant crop in cereal is wheat (*Triticum aestivum* L.) which belongs to poaceae family. It is cultivated on approximately 220 million hectares worldwide, yielding over 765 million metric tonnes of grain with productivity of 3.47 metric tonnes of productivity per hectare (Sendhil *et al*., 2023) [15]. India ranks first in area and second in production of wheat in the World. In India, total area under cultivation of wheat crop during 2021-22 was 304.69 lakh hectares and production was 106.84 million tonnes. It is most important cereals crop after rice in India which contributes 31.5% of food grain basket (Anonymous, 2022-23). In Haryana, total area was 2.356 million hectares and production was 10.45 million metric tonnes (Anonymous, 2021-2022).

Wheat is also called as common bread wheat that is produced for various purposes of food. Nearly ten percent of wheat produced is utilized for production of seed material and industrial use (for production of starch, paste, malt, dextrose, gluten). It contains all needful nutrients like carbohydrates (which contain nearly 70- 80% starch), proteins (8-15%) along with enough amounts of all crucial amino acids, minerals (1.7-2%), fats (1.5-2%), vitamins and 2.2% crude fibers (Shewry *et al* 2015) [19].Wheat is also used in many baked, cookies or in dessert items like breads, cakes, cookies, pizza, ice cream cones.

Weeds are the competitor that causes more damage to the main crop as compared to insects, fungi and other pests. Loss of crop yield may occur due to the category and compactness of unwanted plants. Weeds also serve as agent for most of pest and diseases, which use them as alternative hosts to survive for food and shelter during the off season period. The weed control method such as preventive method, mechanical control, physical control methods are used to control weed. The weed control methods which are commonly used in India include mainly manual weeding but it is expensive, time consuming and does not have that much profit. Also, performing manual weeding is not preferable in all conditions and causes many hurdles in growth of different crops and soils.

Therefore, chemical control method can be a good alternative to control weeds but continuous use of herbicide in same field cause resistance in weed mainly in *Phlaris minor* so herbicides rotation or mixed herbicides should be chosen by farmer.

Herbicide is a chemical which is used to kill or inhibit the growth of unwanted plants (Patel *et al.* 2017) [16]. Continuous use of single herbicide may not provide an effective control due to wide diversity of weed flora. Herbicides applied at the right time and in the right dose have proven profitable increase in yield. Ideal herbicide controls weeds but does not have any harmful effect on crop yield. When weed starts competing with the crop, it has a negative effect on its yield. Herbicides play a crucial role in wheat production by effectively controlling weeds that compete with wheat for essential nutrients, water, sunlight and for space (Khokhar and Nepalia, 2010) [17]. Weeds can significantly reduce wheat yields if left unmanaged, leading to substantial economic losses to the farmers and significant food shortages for the human population.

Weed species nearly grassy and broadleaf weeds such as canary grass, wild oat, annual bluegrass, annual beard grass and broadleaf weed like Bathua, jungali palak, spiny dock, bansoya, motha, kanteli, satyanashi, pilli senji, jangali matar and other weeds are found in the wheat in Haryana state which damaged the crop and reduce the grain yield in wheat Punia *et al.* (2017) [18]. Keeping the above facts in view represent study was designed to determine effect of various herbicides for weed control in late sown wheat (*Triticum aestivum* L.).

Method and Material

Experimental research was undertaken during the *Rabi* season 2022-2023 at the Department of Agriculture research farm (Faculty of Agriculture), MM (DU), Mullana-Ambala 133207, which lies in the Indo-Gangetic plains of Haryana state. The farm is situated at a height of 264 meters above mean sea level and latitudes 30° 170' 0" N and longitudes 77°3' 0" E. Soil is clay loam with a pH of 7.7. The field experiment was laid out in randomized design with three replication using wheat variety Gold 303 and eight treatments of different herbicides, hand weeding and weedy check. Eight treatments included T_1 Pendimethalin 1000 ml ha^{-1}, T_2 Clodinafop Propargyl 60 g ha^{-1}, T_3 Pendimethalin 1000 ml *fb* Metribuzin 250 g ha^{-1}, T_4 2,4-D (Amine salt) 750 ml ha^{-1}, T_5 Sulfosulfuron 35 g ha^{-1}, T_6 Metribuzin 250g ha^{-1}, T_7 Hand weeding (20 and 40 DAS) and T_8 Weedy check. All the treatments were replicated three times.

The other management practices were performed as per standard recommendation .The seeds were sown by pora method. Seed rate of 120 kg/ha was used. Seed sowing was done at 22.5 cm row to row distance. Depth of seed was about 4-5 cm deep. For wheat, dose of fertilizers was used as per recommendation 120, 60, 40 kg/ha of N_2, P_2O_5, and K_2O, respectively .When seeding, a full dose of P_2O5, K_2O, and 25% of N were administered. After seeding an equal amount of the remaining nitrogen doses were administered at 4, 6, and 8 weeks, respectively. Observation on plant growth and grain yield attributes in wheat and weed density and weed control efficiency in various treatments were recorded. The data was satistically analyzed using statistical package op stat.

Result and Discussion

Yield Attributes

Data pertaining in table1 showed the number of spikes, length of spikes, number of grains per spike, and test weight of 1000 grains (g) of wheat crop. The highest number of spikes m^{-2} was resulted in (246.67) with quadrant system at harvest stage in treatment T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}) which was similar to study of Kaur and Singh (2019) [1] and minimum number of spikes was recorded in weedy check which was similar to Saleh (2022) [2]. Maximum spike length was recorded in treatment T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250 g ha^{-1}) and minimum length was obtained in weedy check which was similar to findings of Tiwari and Singh (2024) [3]. The highest number of grains were found in treatment T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}) and minimum number of grains was recorded in weedy check.Likewise the highest test weight of 1000 grains was recorded in treatment T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250 g ha^{-1}) which was similar study of Keshav *et al.* (2024) [4], Kaur and Singh (2019) [1] and Saleh (2022) [2].

Yield

Data presented in table 2 revealed that application of various herbicides influences yield of grains, straw, biological yield, and harvest index. Maximum yield of grain, straw yield, biological yield was recorded (47.30, 56.29, 103.59 q/ha, respectively) and harvest index (45.65%) in treatment T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}) due the less weed density in the wheat crop. This plot was treated with pre and post emergence herbicides.These outcomes were nearly similar to Shahbaz *et al*. (2023) [6], Meena *et al*. (2017) [7] and Sangwan *et al.* (2018) [5].

Weed parameters

Weed density m^{-2}

Data regarding weed density is presented in table 3. Among all the treatments, T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}) recorded the minimum weed density (3.53 m^{-2}, 4.13 m^{-2} and 6.20 m^{-2}) at tillering, earhead and dough stage in wheat and maximum weed density was recorded in T_8 weedy check (14.37 m^{-2}, 17.27 m^{-2} and 23.30 m^{-2}) at tillering, earhead and dough stage in wheat.The weeds in wheat crop included *Cynodon-dactylon and Phlaris minor* and other broad-leaved weeds, *viz. Oxalis purpurea* ,*Medicago denticulata*, *Anagalis arvensis*, *Chenopodium alubum* and *Rumex dentatus*. Similar results were obtained by Kaur *et al*. (2017) [10] and Meena *et al.* (2019) [11]. The treatment T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}) showed the good control on weed population and enhance the wheat growth.

Weed dry weight (g)

Data pertaining to weed dry weight in table 4 indicated that treatment T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}) recorded the minimum weed dry weight (4.60 g, 11.49 g and 15.39 g) at tillering, earhead and dough stage in wheat and maximum weed dry weight was found in treatment T_8 weedy check (18.48 g, 25.37 g and 29.41 g) at tillering, earhead and dough stage in wheat. Similar outcomes were observed by Kaur *et al*. (2015) [13].

Weed control efficiency (%)

A perusal of data set out in table 5 indicated that the maximum weed control efficiency was recorded (75.10%, 54.71% and 47.67%, respectively) at tillering, earhead and dough stage in wheat by treatment T_3 (Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}).Similar findings were reported by Singh and Verma (2013) [12] and Shakya *et al*. (2017) [14].

Table 1: Effects of various herbicides for weed control on yield attributes in late sown wheat (*Triticum aestivum* L.*)*

Symbols	Treatments	No. of Spike /m^2	Length of Spike (cm)	No of grains /spike	Test Weight (g)
T_1	Pendimethalin 1000 ml ha^{-1}	226.00	6.17	44.67	37.32
T_2	Clodinafop Propargyl 60g ha^{-1}	234.33	6.90	45.33	37.82
T_3	Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}	246.67	8.13	48.00	40.26
T_4	2,4-D(Amine salt) 750 ml ha^{-1}	238.33	7.28	46.33	38.25
T_5	Sulfosulfuron 35g ha^{-1}	230.00	6.50	45.00	37.70
T_6	Metribuzin 250 g ha^{-1}	239.67	7.56	46.67	38.76
T7	Hand weeding (20 and 40DAS)	243.33	7.90	47.33	39.11
T8	Weedy check	206.00	5.67	43.00	35.19
	C.D.	4.49	0.24	1.83	0.67
	SE(m)	1.47	0.08	0.60	0.22

Table 2: Effect of various herbicides on yield in late sown wheat (*Triticum aestivum* L.)

Symbols	Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Biological yield(q/ha)	Harvest Index(%)
T_1	Pendimethalin 1000 ml ha^{-1}	37.94	51.03	88.98	42.64
T_2	Clodinafop Propargyl 60g ha^{-1}	40.76	53.93	94.70	43.04
T_3	Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}	47.30	56.29	103.59	45.65
T_4	2,4-D(Amine salt) 750 ml ha^{-1}	42.19	52.80	95.00	44.41
T_5	Sulfosulfuron 35g ha^{-1}	39.35	52.56	91.91	42.81
T_6	Metribuzin 250 g ha^{-1}	43.02	52.18	95.20	45.18
T_7	Hand weeding (20 and 40 DAS)	44.09	52.83	96.93	45.48
T_8	Weedy check	31.07	47.06	78.06	39.71
Factors	C.D.	1.24	0.84	1.50	0.81
	SE(m)	0.4	0.27	0.49	0.26

Table 3: Effect of various herbicides on weed density (m^{-2}) at the tillering, earhead and dough stages in late sown wheat (*Triticum aestivum* L.)

Symbols	Treatments	At tillering stage	At earhead stage	At dough stage
T_1	Pendimethalin 1000 ml ha^{-1}	5.20	8.20	10.27
T_2	Clodinafop Propargyl 60g ha^{-1}	5.67	8.13	10.17
T_3	Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}	3.53	4.13	6.20
T_4	2,4-D (Amine salt) 750 ml ha^{-1}	4.90	8.33	9.67
T_5	Sulfosulfuron 35g ha^{-1}	6.43	9.27	11.50
T_6	Metribuzin 250 g ha^{-1}	4.67	7.87	9.17
T_7	Hand weeding (20 and 40 DAS)	2.67	6.20	7.97
T_8	Weedy check	14.37	17.27	23.30
	C.D.	0.54	1.07	0.95
	SE(m)	0.18	0.35	0.31

Table 4: Effect of various herbicides for weeds control on dry weight of weed (g) m^{-2} at tillering, ear head and dough stage of late sown wheat (*Triticum aestivum* L.)

Symbols	Treatments	At tillering stage	At earhead stage	At Dough Stage
T_1	Pendimethalin 1000 ml ha^{-1}	5.90	19.03	24.68
T_2	Clodinafop Propargyl 60g ha^{-1}	7.10	16.73	22.72
T_3	Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}	4.60	11.49	15.39
T_4	2,4-D(Amine salt) 750 ml ha^{-1}	7.00	15.59	22.19
T_5	Sulfosulfuron 35g ha^{-1}	8.07	17.73	23.57
T_6	Metribuzin 250 g ha^{-1}	6.20	14.61	21.35
T_7	Hand weeding (20 and 40 DAS)	4.97	12.41	17.66
T_8	Weedy check	18.48	25.37	29.41
Factors	C.D.	0.48	0.70	0.54
	SE(m)	0.16	0.23	0.18

Table 5: Effect of various herbicides for weeds control on weed control efficiency (%) at tillering, earhead and dough stage of late sown wheat (*Triticum aestivum* L.)

Symbols	Treatments	@tillering stage	@earhead stage	@dough Stage
T_1	Pendimethalin 1000 ml ha^{-1}	68.06	24.96	16.10
T_2	Clodinafop Propargyl 60g ha^{-1}	61.59	34.02	22.74
T_3	Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1}	75.10	54.71	47.67
T_4	2,4-D(Amine salt) 750 ml ha^{-1}	62.12	38.49	24.55
T_5	Sulfosulfuron 35g ha^{-1}	56.36	30.07	19.88
T_6	Metribuzin 250 g ha^{-1}	66.44	42.37	27.42
T_7	Hand weeding (20 and 40 DAS)	73.10	51.05	39.95
T_8	Weedy check	0.00	0.00	0.00
Factors	C.D.	2.19	2.41	1.75
	SE(m)	0.72	0.79	0.57

Conclusion

Based on this experimental study it may be inferred that the application of Pendimethalin 1000 ml *fb* Metribuzin 250g ha^{-1} showed the good potential to control weeds including narrow leaf, broad leaf and sedges in wheat field. Also this herbicide treatment proved effective in high biomass production of wheat and increase the yield of wheat crop.

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