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The effect of pre and post-emergence herbicide application on the growth and yield of late-sown wheat (*Triticum aestivum* L.)

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Abstract
During the Rabi season of 2022-2023, a field experiment was undertaken at the Department of Agriculture's Research Farm at Maharishi Markandeshwar University in Mullana, Ambala Haryana during Rabi season 2022-2023. The current study was aimed to evaluate effect of pre and post-emergence herbicide application on the growth and yield of late-sown wheat (*Triticum aestivum* L.). The experiment was designed in a Randomized Block Design (RBD) with eight treatments. Different pre and post herbicides such as T_1: Pendimethalin 1000 ml/ha, T_2: Clodinafop Propargyl 60 g/ha, T_3: 24, D (Amine salt) 750 ml/ha, T_4: Pendimethalin 1000 ml/hafb Metribuzin 50 g/ha, T_5: Pyroxasulfone 127g/ hafbsulfosulfurone 25 g/ha, T_6: Metasulfone 4g/ha+ Metribuzin 50 g/ha, T_7: Two hand weeding (20 and 40 DAS) and T_8: Weedy check. All herbicidal treatments considerably decreased weed population, however the magnitude of effectiveness varied amongst herbicides. T_4: Pendimethalin 1000 ml/ha fb Metribuzin 50 g/ha emerged as most effective herbicide treatment showing highest weed control efficiency.

Keywords: Wheat, weed, growth and yield, pendimethalin, Metribuzin

Introduction
Among the most precious crops in the world, Wheat (*Triticum aestivum* L.) is among the most precious crops in the world. It is dietary staple food for a large portion of the global population. While carbohydrates make up about 71% of its content, wheat is a good source of other essential nutrients too. This includes protein, healthy fats, vitamins, and minerals. Notably, wheat boasts a higher protein content compared to many other cereal grains, making it a valuable source of well-rounded nutrition. Globally wheat production worldwide was around 765.77 MT in the year 2022 (Bahaudin *et al*. 2022) [2]. Wheat is grown in counties like China, India, Russia, USA and some parts of Africa. Among wheat producers, India is the world's runner-up, following China as the leader. India ranks first in area and second in production of wheat in the world. In India total area under Wheat crop during 2021-22 was 304.69 lakh hectare and Production of Wheat during 2021-2022 was estimated at 106,84 MT (GOI Annual Report, 2022-23). Haryana, wheat was grown over an area of about 2.55m ha with production of 12.57 MT and productivity of 4.92 t/ ha (DESA, Haryana, 2020).
Weeds are a major hurdle for wheat farmers, acting as ruthless competitors for essential resources. They steal sunlight, water, nutrients, and space from the wheat crop, significantly impacting growth and yield. This hidden competition can lead to yield losses ranging from 7% to a staggering 50%, depending on the weed density and type. Furthermore, weeds can harbor insect pests and diseases, posing an additional threat to wheat health. All herbicidal treatments whether applied singly or as mixture or in sequence and two hand weedings tended to significant enhancement in growth attributes (Meena *et al*. 2017) [6]. The negative effects of weeds extend beyond yield – they can also reduce grain quality, leading to lower market value for the harvest. Traditionally weeds have been controlled either manually or mechanically using hand hoe. However, these methods can be labor-intensive, time-consuming, and impractical for large-scale farming (Mehdizadeh *et al*. 2019) [7] Fortunately, advancements in herbicide technology offer a

more efficient solution. Chemical weed control provides a targeted approach to managing weeds, minimizing their impact on the wheat crop. Considering the significant cost of weed control in wheat production, choosing the right herbicide strategy is critical. By implementing effective weed control measures, particularly during the crucial early stages of wheat growth, farmers can significantly improve their yields and ensure the quality of their harvest. This translates to higher profit and contributes to a more sustainable and efficient agricultural system. Likewise, weed control leads to higher yields and also ensures healthier and more robust wheat grains (Chimote *et al*. 2016) [3]. When left to compete with the crop, weeds become relentless rivals for sunlight, essential nutrients, moisture, and space. Chemical weed control is the preferred method for Rabi season wheat due to limitations in manual and mechanical weeding techniques, particularly considering the scarcity and high cost of labor. Advancements in herbicide technology have led to the development of powerful pre-mixed combinations. These combinations target a broad spectrum of weeds, offering a strong defense against complex weed infestations, including both grassy and broadleaf varieties. Research has shown promising results with combinations like sulfosulfuron + metsulfuron, clodinafop + metsulfuron, and mesosulfuron. By implementing effective weed control strategies, particularly during the critical window of the first 35-45 days after sowing, farmers can significantly improve the health and productivity of their wheat crop. (Atnafu *et al*. 2019) [1]. Keeping these facts in view the present investigation was designed to evaluate effect of pre and post-emergence herbicide application on the growth and yield of late-sown wheat (*Triticum aestivum* L.).

Material and Methods

The field research titled "Effect of Pre and post emergence herbicide application on the growth and yield of late sown Wheat (*Triticum aestivum* L.)*"* was conducted at the Department of Agriculture's research farm in Mullana, Ambala, Haryana, during the *Rabi* season of 2022-2023. The Department of Agriculture at Maharishi Markandeshwar (Deemed to be University), Mullana, Ambala, maintains a research farm situated at 30°17'0" North latitude, 77°03'0" East longitude, with an elevation of 264 meters above sea level. The environment at the location is tropical and semi-arid. The region experiences distinct seasons: hot and dry summers (April to June), hot and humid monsoons (July to September), and cool winters (December to February). During the summer, the maximum temperature approaches 40 °C, while the minimum temperature falls below 4 °C during the winter months of December and January. The average temperature is around 23.6 °C. The area receives an average annual rainfall 650-750 mm. Wheat is a long-day photoperiod plant that requires an optimal temperature range of 20-25 °C for seed germination, while seeds can sprout in temperatures ranging from 3.5 to 35 °C. The experiment was carried out using RBD (Randomized Block Design) and replicated thrice, during Dec-April (2022-2023).Wheat variety HD3086 was used in the experiment with eight herbicides treatments as described below: T_1: Pendimethalin 1000 ml/ha, T_2: Clodinafop Propargyl 60 g/ha, T_3: 24, D (Amine salt) 750 ml/ha, T_4: Pendimethalin 1000 ml/ hafb Metribuzin 50 g/ha, T_5: Pyroxasulfone 127g/ hafbsulfosulfurone 25 g/ha, T_6: Metasulfone 4g/ha + Metribuzin 50 g/ha, T_7: Two hand weeding (20 and 40 DAS), T_8: Weedy check. Observation on plant growth and grain yield attributes in Wheat and, weed density, weed dry weight and weed control efficiency were recorded. The data was analysed staticsally using Analyses of variances using stastical package (OP Stat)

Result and Discussion

Growth parameters

The information about growth parameters is presented in Table 1. Among treatments, T_4 (Pendimethalin 1000 ml/ha fb Metribuzin 50 g/ha) observed the highest plant height (94.5cm), highest dry matter accumulation (1012.11g), number of tillers per meter square (295.0) at 30, 60, 90 DAS and at harvest while the lowest growth parameters were observed in T_8 Weedy check. These results were similar to the findings of Singh *et al*. (2019) [12].

Yield attributes and yield

The data regarding yield and yield attributes is presented in Table 2. Among the various treatments, Treatment T_4 consisted of (Pendimethain1000 ml/ha fb Metribuzin 50 g/ha) observed the highest number of spikes per meter square (253.3), highest number of grains per spike (45.0), test weight (44.57g) and grain yield (47.63q/ha), straw yield (57.32q/ha), biological yield (104.9q/ha), harvest index (45.39%) and the lowest yield and yield attributes were observed in T8 Weedy check. Results were similar to the findings of Singh *et al*. (2019) [12] and Shah *et al.* (2019) [13].

Weed parameters

The data regarding Weed parameters is presented in Table 3. Among the various treatment, T_4 (Pendimethalin1000 ml/ha fb Mertbuzine50 g/ha) observed lowest weed density (4.86, 7.67 and 11.78) at tillering, ear head and dough stage and highest in T_8 Weedy check (10.7, 15.48 and 20.78) at tillering, ear head and dough stage. Similarly, Meena *et al*. (2017) [6] and Rana *et al*. (2017) [9] also reported that weed density can be reduced by the application of herbicide combinations or mixtures than their sole application. Treatment (T_8) Weedy check consistently produced the highest weed dry weight (16.7, 25.9 and 30.4) at tillering, earhead and dough stage. The treatment T_4: Pendimethalin 1000 ml /hafb Metribuzin 50 g/ha had the highest weed control efficiency (54.0, 43.0, and 38.5), whereas the treatment T_8: Weedy check had the lowest weed control efficiency at (0, 0 and 0). Sourav *et al.* (2017) [11].

Table 1: Effect of Pre and Post-emergence Herbicide Application on the Growth Parameters of Late-Sown Wheat (*Triticum aestivum* L.)

Treatments	Plant height (cm)				Dry Matter accumulation				No. of Tillers per meter square			
	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest	30 DAS	60 DAS	90 DAS	Harvest
T_1	20.4	40.6	75.6	84.5	37.20	186.90	458.30	943.54	176.6	271.0	276.6	273.6
T_2	20.2	36.6	68.6	78.6	37.17	180.68	441.71	890.93	176	257.0	262.0	259.3
T_3	20.3	38.5	72.6	81.5	37.19	183.23	452.9	919.91	176.3	264.0	269.0	267.0
T_4	21.6	46.4	83.4	94.5	37.23	197.82	485.46	1012.11	177.3	288.0	295.0	292.0
T_5	21.3	44.4	81.5	92.5	37.23	194.5	476.41	985.48	177.2	284.0	290.0	287.3
T_6	20.5	42.6	79.5	89.5	37.21	189.22	470.37	968.17	177	280.0	284.3	282.3
T_7	19.3	33.5	65.6	75.7	37.23	196.67	483.92	1010.93	175	250.6	256.0	252.0
T_8	19.0	32.6	63.7	74.7	37.17	158.7	396.0	785.29	174	242.0	249.0	246.0
C.D.	NS	0.17	0.13	0.13	NS	1.77	2.67	2.57	NS	2.73	1.74	2.01
SE(m)	0.8	0.05	0.04	0.04	0.04	0.58	0.87	0.84	0.4	0.89	0.56	0.65
SE(d)	1.1	0.08	0.06	0.06	0.06	0.82	1.23	1.19	0.6	1.26	0.80	0.92

Note:
T_1: Pendimethalin 1000 ml/ha
T_2: Clodinofop-propargyl 60 g/ha
T_3: 2-4, D (Amine salt) 750 ml/ha
T_4: Pendimethalin1000 ml/ha fb Metribuzin 50 g/ha
T_5: Pyroxasulfone127g/ha fb sulfosulfurone 25 g/ha
T_6: Metsulfone4h/ha+ Metribuzin 50 g/ha
T_7: Two hand weeding (20 and 40 DAS)
T_8: Weedy check

Table 2: Effect of Pre and Post-emergence Herbicide Application on the yield attributes and yield of Late-Sown Wheat (*Triticum aestivum* L.)

Treatments	No. of spikes per meter square	Length of spike (cm)	No. of grain per spike	Test weight	Grain yield	Straw yield	Biological yield	Harvest index
T_1	248.3	7.68	43.34	43.32	41.73	52.82	94.5	44.13
T_2	245.0	7.36	42.34	42.59	39.74	51.55	91.2	43.52
T_3	246.3	7.49	42.66	42.66	40.60	52.46	93.0	43.63
T_4	253.3	8.56	45.00	44.57	47.63	57.32	104.9	45.39
T_5	251.6	8.54	44.00	43.69	44.26	54.57	98.83	44.83
T_6	249.3	8.33	43.67	43.70	43.30	53.64	96.94	44.67
T_7	243.6	6.31	42.00	42.36	38.06	50.78	88.84	42.85
T_8	240.6	5.69	41.67	41.78	34.57	49.76	84.34	40.99
C.D.	1.53	0.11	1.35	0.67	1.61	2.64	3.54	1.27
SE(m)	0.50	0.03	0.44	0.21	0.52	0.86	1.15	0.41
SE(d)	0.71	0.05	0.62	0.30	0.74	1.22	1.63	0.58

Note:
T_1: Pendimethalin 1000 ml/ha
T_2: Clodinofop-propargyl 60 g/ha
T_3: 2-4,D (Amine salt)750 ml/ha
T_4: Pendimethalin1000 ml/ha fb Metribuzin 50 g/ha
T_5: Pyroxasulfone127g/ha fb sulfosulfurone 25 g/ha
T_6: Metsulfone4h/ha+ Metribuzin 50 g/ha
T_7: Two hand weeding (20 and 40 DAS)
T_8: Weedy check

Table 3: Effect of Pre and Post-emergence Herbicide Application on weed parameters of Late-Sown Wheat (*Triticum aestivum* L.)

Treatments	Weed density			Weed dry weight			Weed control efficiency		
	At Tillering (m^2)	At Earhead (m^2)	At Dough (m^2)	At Tillering (m^2)	At Earhead (m^2)	At Dough (m^2)	At Tillering (m^2)	At Earhead (m^2)	At Dough (m^2)
T_1	6.17	10.21	14.18	10.2	20.7	25.2	38.6	20.0	18.9
T_2	6.82	11.11	15.83	12.0	23.4	28.5	28.1	9.7	6.2
T_3	6.47	10.7	14.80	11.6	22.1	26.6	30.3	14.4	12.5
T_4	4.86	7.67	11.78	7.7	14.7	18.7	54.0	43.0	38.5
T_5	5.26	8.85	12.74	8.8	16.6	21.2	47.2	35.9	30.0
T_6	5.87	9.88	13.67	9.6	18.6	22.4	42.2	28.1	26.3
T_7	2.81	5.86	10.31	14.7	24.7	29.6	11.9	4.8	2.6
T_8	10.7	15.48	20.72	16.7	25.9	30.4	0	0	0
C.D.	1.0	0.77	0.91	1.0	0.84	1.37	6.4	3.4	5.3
SE(m)	0.32	0.25	0.3	0.35	0.27	0.44	2.1	1.1	1.7
SE(d)	0.46	0.35	0.42	0.50	0.38	0.63	3.0	1.6	2.5

Note:
T_1: Pendimethalin 1000 ml/ha
T_2: Clodinofop-propargyl 60 g/ha
T_3: 2-4, D (Amine salt) 750 ml/ha
T_4: Pendimethalin1000 ml/ha fb Metribuzin 50 g/ha
T_5: Pyroxasulfone127g/ha fb sulfosulfurone25 g/ha
T_6: Metsulfone4h/ha+ Metribuzin 50 g/ha
T_7: Two hand weeding (20 and 40 DAS)
T_8: Weedy check

Conclusion
Based on the data outlined above, it can be said that the greatest outcomes in terms of growth, yield attributes and yield, were obtained when T_4-Pendimethalin 1000 ml/ha fb Metribuzin 50 g/ha was applied to wheat under favorable conditions. Treatment (T_8) weedy check, however, showed the lowest growth, yield attributes and yield. It can be concluded that in late sown wheat weed management with the application of treatment (T_4) Pendimethalin 1000 ml/ha fb Metribuzin 50 g/ha as pre and post-emergence should be used for the control of complex weed flora in late sown wheat and the highest gross return, net return and B: C was recorded in treatment (T_4) Pendimethalin 1000 ml/ha fb Metribuzin 50 g/ha and the lowest was observed in (T_8) Weedy check. Thus, it can be said that using herbicides before and after emergence has a beneficial effect on crop output. By controlling weeds, particularly during critical growth stages, farmers can significantly reduce yield losses and ensure optimal harvests (Sharma *et al.*, 2016) [10].

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