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CONTENTS

Integrated weed management practices in wheat (*Triticum aestivum* L.) under the humid sub-tropical condition of Uttarakhand

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ABSTRACT: A field experiment was conducted during *Rabi* season of 2022-2023 at Research Farm of Graphic Era Hill University, Dehradun, Uttarakhand with an objective to assess integrated weed management practices on weed dynamics, growth and productivity of wheat (*Triticum aestivum L.,*). The experiment consisted of ten weed management treatments were laid out in randomized block design with three replications. Amongst weed management treatments -pre-emergence application of pendimethalin 1 kg/ha *fb*1 HW (30 DAS) significantly reduced the weed density, dry weight of grassy and non-grassy weeds while recorded highest weed control efficiency (70.7%). Amongst various weed management treatments, maximum grain and straw yield (4233 and 5020 kg/ha, respectively) was also recorded with pendimethalin 1 kg/ha PE *fb* 1 HW (30 DAS) followed by pendimethalin 1 kg/ha PE *fb* metribuzin 42% + clodinafop- propargyl 12% WG (0.210 + 0.06 kg/ha) PoE (premix). Superiority of these treatments were proved by increment of yield of grain to the tune of 139.6 and 130.9% respectively over weedy check and only 3.8% and 7.3% respectively lesser than the weed free treatment. Pendimethalin 1 kg/ha PE +1 HW (30 DAS) also proved to be more effective in improving yield attributes like spikes/m^2, spike length (cm), no. of grains/spike, grain weight/spike (g) and 1000 grain weight (g).

Key words: Days after sowing, herbicide, Integrated weed management, pendimethalin, pre-emergence, post-emergence, wheat

Wheat is second most important staple food crop next to rice in India and extensively grown crop of the world. During 2024-25 *Rabi* season, wheat occupied 328.04 lakh ha area, with the production and productivity of 1179.45 lakh tonnes and 3595 kg/ha, respectively in India (GOI, 2024).Being the richest sources of energy and proteins, its higher productivity becomes vital to ensure the national and global food security for rising population. To attain potential yield, improved varieties, proper use of fertilizer, irrigation, time of sowing and efficient weed management are essential. Among various inputs, timely and efficient weed control is crucial to minimize the yield losses caused by weeds.

According to numerous studies, the amount of wheat yield lost due to weeds can vary from 16 to 60%, depending on the type of weed, its severity, the length of the infestation, the crop plant ability to compete under various agro-ecological conditions (Rao *et al*., 2014, Yaduraju*et al*., 2015).Weeds compete with crops for natural resources like nutrients,water, sun light, and space at maximum extent during critical period of crop- weed competition and caused heavy loss in the yield and reduce the quality of wheat produce. Many grassy and broad-leaved weeds are major problem in wheat production in the country. The prominent weeds noted in wheat fields are *Phalaris minor*, *Chenopodium album*, *Anagalis arvensis* and *Cynodondactylon* etc. Weeds alone cause about 33-50% to reduction in wheat yield (Kumar *et. al*., 2023). Thus, the weed management is a basic requirement for obtaining higher production of the wheat.

Weed management in wheat can be done by different methods like manual, cultural, mechanical and chemical methods. Hand weeding being very laborious, energy intensive and time consuming is only applicable in small scale area for weed management. Mechanical weeding can also manage weeds in between rows only. So, in these cases, chemical method proved to be beneficial but it also has limitation of creating resistance in weeds. That's why integrated approach is considered as the most effective method of weed control (Sunil *et al*., 2023). Among various weed management methods, integration of suitable chemical and cultural method is found more successive in managing weeds and reduces labourrequirement, minimizing crop-weed competition, provides better environment for growth and development of crop, reduces soil weed seed bank, avoids herbicide resistance in weeds, increases productivity of the crop which ultimately enhances the socio-economic condition of farmers. Wheat is less competitive against many weeds at top most period of crop-weed competition which falls between 30-45 days after sowing.

Among weed management methods, chemical control is considered the most efficient, cost-effective, and time-saving. Moreover, various herbicides have been recommended for different types of weed flora (Nibhoria *et al*., 2025).Combination of herbicides that manage both grassy and broadleaved weeds was better than their sole application for weed control in wheat (Shahzad *et al*., 2016). IWM consist of physical, cultural, chemical and biological means develop on knowledge based on weed biology and ecology. By employing integrated weed management practices that incorporate herbicides, manual, and mechanical weeding as appropriate, farmers can better control weed infestations, minimize yield losses, and significantly increase crop productivity. Such a comprehensive approach is a key to meet the growing demand for food and ensure food security in the face of challenges posed by weed infestations (Debnath *et al*., 2021). Integrated weed management (IWM) involves deployment of different methods of weed prevention and control in right proportion and at appropriate time against target weeds and it is a need of today (Kadam *et al.,* 2021). Weed control by hand weeding with the use of hand tools or hoes alone is high time conjuming, costly, labour intensive, ineffective and require regular repetition. So, integration of hand weeding with herbicide proves to be more effective. Weed growth and yield performed effectively with post emergence herbicides with rice straw mulching in wheat (Halder *et al.,* 2024). Therefore, integrated weed management is a central key to managing weeds in long run and improving productivity of wheat. Moreover, none of the single weed control method is efficient to control all weeds effectively; therefore, it is essential to develop integrated weed management (IWM) practices to overcome this problem. Hence the present study was conducted to determine the efficient integrated weed management practice for managing weeds and improving productivity of wheat.

MATERIALS AND METHODS

A field experiment was conducted during *Rabi* season of 2022-2023 at Research Farm of Graphic Era Hill University, Dehradun, Uttarakhand in humid sub-tropical condition of Himalaya. The average yearly rainfall is about 2025 mm of which 75 per cent is received during rainy season (July - September). The daily average minimum temperature in coldest month during winter varies from 1.0 - 9.0 °C and during summer the maximum temperature varies from 30-40 °C. The soil of experimental field was sandy loam, low in organic carbon (0.43%), available nitrogen (210 kg/ha) and available phosphorus (8.78 kg/ha) and medium in available potassium (188 kg/ha) with a pH value of 6.4. The experiment was laid out in randomized block design comprised of ten treatments with three replications. Treatment were consisted of pendimethalin 30 EC 1 kg/ha PE, pendimethalin 30 EC 1 kg/ha PE *fb* 1HW (30 DAS), metribuzin 42%+clodinafop-propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE, pendimethalin 30 EC 1 kg/ha PE *fb*metribuzin 42% + clodinafop- propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE, 2,4-D 80 WP sodium salt 0.5 kg/ha PoE, pendimethalin 30 EC 1 kg/ha PE *fb*2,4-D 80 WP sodium salt 0.5 kg/ha PoE, metribuzin 70 WP 0.3 kg/ha PoE,pendimethalin 30 EC 1 kg/ha PE *fb* metribuzin 70 WP 0.3 kg/ha PoE, weedy check and weed free. The pre-emergence herbicide was appliedon 30.11.2022 (just after sowing) whereas post-emergence herbicides were applied at 30 days after sowing on 30.12.2022. Under weed free treatment, hand weeding was done as and when required. Pre-emergence herbicide was applied after dissolving in 750 liter of water and post-emergence herbicides were applied after dissolving in 500 liter of water per hectare with knapsack sprayer using flat fan nozzle. Wheat variety HD2967 was sown on 30.11.2022 with row spacing of 22.5cm and the crop was harvested on 18.04.2023. All other recommended package of practices was adopted to raise the crop. Recommended dose of fertilizer, 120 kg nitrogen, 60 kg phosphorus and40 kg potassium was applied per hectare. Half dose of nitrogen and full dose phosphorus and potassium was applied as basal and half dose of nitrogen was top dressed through urea into two splits, first at 25 days after sowing and second at 60 days after sowing. All nutrients were supplied through urea, single super phosphate and murate of potash. Experimental field was prepared through one disc ploughing followed by four cross harrowing and leveling. Sowing of wheat was done through seed drill.No any other pesticide was applied in the crop.

The weed sample were collected randomly at two places in each plot with 0.25 m^2 quadrate on 60 days after sowing, weeds were counted species wise and total weed density was calculated. Weeds inside each quadrate were uprooted, cleaned and dried. After drying dry weight of weed was recorded and presented in g/m^2, relative weed density and weed control efficiency was calculated using standard formula. At the time of harvest plant height (cm), no. of spikes /m^2, spike length (cm) no. of grains / spike, 1000 grains weight (g) as well as net plot grain, straw and biological yield were determined and presented in kg/ha Grain yield increase over weedy check and per cent increase was also calculated. Observations recorded were statistically analyzed according to Gomez and Gomez (1984) and means were compared at 5% level of significance by the least significance difference (LSD) test. Observations on weed density and weed dry weight were subjected to square root transformation before statistical analysis.

RESULTS AND DISCUSSION

Weed flora

Major weed flora infested the experimental site were *Phalaris minor* (20.9%) among grasses and *Anagallis arvensis*(12.9%), *Fumaria parviflora* (10.9%), *Chenopodium album* (9.9%), *Argemone mexicana* (8.9%) and *Vicia sativa* (6.9%) among non-grassy weeds and *Cyperus rotundus* (29.7%) among the sedges.

Effect on weeds

All the herbicidal treatments effectively reduced the weed growth and were found superior over weedy check (Table 1). At 60 DAS, among the herbicides, pre-emergence application of pendimethalin 30 EC 1 kg/ha fb 1HW (30 DAS) caused maximum reduction in the weed density of grasses while complete controlled of non-grassy weeds and significantly reduced the total weeds density and weed dry weight. This treatment was also recorded 87.95 % suppression of grassy weeds as compared to weedy check. Next to this treatment, Pendimethalin 30 EC 1 kg/ha PE *fb*metribuzin 42%+ clodinafop- propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE and Pendimethalin 30 EC 1 kg/ha PE *fb* metribuzin 70 WP 0.3 kg/ha PoE were recorded 81.8 and 78.9 % weed suppression over weedy check, respectively. These treatments were followed by metribuzin 42%+ clodinafop- propargyl 12% WG 0.210 + 0.06 kg/ha (premix) PoE which was statistically at par with pendimethalin 30 EC 1 kg/ ha PE *fb* 1HW (30 DAS). Next to pendimethalin 30 EC 1 kg/ha PE *fb* 1HW (30 DAS), higher reduction of broad-leaved weeds density (97.4%) was recorded with metribuzin 42%+ clodinafop- propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE was found similar to pendimethalin 30 EC 1 kg/ha PE *fb* metribuzin 70 WP 0.3 kg/ha PoE followed by metribuzin 70 WP 0.3 kg/ha PoE (94.6%) being on par with each other. Pendimethalin 30 EC 1 kg/ha PE *fb* 1HW (30 DAS) recorded lowest total weed density and dry weight as compared to other treatments next to weed free plots which suppressed 95.2 and 94.5 per cent total weed density and dry weight over weedy check.

Effect on yield attributes and yield

Amongst different herbicidal treatments, pendimethalin 30 EC 1 kg/ha PE *fb* 1HW (30 DAS) recorded higher number of spikes/m^2, length of spike (cm), number of grain/spike, grain weight/spike (g) and 1000 grain weight (g) followed by pendimethalin 30 EC 1 kg/ha PE *fb*metribuzin 42%+ clodinafop-propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE being at par with each other which were comparable to weed free treatment (Table 2). The highest grain yield (4233 kg/ha) was attained with pendimethalin

Table 1: Effect of treatments on weed density, weed dry weight and weed control efficiency at 60 DAS

Treatments	Weed density			Total weed density (no./m^2)	Total weed dry weight (g/m^2)	WCE (%)
	Grassy	BLWs	Sedges			
Pendimethalin 30 EC 1 kg /ha PE	4.4(18.7)	4.3(18.0)	2.7(6.7)	6.6(43.3)	3.7(12.6)	36.2
Pendimethalin 30 EC 1 kg / ha PE *fb* 1 HW (30 DAS)	2.5(5.3)	1.0(0.0)	1.0(0.0)	2.5(5.3)	1.7(1.8)	70.7
Metribuzin 42% + clodinafop – propargyl 12% WG 0.210 + 0.06 kg/ ha PoE (30 DAS)	3.2(9.3)	1.5(1.3)	3.0(8.0)	4.4(18.7)	2.8(7.0)	51.7
Pendimethalin 30 EC 1 kg /ha PE *fb* metribuzin 42% + clodinafop – propargyl 12% WG 0.210 + 0.06 kg/ ha PoE (30 DAS)	2.9(8.0)	2.5(5.3)	3.0(8.0)	4.7(21.3)	2.5(5.2)	56.9
2,4-D 80 WP Na salt 0.5 kg /ha PoE (30 DAS)	5.4(28.0)	2.5(5.3)	3.2(9.3)	6.6(42.7)	4.2(16.7)	27.6
Pendimethalin 30 EC 1 kg /ha PE *fb*2,4-D 80 WP Na salt 0.5 kg /ha PoE (30 DAS)	4.1(16.0)	2.3(4.7)	2.7(6.7)	5.3(27.3)	3.4(10.6)	41.4
Metribuzin 70 WP 0.3 kg /ha PoE(30 DAS)	3.9(14.7)	1.8(2.7)	2.5(5.3)	4.8(22.7)	3.1(8.8)	46.6
Pendimethalin 30 EC 1 kg /ha PE *fb* metribuzin 70 WP 0.3 kg/ha PoE (30 DAS)	2.9(8.0)	1.5(1.3)	3.6(12.0)	4.7(21.3)	2.9(7.8)	50
Weedy check	6.7(44.0)	7.1(50.0)	4.1(16.0)	10.5(110.0)	5.8(33.0)	-
Weed free	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	82.8
SEm±	0.33	0.3	0.21	0.26	0.18	-
LSD (p=0.05)	0.98	0.9	0.62	0.79	0.53	-

Original values are given in parentheses and data are subjected to "(x+1) transformation before analysis
DAS- Days after sowing, PE- Pre- emergence, PoE- Post –emergence

30 EC 1 kg/ha PE *fb* 1HW (30 DAS) which was at par with pendimethalin 30 EC 1 kg/ha PE *fb* metribuzin 42%+clodinafop-propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE (4080 kg/ha) and weed free treatment and recorded 139.6 % increment over weedy check. In weed free treatments thrice hoeing at 20, 40 and 60 days after sowing were done whereas in pendimethalin 30 EC 1 kg/ha PE *fb* 1HW (30 DAS) at later stages some weeds were emerged due to which the lower yield was recorded in this treatment as compared to weed free treatments. The grain yield was negatively associated with weed density and weed dry weight of total weeds and positively associated with yield and yield attributing characters of crop. It might be due to effective control of weeds tends to less crop-weed competition throughout the crop growth period resulted in proper growth and development of crop which ultimately improved crop yield and yield attributes.

The maximum grain yield (4233kg/ha) was attained with pendimethalin 30 EC 1 kg/ha PE *fb* 1 HW (30DAS) being at par with pendimethlin 30EC1 kg/ha PE *fb* metribuzin 42% + clodinafop- propargyl 12% WG 0.210 + 0.06 kg/ha (premix) PoE (4080 kg/ha) and weed free treatment and recorded139.6% increment over weedy check. Among the various pre- and post-emergence herbicidal combination, highest harvest index (45.75%) was found with pendimethalin 30 EC 1 kg/ha PE *fb* 1HW (30 DAS) being at par with pendimethalin 30 EC 1 kg/ha PE *fb*metribuzin 42%+ clodinafop-propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE (30 DAS) and weed free treatment (Table 3).

Pisal *et al.* (2013) concluded that pre-emergence application of pendimethalin 30 EC 1 kg/ha is effective in managing monocot and dicot weeds in wheat, whereas 2,4-D is found effective in reducing broad leaved leaf weeds only in wheat. Among different combinations, pendimethalin 30 EC 1 kg/ha PE *fb* 1HW (30 DAS) and pendimethalin 30 EC 1 kg/ha PE *fb*metribuzin 42%+

Table 2: Effect of treatments on yield attributing characters of wheat crop at harvest

Treatments	No. of spikes /m^2	Spike length (cm)	No. of grains / spike	Grain wt /spike (g)	1000 grain wt (g)
Pendimethalin 30 EC 1 kg /ha PE	286.7	9.33	41.1	1.76	41.37
Pendimethalin 30 EC 1 kg / ha PE *fb* 1 HW (30 DAS)	295.3	9.83	43.7	2.03	43.33
Metribuzin 42% + clodinafop – propargyl 12% WG 0.210 + 0.06 kg/ ha PoE (30 DAS)	283.3	8.80	39.9	1.68	41.77
Pendimethalin 30 EC 1 kg /ha PE *fb* metribuzin 42% + clodinafop – propargyl 12% WG 0.210 + 0.06 kg/ ha PoE (30 DAS)	292.7	9.20	42.2	1.99	43.27
2,4-D 80 WP Na salt 0.5 kg /ha PoE (30 DAS)	273.3	9.57	39.7	1.40	41.03
Pendimethalin 30 EC 1 kg /ha PE *fb*2,4-D 80 WP Na salt 0.5 kg /ha PoE (30 DAS)	282.3	9.70	40.2	1.96	42.20
Metribuzin 70 WP 0.3 kg /ha PoE(30 DAS)	277.3	9.53	39.6	1.65	41.40
Pendimethalin 30 EC 1 kg /ha PE *fb* metribuzin 70 WP 0.3 kg/ha PoE (30 DAS)	280.7	9.13	39.2	1.80	41.60
Weedy check	234.0	8.77	37.1	1.38	40.13
Weed free	298.7	12.47	45.4	2.17	45.73
SEm±	10.9	0.33	1.4	0.13	0.97
LSD (p=0.05)	32.7	0.99	4.3	0.39	2.90

DAS- Days after sowing, PE- Pre- emergence, PoE- Post–emergence

Table 3: Effect of treatments on yield and harvest index of wheat crop

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Pendimethalin 30 EC 1 kg /ha PE	3757	4813	8570	43.83
Pendimethalin 30 EC 1 kg / ha PE *fb* 1 HW (30 DAS)	4233	5020	9253	45.75
Metribuzin 42% + clodinafop – propargyl 12% WG 0.210 + 0.06 kg/ ha PoE (30 DAS)	3913	4973	8887	44.03
Pendimethalin 30 EC 1 kg /ha PE *fb* metribuzin 42% + clodinafop – propargyl 12% WG 0.210 + 0.06 kg/ ha PoE (30 DAS)	4080	4867	8947	45.60
2,4-D 80 WP Na salt 0.5 kg /ha PoE (30 DAS)	3450	4595	8045	42.90
Pendimethalin 30 EC 1 kg /ha PE *fb*2,4-D 80 WP Na salt 0.5 kg /ha PoE (30 DAS)	4033	4803	8837	45.64
Metribuzin 70 WP 0.3 kg /ha PoE(30 DAS)	3700	4947	8647	42.79
Pendimethalin 30 EC 1 kg /ha PE *fb* metribuzin 70 WP 0.3 kg/ha PoE (30 DAS)	3883	4997	8880	43.73
Weedy check	1767	2783	4550	38.82
Weed free	4400	5040	9440	46.61
SEm±	121	165	261	0.64
LSD (p=0.05)	362	493	783	1.93

DAS- Days after sowing, PE- Pre- emergence, PoE- Post –emergence

clodinafop-propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE were found better in supression of the dry weight of weeds with maximum grain yield. Kaur *et al.*(2017), Chaudhary *et al.* (2010) and Singh *et al.*(2012) reported that sequential application of pendimethalin 30 EC 1 kg/ha PE *fb*metribuzin 42%+ clodinafop-propargyl 12% WG 0.210+0.06 kg/ha (premix) PoE recorded lowest weed density, weed dry weight, better weed control efficiency and yield of wheat due to two hand weeding also. Singh *et al.* (2012) also reported that clodinafop-propargyl 0.06g+ metribuzin 0.122kg/ha PoE recorded lowest weed dry weight of mixed weed flora in wheat.

CONCLUSION

It is concluded that pre-emergence application of pendimethalin 30 EC 1.0 kg/ha *fb* 1 HW (30 DAS) recorded highest grain yield and harvest index of wheat followed by metribuzin 42% +clodinafop –

propargyl 12% WG 0.210 + 0.06 kg/ ha PoE is recommended for effective weed management and attaining higher wheat yield.

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