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Effect of integrated weed management on growth, yield and economics of wheat (*Triticum aestivum* L.)

Rajnish Kumar, Ashutosh Tripathi, Ram Niwas, AS Yadav, Shravan Kumar Maurya and Jitendra Kumar

Abstract
An agronomic investigation to study the response of integrated n weed management (IWM) in wheat crop. Experiment was conducted during *Rabi* season of year 2020-21 an agricultural Farm at Rama University, Kanpur 209217 (U.P) India. The experiment was laid out in Randomized Block Design with three replications and 12 treatments *viz.* T_1-Pendimathelin 30 EC @ 1**.**0 kg ha $^{-1}$, T_2 – Metribuzin 70 WP @ 0**.**3 kg ha $^{-1}$, T_3 – Metsulfuron 10 EC @ 0.02 kg ha **-**1 25 DAS, T_4– Pendimethalin 30 EC @ 1.0 kg ha^{-1}+ one hand weeding 40 DAS, T_5– Pendimethalin 30 EC @ 1.0 kg ha^{-1}+ one hand weeding 40 DAS, T_6 – Metribuzin 70 WP @ 0**.**3 kg ha^{-1} + one hand weeding 40 DAS, T_7– Metribuzin 70 WP @ 0**.**30 kg ha^{-1} + 2,4**-**DEE@ 0**.**5 kg ha^{-1} 25 DAS, T_8– Pendimethalin 30 EC @ 1.0 kg ha^{-1} + Metsulfuron 10 EC @0.3 kg ha^{-1} 25 DAS, T_9 – Metribuzin 70 WP @ 0**.**3 kg ha^{-1}+Metsulfuron 10 EC @ 0**.**02 kg ha^{-1} DAS, T_{10} – 2,4**-**122DEE @ 0.5 kg ha $^{-1}$ 25 DAS, T_{11} – Weeds free check (Two hand weeding 25 and 45 DAS***)***, T_{12}– Control. Higher growth attributing characters at different crop stages and yield attributing characters at harvest *viz.* plant height, number of tillers, leaf area index, plant dry matter, length of ear, number of grains per ear and test weight were produced with weeds free (Two hand weeding 25 and 45 DAS). Similarly, higher grain yield, straw yield, biological yield and harvest index along with gross return, net return and B: C ratio was recorded with Weeds free check (Two hand weeding 25 and 45 DAS) treatment as compared to all the other treatments in wheat crop.

Keywords: IWM, growth attribute, weed, wheat and yield

Introduction
The foundation of our country's food security system is wheat (*Triticum aestivum* L.), a significant prehistoric crop. The phrase "Dal roti chalna" itself devalued its importance to our way of life. Many cattle consider its straw to be their main source of food. Thus, wheat is the cereal grain with the highest protein content and comes in second to pulses in terms of protein content. Noodles, petri dishes, chapatti, cakes, and cookies are among the items that may be made with it. Starch makes up 60-68 percent of wheat grain, followed by protein, 8-15 percent fat, 1.5 to 2.0 percent cellulose, and 1.5 to 2.0 percent minerals. Around 224 million hectares of land are used to grow wheat, with an average annual production of 775.8 million metric tonnes. China is the second-largest producer of wheat in the world, after the European Union. United States of America and India. Being blessed and supplied with a diverse agro-ecological environment, India is the world's second-largest producer of wheat, providing food and nutritional security to the majority of its population through production and constant supply, notably in the recent past. In India, 33.64 million hectares of wheat are cultivated, producing 107.86 million tonnes and yielding 1206.30 kg per hectare in 2019–20. There are six main zones that make up the entirety of the nation's wheat-growing region. The North Western Plain Zones have the highest area under cultivation of wheat (NEPZ). In India, Uttar Pradesh (UP) is first in terms of output (39.29 million tonnes) and area (9.73 million ha), while Haryana is best in terms of productivity (50.30 q ha^{-1}), followed by Punjab, Rajasthan, and Uttar Pradesh (48.95 q ha^{-1}, 31.75 q ha^{-1}, and 31.13 q ha^{-1}, respectively) (Anonymous, 2012) [3]. Wheat must deal with a variety of biotic and abiotic stressors since it is grown under a wide range of agro-climatic conditions. Having weeds in a crop has a lot of negative effects on yield. For space, light, moisture, and nutrients, weeds compete with agricultural plants. Weed also raises the cost of harvesting, lowers product quality, and raises the risk of fire. It is crucial to control weeds in order to boost wheat yields, which has led to increased wheat crop yields**.** Numerous monocotyledonous and dicotyledonous weeds infest wheat fields, which may result in yield

losses of 7 to 50% and 15 to 50% depending on the kind of weed flora and its intensity. *Phalaris minor* is one of the most noticeable weeds in wheat crops. *Melilotus alba*, *Melilotus indica*, *Vicia hirsuta*, *Avena ludoviciana*, *Chenopodium album*, *Medicago denticlulate*, and *Indica sativa* etc. Due to a heavy weed infestation, one of the most important issues with wheat is *phalaris minor*. Pandey and Verma (2004) [9] find a considerable drop in wheat output ranging from 18 to 73 percent. However, while other broad leaf weeds pose a concern as well, managing them is generally simpler and more successful than managing *Phalaris minor* very major difficulty. Depending on the cultivar, the wild out affects the grain yield of winter wheat by 17–62 percent.

For the effective management of weeds applied prior to sowing and subsequent crop growth stages, a variety of solutions including manual weeding and herbicide application are available. Both direct and indirect measures, such as improved field preparation, soil moisture regulation, planting techniques, seeding rates, and fertilizer management, are used to control weeds. Chemical methods play a significant impact in weed population reduction and wheat grain production when used as a direct technique of weed management. In wheat, manual weeding is a popular practice, although it is expensive and labour is difficult to find, particularly during peak season. Weeds must be controlled quickly, which is usually impossible to do with hand weeding on a wide scale. The use of mechanical techniques may be further constrained by the close cattle spacing and weed predominance in wheat. Control the grassy weeds like *Phalaris minor* and *Avena spp*. as there are limits. Due to the early phases of their morphology being similar to wheat. It appears promising to use herbicides in these circumstances. However, there isn't currently a single herbicide on the market that will completely eradicate weeds. Controlling weeds while using one herbicide indiscriminately can result in a variety of issues, including residue in crops and soil, pollution risks, and health risks to creatures that aren't the intended target. Without a doubt, the herbicides have successfully controlled weeds that have become resistant to isoproturon because it has been used so frequently on *Phalaris minor*. Three other herbicides, Fenoxaprop-p-ethyl, Clodinafop-propargyl, and Sulfosulfuronl, have been recommended for controlling Isoproturon-resistant *Phalaris minor* in rice-wheat producing zones in order to solve this issue. These herbicides effectively controlled the isoproturon-resistant *Phalaris minor* in the north-west, particularly in Haryana and Punjab. They also significantly increased wheat yields.

Materials and Methods

The field experiment was carried out in the *Rabi* season of 2020–2021 at the Rama University's Mandhana Agricultural Research Farm in Kanpur Nagar, Uttar Pradesh, which is located in the Indo-Gangatic Plain's alluvial tract in the central part of the state between $25^0 26'$ and $26^0 58'$ North latitude and $79^0 31'$ to $31^0 34'$ East longitude at an altitude of 125.9 metres. This farm has sufficient irrigation facilities accessible. On the university's main campus, the farm is located. The lowest temperature during the growing season is between 6 and 21.7 ^{0}C, while the highest temperature during that time is between 17 and 35.1 ^{0}C. During the cropping period, relative humidity ranged from 24 to 94 percent. During the trial, average wind speeds ranged from 1.3 to 6.3 km hr^{-1}. During the testing period, the trail location got a total of 43.2 mm of rain in one wet day, providing favourable conditions for crop development. The experiment was laid out in Randomized Block Design with three replications. 12 treatments *viz.* T_1-Pendimathelin 30 EC @ 1'0 kg ha $^{-1}$, T_2 – Metribuzin 70 WP @ 0.3 kg ha $^{-1}$, T_3 – Metsulfuron 10 EC @ 0.02 kg ha -1 25 DAS, T_4– Pendimethalin 30 EC @ 1.0 kg ha^{-1}+ one hand weeding 40 DAS, T_5– Pendimethalin 30 EC @ 1.0 kg ha^{-1}+ one hand weeding 40 DAS, T_6 – Metribuzin 70 WP @ 0.3 kg ha^{-1} + one hand weeding 40 DAS, T_7– Metribuzin 70 WP @ 0.30 kg ha^{-1} + 2,4-DEE@ 0.5 kg ha^{-1} 25 DAS, T_8– Pendimethalin 30 EC @ 1.0 kg ha^{-1} + Metsulfuron 10 EC @0.3 kg ha^{-1} 25 DAS, T_9 – Metribuzin 70 WP @ 0.3 kg ha^{-1}+Metsulfuron 10 EC @ 0.02 kg ha^{-1} DAS, T_{10} – 2,4-122DEE @ 0.5 kg ha $^{-1}$ 25 DAS, T_{11} – Weeds free check *(*Two hand weeding 25 and 45 DAS*)*, T_{12}– Control. All plots of experiment was equally fertilized with recommended dose of fertilizers (150:60:40 kg ha^{-1} NPK). The sources of nitrogen, phosphorus, and potassium were urea, di-ammonium phosphate, and murate of potash, respectively. Farmyard manure was equally distributed throughout the plots prior to 15 days after wheat was sowed, in accordance with the treatments. The soil at the test location was clay loamy, with low amounts of organic carbon (0.40%), available nitrogen (166.53 kg ha^{-1}), available phosphorus (18.73 kg ha^{-1}), and available potash (266.27 kg ha^{-1}) with a moderate response that was somewhat alkaline (8.2 pH). The experimental crop was sown using the wheat variety HD-2967 at a seed rate of 120.0 kg ha-1 and a row-to-row spacing of 20 cm. The seed was treated with Vitavax at a rate of 2.5 g kg^{-1} prior to planting. A test crop was watered with irrigation as per treatments.

Results and Discussion

Effect of IWM on growth attributing characters of wheat crop

The data plant height as affected by IWM is presented in (Table. 1)**.** The maximum plant height (86.75cm) was recorded under weed free condition followed by treatment (Pendimethalin 30 EC @ 1.0 kg ha^{-1}+ Metsulfuron 10 EC @0.3 kg ha^{-1} 25 DAS) (84.50 cm), treatment (Metribuzin 70 WP @ 0.3 kgha^{-1} + Metsulfuron 10 EC @ 0.02 kg ha^{-1} DAS), (82.40 cm). It might be due to the effective weed control at growth stages. Ali *et al.* (2006) [1], Pal *et al.* (2012) [8], and Saquib *et al.* (2012) [10] also reported the similar results. It have fulfill the presence of enough nutrient uptake by the weed free plant through crop root zone, and a relative improvement in plant growth characteristics. Similarly, Besides among treatments weed free plot was produced maximum number of tillers (421.65) followed by (411.55) under treatment (Pendimethalin 30 EC @ 1.0 kg ha^{-1}+Metsulfuron 10 EC @0.3 kg ha^{-1} 25 DAS), and (401.40) under treatment (Metribuzin 70 WP @ 0.3 kg ha^{-1} + Metsulfuron 10 EC @ 0.02 kg ha^{-1} DAS). Such effect of IWM on number of tillers was also reported earlier by Ali *et al.* (2006) [1] and Malik (2012). Similar reasons might be responsible for higher LAI (1.50, 4.35, 5.31) with weeds free practices at 60, 90, 120 DAS respectively in comparison to other treatments. Higher plant dry matter accumulation at harvest was a result of the superior vegetative development and morphological characteristics, including plant height, LAI, and the number of tillers with weed-free tillers. It is also reported by many researches Pal *et al.* (2012) [8] and Saquib *et al.* (2012) [10].

Effect of IWM on yield and yield attributing characters of wheat crop

Growth-related character increases finally manifested as yield-related character increases *viz.* spike length (cm), number of grains per spike and test weight (Table. 2); which were recorded higher (11.86 cm, 59.06 and 41.60g respectively) with weed free plot. The advantages of using IWM to plan crops based on yield-contributing qualities including ear length (cm), quantity of grains per ear, test weight, and growth features (plant height, number of tillers, LAI, dry matter accumulation) resulted in higher grain yield, straw yield, biological yield and harvest index (48.50 q ha-^{1}, 84.25 q ha-^{1}, 141.40 q ha-^{1} and 38.46% respectively) was produced under weed free followed by (Pendimethalin 30 EC @ 1.0 kg ha-1 + Metsulfuron 10 EC @0.3 kg ha-1 25 DAS) and (Metribuzin 70 WP @ 0.3 kg ha-1 + Metsulfuron 10 EC @ 0.02 kg ha-1 DAS). Similar results were also reported by Ghosh *et al.* (2006) [4], and Kaur and Mahal (2017) [6].

Effect of IWM on economics of wheat crop

The maximum cost of cultivation (54667 Rs. ha^{-1}) was incurred under treatment (Pendimethalin 30 EC @ 1.0 kg ha-1 + Metsulfuron 10 EC @0.3 kg ha-1 25 DAS) against the lowest cost of cultivation under control (51796 Rs. ha^{-1}) in all weed management practices regarded higher gross return, net return and benefit cost ratio over control (Table. 3) The maximum gross return (118573 Rs. ha^{-1}) was obtained under weed free condition. Followed by (115348 Rs. ha^{-1}) under treatment (Pendimethalin 30 EC @ 1.0 kg ha-1 + Metsulfuron 10 EC @0.3 kg ha-1 25 DAS) against lowest gross income (85463 Rs. ha^{-1}) under control. Maximum return (63931 Rs. ha^{-1}) under weed free condition followed by (60681 Rs. ha^{-1}) against the lowest net return (33667 Rs. ha^{-1}) under control. Highest benefit cost ratio (2.17:1) under weed free condition and lowest benefit cost ratio (1.65:1) under control. Similar results have been also reported by Ali *et al.* (2006) [1], Tomar and Tomar (2014) [11], Javed *et al.* (2020) [5].

Table 1: Effect of integrated weed management on growth attributing characters of wheat

Treatment	Plant height at 120 DAS	Effective tillers at harvest	Dry matter accumulation at maturity	LAI		
				30 DAS	60 DAS	90 DAS
T_1- Pendimathelin 30 EC @ 1 0 kg ha $^{-1}$	72.95	355.75	16.70	1.31	3.65	4.46
T_2- Metribuzin 70 WP @ 0.3 kg ha $^{-1}$	73.90	360.33	21.10	1.34	3.70	4.52
T_3- Metsulfuron 10 EC @ 0.02 kg ha $^{-1}$ 25 DAS	74.65	363.75	19.88	1.36	3.73	4.56
T_4- Pendimethalin 30 EC @ 1.0 kg ha^{-1} +one hand weeding 40 DAS	76.15	371.25	19.30	1.42	3.81	4.65
T_5- Pendimethalin 30 EC @ 1.0 kg ha^{-1} +2,4-DEE @ 0.5 kg ha^{-1} 25 DAS	77.36	376.98	21.31	1.30	3.87	4.73
T_6- Metribuzin 70 WP @ 0.3 kg ha^{-1} +one hand weeding 40 DAS	79.15	385.65	21.44	1.35	3.96	4.84
T_7- Metribuzin 70 WP @ 0.30 kg ha^{-1} +2,4-DEE@ 0.5 kg ha^{-1} 25 DAS	80.36	392.50	20.51	1.39	4.02	4.91
T_8-Pendimethalin 30 EC @ 1.0 kg ha^{-1} +Metsulfuron 10 EC @0.3 kg ha^{-1} 25 DAS	84.50	411.55	21.64	1.45	4.22	5.16
T_9- Metribuzin 70 WP @ 0.3 kg ha^{-1} +Metsulfuron 10 EC @ 0.02 kg ha-1 DAS	82.40	401.40	20.91	1.41	4.12	5.04
T_{10}-2,4-122DEE @ 0.5 kg ha $^{-1}$ 25 DAS	72.15	352.65	20.14	1.20	3.61	4.41
T_{11}- Weeds free check (Two hand weeding 25 and 45 DAS)	86.75	421.65	22.32	1.50	4.35	5.31
T_{12}-Contral	63.75	307.90	16.12	0.98	3.20	3.91
SE m+	1.30	6.13	0.52	0.06	0.18	0.22
C.D. at 5%	3.82	18.00	1.52	N.S.	0.54	0.63

Table 2: Effect of integrated weed management on yield and yield attributing characters of wheat

Treatment	Spike length (cm)	Number of grains spike^{-1}	Test weight (gm)	Grain yield qha^{-1}	Biological yield qha^{-1}	Straw yield qha^{-1}	Harvest index (%)
T_1- Pendimathelin 30 EC @ 1 0 kg ha $^{-1}$	9.97	49.65	39.75	46.35	123.50	77.15	37.53
T_2- Metribuzin 70 WP @ 0.3 kg ha $^{-1}$	10.10	50.30	39.93	46.95	124.87	77.92	37.60
T_3- Metsulfuron 10 EC @ 0.02 kg ha $^{-1}$ 25 DAS	10.20	50.80	40.05	47.40	125.93	78.53	37.64
T_4- Pendimethalin 30 EC @ 1.0 kg ha^{-1} +one hand weeding 40 DAS	10.40	51.79	40.25	47.35	128.28	79.93	37.69
T_5- Pendimethalin 30 EC @ 1.0 kg ha^{-1} +2,4-DEE @ 0.5 kg ha^{-1} 25 DAS	10.56	52.64	40.65	47.15	130.20	81.05	37.75
T_6- Metribuzin 70 WP @ 0.3 kg ha^{-1} +one hand weeding 40 DAS	10.81	53.83	40.81	46.25	132.62	82.37	37.89
T_7- Metribuzin 70 WP @ 0.30 kg ha^{-1} +2,4-DEE@ 0.5 kg ha^{-1} 25 DAS	10.98	54.68	40.95	47.05	133.81	82.76	38.15
T_8-Pendimethalin 30 EC @ 1.0 kg ha^{-1} +Metsulfuron 10 EC @0.3 kg ha^{-1} 25 DAS	11.54	57.47	41.30	48.35	139.86	86.21	38.36
T_9- Metribuzin 70 WP @ 0.3 kg ha^{-1} +Metsulfuron 10 EC @ 0.02 kg ha-1 DAS	11.26	56.07	40.75	48.25	136.86	84.51	38.25
T_{10}-2,4-122DEE @ 0.5 kg ha $^{-1}$ 25 DAS	9.85	49.05	39.60	47.80	122.20	76.40	37.48
T_{11}- Weeds free check (Two hand weeding 25 and 45 DAS)	11.86	59.05	41.60	48.50	141.40	86.25	38.46
T_{12}-Contral	8.55	42.60	37.75	39.75	106.14	66.39	37.45
SE m+	0.24	0.99	0.23	1.20	2.35	1.36	0.095
C.D. at 5%	0.69	2.93	N.S.	3.52	6.88	3.99	N.S.

Table 3: Effect of integrated weed management on economics of wheat

Treatment	Cost of cultivation Rs ha^{-1}	Gross return Rs ha^{-1}	Net return Rs ha^{-1}	B:C ratio
T_1- Pendimathelin 30 EC @ 1 0 kg ha $^{-1}$	53866	99653	45787	1.85
T_2- Metribuzin 70 WP @ 0.3 kg ha $^{-1}$	53980	100943	46963	1.87
T_3- Metsulfuron 10 EC @ 0.02 kg ha $^{-1}$ 25 DAS	53356	101910	48554	1.90
T_4- Pendimethalin 30 EC @ 1.0 kg ha^{-1} +one hand weeding 40 DAS	53862	103953	50091	1.93

T_5- Pendimethalin 30 EC @ 1.0 kg ha^{-1} +2,4-DEE @ 0.5 kg ha^{-1} 25 DAS	53915	105673	51758	1.96
T_6- Metribuzin 70 WP @ 0.3 kg ha^{-1} +one hand weeding 40 DAS	54290	108038	53748	1.99
T_7- Metribuzin 70 WP @ 0.30 kg ha^{-1} +2,4-DEE@ 0.5 kg ha^{-1} 25 DAS	54068	109758	55690	2.03
T_8-Pendimethalin 30 EC @ 1.0 kg ha^{-1} +Metsulfuron 10 EC @0.3 kg ha^{-1} 25 DAS	54667	115348	60681	2.11
T_9- Metribuzin 70 WP @ 0.3 kg ha^{-1} +Metsulfuron 10 EC @ 0.02 kg ha-1 DAS	54112	112553	58441	2.08
T_{10}-2,4-122DEE @ 0.5 kg ha^{-1} 25 DAS	54104	98470	44366	1.82
T_{11}- Weeds free check (Two hand weeding 25 and 45 DAS)	54642	118573	63931	2.17
T_{12}-Contral	51796	85463	33667	1.65
SE m+	0165.75	1496.2	997.5	0.052
C.D. at 5%	486.25	4389.36	2926.3	0.15

Conclusion

It can be concluded from the present investigation that IWM practices with weed free condition treatment (Two hand weeding 25 and 45 DAS*)* increases the growth & yield attributes and yield of wheat. Similarly, higher net return (63931 Rs. ha^{-1}) and benefit cost ratio (2.17:1) noticed under the weed free treatment followed by treatment (Pendimethalin 30 EC @ 1.0 kg ha^{-1} Metsulfuron 10 EC @0.3 kg ha^{-1} 25 DAS).

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