Determining the Effect of Weed Management Practices on Yield and Economics of Wheat (*Triticum aestivum* L.)

Abstract

A field experiment was conducted at the Instructional cum Research Farm, IGKV, Jagdalpur, Chhattisgarh, India, to evaluate the effect of different weed management practices on yield and economic returns of wheat during the *Rabi* season of 2020-21. The experiment, laid out in a Randomized Complete Block Design (RCBD) with four replications, included five treatments: hand hoeing at 30 days after sowing (DAS) (T_1), metribuzin application @ 175 g a.i. ha^{-1} at 20 DAS (T_2), one hand weeding at 20 DAS (T_3), two hand weeding at 20 and 40 DAS (T_4), and an absolute control (T_5). Results revealed that two hand weeding at 20 and 40 DAS registered highest grain yield (21.38 q ha^{-1}) and straw yield (45.63 q ha^{-1}), followed by metribuzin application (grain yield of 18.60 q ha^{-1} and straw yield of 43.26 q ha^{-1}). Economic analysis revealed that two hand weeding yielded highest gross returns (73,624 ₹ ha^{-1}) and net returns (53,492 ₹ ha^{-1}) but incurred a higher cost of cultivation (20,132 ₹ ha^{-1}) due to increased labor requirements. Metribuzin, though slightly less effective in terms of yield, provided a cost-effective alternative with a lower cost of cultivation (14,004 ₹ ha^{-1}), high net return (49,794 ₹ ha^{-1}) and higher B:C ratio (3.56) making it suitable for situations with labor scarcity. In conclusion, two hand weedings maximize yield and returns in labor-available areas, while metribuzin offers practically cost-effective alternative when labours are scarce.

Key words: Wheat, Hand weeding, Metribuzin, Yield, Economics

1.Introduction

"Wheat (*Triticum aestivum* L.) is a staple crop of the world contributing as a food source for more than 40% of the world's population thus considering as principal cereal crop" (Acevedo et al., 2018) playing a vital role in food security. In India, wheat is cultivated on 31.83 million hectares area and produced 113.29 million tonnes with average productivity of 35.59 q ha^{-1}. In Chhattisgarh, wheat occupies 0.134 million hectares with a production of 0.181 million tonnes and an average productivity of 13.5 q ha^{-1} (Indiastat. 2024). As food demand is projected to rise from 236.2 million tonnes in 2010 to 303-318 million tonnes by 2030, improving wheat production and productivity becomes imperative (DACFW, 2017). The productivity of wheat is influenced by various factors, including soil fertility, water availability, and notably, weed competition. Across the world, research studies revealed that crop yield losses were greater than the combined effects of insect pests and diseases because of weed competition (Amare et al., 2014). "Weeds compete with wheat for essential resources such as water, nutrients, and light, often leading to significant reductions in yield by 37-50%" (Waheed et al. 2009).

Effective weed management is crucial in wheat cultivation to minimize competition and optimize resource use efficiency. Several weed control strategies including mechanical, chemical, and manual methods are widely employed to reduce the negative impact of weeds on wheat production. Among these hand weeding, herbicide application, and hoeing are commonly practiced due to their efficacy in maintaining weed-free conditions during critical growth stages (Jeevan et al., 2024, Kumar et al., 2023 and Gaddala et al., 2021). Beyond yield impacts, weeds increase production costs due to the need for manual or chemical weed control, further affecting the economic returns from wheat farming. Without effective weed management practices, these factors together threaten both yield stability and farm profitability. Among different weed management practices, chemical control of weeds is preferred due to less labor requirement and economic losses due to mechanical damage to the wheat crops during the manual weeding process (Shivran et al., 2020 and Kushwaha et al., 2023). Considering all the above facts, an attempt was made to determine the efficacy of different weed management practices, including mechanical control (hand weeding) and application of herbicides against complex weed flora, to improve wheat productivity and profitability.

2. Materials and methods

A field experiment was carried out during *Rabi* 2020-21 at Instructional cum Research Farm, S.G. College of Agriculture and Research Station, IGKV, Kumhrawand, Jagdalpur, Chhattisgarh, India. Geographically lies at 19°5'17.79"N latitude and 81°57'44.99"E longitude with an altitude of 552

meters above mean sea level**.** The average annual rainfall and temperature of the area were recorded about 1665.4 mm and 24.6^{0}C, respectively during 2020-21. The soil at experimental site was sandy loam, characterized by low in available N (139.08 kg ha^{-1}), medium in available P (7.82 kg ha^{-1}), high in available K (359.92 kg ha^{-1}), low pH (6.7), EC (0.18 dS m^{-1}) and medium organic carbon (0.52%). Test variety GW- 273 was sown at spacing of 20cm × 5cm on 3rd December, 2020. Recommended dose of fertilizers (80:60:40 kg NPK ha^{-1}) were applied in the field. Basal application of fertilizers with 100% recommended dose of phosphorus and potassium, 50% nitrogen during sowing the seeds and remaining 50% nitrogen at 30 DAS. Experiment was laid out in RCBD (Randomize Complete Block Design) with four replications. The treatment comprised of five weed management practices *viz*., one hand hoeing at 30 DAS (T_1), metribuzin @ 175 g a.i. ha^{-1} at 20 DAS (T_2), one hand weeding at 20 DAS (T_3), two hand weeding at 20 and 40 DAS (T_4), Absolute control (T_5).

Harvesting was done when the crop turned to golden yellow colour. The plants within the net plot area were manually harvested to the ground level, then dried, threshed, and winnowed to separate the grains from the straw. These separated grains were then subjected to sun drying until they reached to a moisture content of 14%. Finally, the dried grains were weighed to determine the grain yield, which is expressed in quintals per hectare (q ha^{-1}). Straw yield was calculated from the remaining biomass after grain separation and recorded as q ha^{-1}. The cost of cultivation (COC) included all the expenses for field preparation, seed sowing, fertilizer application, irrigation, weed management, and harvesting. Gross returns (GR) were calculated by multiplying the grain and straw yields with the prevailing market prices of wheat grain. Net returns (NR) were derived by subtracting the total cost of cultivation from the gross returns. The COC, GR and NR were expressed in Rupees per hectare (Rs. ha^{-1}).

Net returns (Rs ha^{-1}) = Gross returns (Rs ha^{-1}) – Cost of cultivation (Rs ha^{-1}).

3. Results and discussion

3.1 Yield

3.1.1 Grain yield (q ha^{-1})

The data pertaining to grain yield was significantly influenced by different weed management practices of wheat which was statistically analysed and presented in the Table 1. Significantly highest grain yield was recorded with two hand weeding at 20 and 40 DAS (21.38 q ha^{-1}) over all weed management practices but found statistically comparable with metribuzin @ 175 g a.i. ha^{-1} at 20 DAS (18.60 q ha^{-1}). Hand hoeing at 30 DAS (15.36 q ha^{-1}) and hand weeding once at 20 DAS (15.16 q ha^{-1}) were found statically similar with each other. Lowest grain yield was recorded with control plot (10.79 q ha^{-1}).

The percentage of the entire biomass that becomes economically usable (grain yield) as a result of bio-physiological processes is known as the grain yield. The maximum grain yield was recorded with two hand weeding which was 50.53% high in contrast with control shown remarkable increase in grain yield might be contributed to two weedings at critical period of crop-weed competition (20 and 40 DAS). The two hand-weeding application effectively inhibited the emergence of monocot, dicot, and grassy weeds by suppressing root and shoot growth. This ensured the crop free from weed competition during critical early growth stages, creating a favorable environment for enhanced nutrient uptake and a better source-sink relationship. Consequently, these treatments improved weed control, promoted crop growth, by reducing weed dry matter and minimizing crop-weed competition, thereby supporting better reproductive potential of the wheat crop. These findings were similar to Kulsoom and Khan
(2015) and Kumari et al. (2024).

Table 1. Effect of weed management practices on grain and straw yield of wheat

Treatment	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1: Hand hoeing at 30 DAS	15.36	37.87
T_2: Metribuzin @ 175 g a.i. ha^{-1} at 20 DAS	18.60	43.26
T_3: One hand weeding at 20 DAS	15.16	38.15
T_4: Two hand weeding at 20 and 40 DAS	21.38	45.63
T_5: Control (Absolute control)	10.79	25.63
SEm±	1.09	2.33
CD (*P* = .05)	3.11	5.90

3.1.2 Straw yield (q ha^{-1})

The data pertaining to straw yield was significantly influenced by different weed management practices of wheat which was statistically analysed and presented in the Table 1. Statistically superior straw yield was recorded with two hand weeding at 20 and 40 DAS (45.63 q ha^{-1}) over other weed management practices but found statistically comparable with metribuzin @ 175 g a.i. ha^{-1} at 20 DAS (43.26 q ha^{-1}). One hand weeding at 20 DAS (38.15 q ha^{-1}) and hand hoeing at 30 DAS (37.87 q ha^{-1}) were found statistically similar with each other. Lower straw yield was recorded with absolute control plot (25.63 q ha^{-1}).

Two hand weeding effectively removed weeds during critical growth stages (at 20and 40 DAS) thus reducing competition in between crop and weeds for essential resources *viz*., water, nutrients and sunlight. Manual weeding allows precise weed removal without causing crop injury or leaving residual effects, which can sometimes occur with chemical treatments. This level of precision ensures that weeds are consistently suppressed throughout the season, maintaining favorable conditions for crop growth and development. This encourages wheat crop to utilize resources efficiently, promoting healthy crop growth and accumulation of biomass further leading to higher grain and straw yield. The reduction in straw yield due to weed infestation was obviously because of the reduced vegetative growth and development inturn reduced dry matter production of crop plants under intense weed competition in control condition. Similar outcomes were obtained from the research work of Kumar *et al*. (2013), Duary *et al*. (2021), Kumari *et al*. (2024).

3.2 Economics

The economic analysis was completed on the basis of prevailing market price of wheat including cost of cultivation, gross return and net return and depicted in Table 2.

3.2.1Cost of cultivation

The data pertaining to cost of cultivation was influenced by different weed management practices and presented in the Table 2. Among all the weed management practices, two hand weeding at 20 and 40 DAS recorded higher cost of cultivation (20,132 ₹ ha^{-1}) over rest of treatments. Two hand weeding has elicited by higher cost of cultivation as compared to other methods of weed control due to high requirement of human labour and their huge wages. Moreover, the labour inputs were offset with higher yields of wheat also compensated the gap of inputs as compared to other treatments that is a reason many farmers still adopted the hand weeding. This cost was reduced with application of metribuzin @ 175 g a.i. ha^{-1} at 20 DAS (14,004 ₹ ha^{-1}) as post-emergence in controlling weeds effectively with minimizing human labours. These findings are in close vicinity with those reported by Kalhapure et al. (2013) and Yadav et al. (2014). Whereas, the minimum cost of cultivation was analyzed under control plot (12,788 ₹ ha^{-1}) and similar findings are reported by Rahaman *et al*. (2009) and Safdar *et al*. (2011).

3.2.2 Gross returns

The data pertaining to gross returns was significantly influenced by different weed management practices of wheat which was statistically analysed and presented in the Table 2. Among all the weed management practices, two hand weeding at 20 and 40 DAS (73,624 ₹ ha^{-1}**)** registered significantly highest gross monetary returns over rest of the treatments but being on par with metribuzin @ 175 g a.i. ha^{-1} at 20 DAS (63,798 ₹ ha^{-1}) and one hand weeding at 20 DAS (60,592 ₹ ha^{-1}). The higher weed control efficiency of two hand weeding contributed to increased grain and straw yields, resulting in higher gross returns. The higher gross monetary returns might be because of higher grain yield of wheat which was pertained to effective control of weeds by keeping the weed free environment that had positive effect on crop growth and yield of wheat. These findings are similar with the findings reported by Chaudhary et al. (2022). However, gross returns obtained under weed-control plot was significantly lowest among the treatment as yield of both grain and straw were lower in this treatment due to fact that weed infestation resulted into significant reduction of yield. Similar findings were reported by several authors Ramesh (2013) and Saquib et al. (2014).

3.2.3 Net Returns

The data pertaining to net returns was significantly influenced by different weed management practices of wheat which was statistically analysed and presented in the Table 2. Among all the weed management practices, two hand weeding at 20 and 40 DAS recorded significantly highest net monetary return (53,492 ₹ ha^{-1}) over rest of the treatments but being on par with metribuzin @ 175 g a.i. ha^{-1} at 20 DAS (49,794 ₹ ha^{-1}) and one hand weeding at 20 DAS (42,364 ₹ ha^{-1}). The higher net

monetary return was due to higher grain and straw yield of wheat. Similar findings were reported by Singh et al. (2021), Duary et al. (2021) and Saquib et al. (2014). Among all the weed management practices, plot without weed control (control) had lowest net monetary return (25,922 ₹ ha^{-1}) as suggested by Shakya *et al*. (2017) in tuning of higher grain and straw yields.

Table 2. Effect of weed management practices on Economics of wheat

Treatment	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1: Hand hoeing at 30 DAS	17412	57949	40537	2.33
T_2: Metribuzin @ 175 g a.i. ha^{-1} at 20 DAS	14004	63798	49794	3.56
T_3: One hand weeding at 20 DAS	18228	60592	42364	2.32
T_4: Two hand weeding at 20 and 40 DAS	20132	73624	53492	2.66
T_5: Control (Absolute control)	12788	38710	25922	2.03
SEm±		4317	4317	0.25
CD (*P* = .05)		13303	13303	0.78

3.2.4 Benefit Cost ratio (B:C ratio)

The data pertaining to B:C ratio was significantly influenced by different weed management practices of wheat which was statistically analysed and presented in the Table 2. Plots treated with application of herbicide (Metribuzin at 20 DAS) had significantly higher benefit cost ratio (3.56) followed by two hand weeding at 20 and 40 DAS (2.66) and hand hoeing at 30 DAS (2.33) which was on par with one hand weeding at 20 DAS (2.32) where as minimum B:C ratio was recorded in control plot (no weeding).The differences in B:C ratio is due to differences in cost of herbicide and productivity of crop. Two hand weeding at 20 and 40 DAS had second higher B:C ratio which might be due to higher labour cost for manual weeding resulted in higher cost of cultivation inturn decreases the B: C ratio over chemical management of weeds. The results are similar to the findings reported by Chaudhary et al. (2022), Singh et al. (2021), and Duary et al. (2021).

4. Conclusion

Based on the results of experimentation, it can be concluded that all weed control practices proved effective in controlling the weeds and gave significantly higher grain yield over control plot. However, two hand weeding were associated with highest economic yields, suggesting that for farmers with access to labor, this method may be beneficial despite the higher cost of cultivation. Metribuzin application is a cost-effective alternative to labor-intensive two-hand weeding, as it can be applied at critical growth stages when labor is not on hand, ensuring timely and effective weed control.

Future line of work

Sole dependence on herbicides along with mono-cropping sequence leads to the shift towards hard-to-control weeds and the rapid development of herbicide resistance, which could threaten crop productivity. There is a need to advocate suitable wheat-based crop rotations and alternate herbicidal options along with manual weeding for management of herbicide-resistant weeds so that the problem of weeds can be undertaken effectively. More hand weedings and herbicides should be used in the critical time period of crop growth, as using different mechanisms of action have a pronounced effect in delaying the appearance and emergence of weeds. Even proper advisory should be given for practicing integrated weed management with high-risk herbicides during recommendation and introduction of new chemicals.

Disclaimer (Artificial intelligence)

Author(s) hereby declared that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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