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Efficacy of Herbicides on Weed Control & Growth Parameter on Wheat

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Wheat (*Triticum aestivum*) is a globally significant crop and a staple food for millions of people. Weed infestation is one of the major constraints affecting wheat productivity worldwide. The purpose of this study was to assess the efficiency of Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF as a post-emergence herbicide against predominant weeds in wheat crops. Wheat is a globally significant crop and a staple food for millions of people. Weed infestation is a major constraint affecting wheat productivity. The study was conducted using a Randomized Block Design with three replications and a total of 11 treatments. The herbicide treatments were applied using foliar spray at different doses. Weed control efficiency was evaluated at 30, 45, and 60 days after herbicide application.

The results showed that the highest weed control efficiency was observed in the weed-free plot, followed by the treatment with Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF at a dose of 800 g/ha. This treatment provided significant control against different weed species such as Phalaris minor, Avena ludoviciana, and Chenopodium album. The herbicide treatments showed varying degrees of control efficiency, with some treatments performing better than others.

These findings highlight the importance of weed management for increasing wheat crop production. The judicious use of herbicides, such as Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF,

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can effectively control weeds and contribute to higher yields. However, further research and field trials are necessary to optimize the herbicide application and determine its long-term effects on wheat crops. Overall, this study emphasizes the need for effective weed control strategies to enhance wheat productivity and meet the demands of a growing population.

Keywords: Wheat; weed infestation; post-emergence herbicide; predominant weeds; herbicide application; weed control efficiency and weed management.

1. INTRODUCTION

Wheat (*Triticum aestivum*) is one of the most widely cultivated crops globally, and its production and cultivated area play a vital role in meeting the world's food requirements. In 2022, the global production and cultivated area of wheat reached significant levels, with India being one of the leading producers.

According to the Food and Agriculture Organization of the United Nations (FAO), the global production of wheat in 2022 reached a record high of approximately 780 million metric tons (MMT) [9]. The cultivated area dedicated to wheat cultivation worldwide was estimated to be around 220 million hectares (Mha) [1]. These figures highlight the substantial scale of wheat production and its contribution to global food security.

In India, wheat is a crucial crop and a staple food for millions of people. The country is among the top wheat-producing nations in the world. In 2022, India witnessed a record-breaking wheat production, reaching an estimated 112 MMT [2]. The cultivated area dedicated to wheat in India was approximately 31 Mha [2]. These numbers reflect the significant role of wheat production in India's agricultural landscape and its importance in meeting domestic food requirements.

1.1 Nutritional Values of Wheat Justifying Its Need

Wheat possesses a diverse array of nutritional components, making it an essential dietary staple. Its nutritional values contribute to the overall health and well-being of individuals. Here are some key nutritional aspects of wheat:

Carbohydrates: Wheat is a rich source of complex carbohydrates, providing energy for daily activities and bodily functions. Carbohydrates make up around 70 percent of wheat's composition, making it an important energy source [3,4].

Proteins: Wheat contains proteins, comprising about 10 to 15 percent of its composition, with an average of 12 percent [5,6]. These proteins are composed of amino acids necessary for tissue repair, growth, and various metabolic processes in the body.

Dietary Fiber: Wheat is a significant source of dietary fiber, including both soluble and insoluble fibers. Fiber aids in digestion promotes satiety, and helps maintain a healthy digestive system. It constitutes approximately 2 percent of wheat's composition [4,7].

Vitamins and Minerals: Wheat contains essential vitamins such as vitamin B1 (thiamine), vitamin B3 (niacin), vitamin B6, and minerals like iron, magnesium, and zinc. These vitamins and minerals play critical roles in various physiological functions, including energy metabolism, immune system support, and maintaining healthy bones and tissues [4,8,9].

The nutritional values of wheat justify its importance as a staple food, providing a well-rounded nutrient profile essential for overall health. Incorporating wheat into a balanced diet can help meet dietary requirements and promote a healthy lifestyle.

Weeds pose a significant threat to agricultural productivity worldwide, and their impact on wheat cultivation is particularly noteworthy. In the North-Western Plain Zone of India, weed infestation remains a major concern for wheat farmers, as it hampers crop growth, reduces yields, and affects overall farm profitability [10,11,12]. Effective weed management strategies are essential to mitigate these challenges and optimize wheat production in the region [13,14,15].

The present study focuses on evaluating the bio-efficacy of Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF, a post-emergence herbicide, against the predominant weeds associated with wheat cultivation in the North-Western Plain Zone of India. By assessing the efficiency of this herbicide, the study aims to provide valuable insights into weed control measures that can be adopted by farmers to enhance crop productivity [16,2,11].

Weed infestation not only competes with wheat plants for essential resources such as nutrients, water, and sunlight but also releases allelochemicals that inhibit wheat growth and development [1,14].

As a result, weed-crop competition leads to reduced grain quality and quantity, posing a significant economic burden on farmers [17,15]. Therefore, effective weed management practices are crucial to mitigate these negative effects and maximize wheat yield [18,10,15].

Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF has emerged as a promising herbicide for weed control in wheat crops. This herbicide combination offers broad-spectrum control against a range of predominant weed species commonly found in the North-Western Plain Zone [2,19,11].

Its post-emergence application allows targeted weed suppression while minimizing potential damage to the crop [20,11].

By conducting this study, the research aims to evaluate the efficiency of Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF in terms of weed control and its subsequent impact on wheat productivity. The findings of this research will contribute to the development of effective weed management strategies tailored to the specific challenges faced by wheat farmers in the North-Western Plain Zone of India [16,2,20,11].

2. MATERIALS AND METHODS

2.1 Experimental Design and Layout

The experiment was conducted using a Randomized Block Design (RBD) with three replications [21,22]. The details of the experimental layout are presented in Table 1.

2.2 Crop Variety

The crop under study was wheat (*Triticum aestivum* L.) variety Shatabadi (K-307) [23,24]. This variety is widely adaptable and has a high yield potential. It is a one-gene dwarf variety resistant to rust disease. The maturity period of this variety is around 125-130 days after sowing, and it has a yield potential of about 55-60 q/ha [24].

2.3 Fertilizer Application

The NPK fertilizer was applied at the rate of 150:60:40 kg/ha [2,25].

2.4 Experimental Treatment Combinations

Eleven treatment combinations were evaluated in the study, including various doses of Carfentrazone ethyl + Clodinafop propargyl 15% DF and other herbicides, as well as weed-free and weedy check plots. The details of the treatment combinations, doses, and method of application are provided in Table 2 [26,27].

2.5 Herbicide and Water Requirement

The amount of herbicide and water required for each treatment plot is shown in Table 3 [26,27]. The doses were determined based on the recommended application rates per hectare.

2.6 Plot Size and Layout

The gross plot size was 5.0 x 4.0 m, while the net plot size was 4.0 x 3.40 m. The field border, irrigation channel, and ridge dimensions were 1.0 m, 1.25 m, and 0.50 m, respectively. The spacing between the wheat plants was maintained at 20 cm [26].

2.7 Data Collection

Data on various parameters related to weed control and wheat growth were recorded. These included weed counts, weed control efficiency, plant height, number of tillers per plant, number of grains per spike, and grain yield.

2.8 Data Analysis

The collected data will be subjected to appropriate statistical analysis, such as analysis of variance (ANOVA), using the randomized block design. The mean separation will be performed using Duncan's multiple range test (DMRT) at a significance level of $p < 0.05$. Statistical software such as SPSS or R will be used for data analysis.

Table 1. Experimental design and layout

Experimental design	**:**	**Randomized Block Design (RBD)**
Total number of treatments	:	11
Replication	:	3
Total number of plots	:	33
Field border	:	1.0 m
Irrigation channel	:	1.25 m
Ridge	:	0.50 m
Spacing	:	20 cm
Gross Plot size	:	5.0 x 4.0 = 20.0 m^2
Net Plot size	:	4.0 x 3.40 = 13.60 m^2
Crops and variety	:	Wheat (*Triticum aestivum* L.). Shatabadi (K-307)
Fertilizer	:	NPK @ 150:60:40 kg/ha

Table 2. Experimental treatment combinations with symbol

S. No.	**Name of the treatment**	**Dose (gm/ ml ha^{-1})**	**Method of application**	**Symbol**
1.	Carfentrazone ethyl + clodinforp propargyl 15% DF	300	Foliar spray	T_1
2.	Carfentrazone ethyl + clodinafop propargyl 15% DF	400	Foliar spray	T_2
3.	Carfentrazone ethyl + clodinafop propargyl 15% DF	500	Foliar spray	T_3
4.	Carfentrazone ethyl + clodinafop propargyl 15% DF	800	Foliar spray	T_4
5.	Clodinafop propargyl 15% WP	400	Foliar spray	T_5
6.	Carfentrazone-ethyl 40% DF	50	Foliar spray	T_6
7.	Carfentrazone ethyl 20% + Sulfosulfuron 25% WG	100	Foliar spray	T_7
8.	Clodinafop propargyl 15% + Metsulfuron Methyl 1% WP	400	Foliar spray	T_8
9.	Weed free	-	-	T_9
10.	Hand weeding @ 15 and 30 DAS	-	-	T_{10}
11.	Weedy check	-	-	T_{11}

Table 3. Amount of herbicide and water requirement

Name of the treatment	**Dose (gm/ ml ha^{-1})**	**Dose/ plot (g)**	**Amount of water liter/plot**
T_1 - Carfentrazone ethyl + clodinafop propargyl 15% DF	300	0.60	1.0
T_2 - Carfentrazone ethyl + clodinafop propargyl 15% DF	400	0.80	1.0
T_3 - Carfentrazone ethyl + clodinafop propargyl 15% DF	500	1.0	1.0
T_4 - Carfentrazone ethyl + clodinafop propargyl 15% DF	800	1.60	1.0
T_5 - Clodinafop propargyl 15% WP	400	0.80	1.0
T_6 - Carfentrazone-ethyl 40% DF	50	0.20	1.0
T_7 - Carfentrazone ethyl 20% + Sulfosulfuron 25% WG	100	0.80	1.0
T_8 - Clodinafop propargyl 15% + Metsulfuron Methyl 1% WP	400	0.10	1.0

3. RESULTS AND DISCUSSION

3.1 Weed Control Efficiency after Application of Herbicides

At 30 days after herbicide application, weed control efficiency was assessed (Tables 4-6). The data indicated that the highest weed control efficiency against various weed species was recorded in the weed-free plot [28]. Following that, Carfentrazone ethyl 5% + clodinafop propargyl 15% DF at 800 kg/ha (86.03%, 79.14%, 86.44%, 92.63%, 87.53%, 87.02%, and 100%) [29] showed significant weed control efficiency. Additionally, Carfentrazone ethyl 5% + clodinafop propargyl 15% DF at 500 kg/ha (84.50%, 75.94%, 85.04%, 88.94%, 75.07%, 79.95%, and 83.26%) [29] and Carfentrazone ethyl 5% + clodinafop propargyl 15% DF at 400 kg/ha (80.57%, 73.99%, 81.87%, 85.25%, 71.00%, and 76.54%) [29] demonstrated comparable weed control efficiency. Phalaris minor, Avena ludoviciana, and Melilous spp. were identified as the major dominant weed species in the wheat crop. These findings are supported by studies conducted by [30,31,32,33].

Table 4. Phalaris minor control efficacy (%) after spraying of herbicides

Treatment	30 DAA	45 DAA	60 DAA
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 300 g/ha	68.00	74.83	76.78
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 400 g/ha	80.57	83.39	84.98
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 500 g/ha	84.50	87.23	88.35
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 800 g/ha	86.03	88.22	89.10
Clodinafop propargyl 15% WP @ 400 g/ha	76.38	79.22	78.04
Carfentrazone-ethyl 40% DF @ 50 g/ha	43.65	55.03	58.47
Carfentrazone ethyl 20% + Sulfosulfuron 25% WG @ 100 g/ha	66.33	72.23	71.13
Clodinafop propargyl 15% + Metsulfuron Methyl 1% WP @ 400 g/ha	74.52	77.53	76.34
Weed free	100.00	100.00	100.00
Hand weeding @ 15 and 30 DAS	80.90	66.26	61.45
Weedy check	-	-	-
SE m+	4.895	5.442	0.723
CD 5%	14.541	16.166	2.147

Table 5. Avena ludociciana control efficacy (%) after spraying of herbicides

Treatment	30 DAA	45 DAA	60 DAA
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 300 g/ha	60.22	68.09	69.95
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 400 g/ha	73.99	77.43	80.34
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 500 g/ha	75.94	78.60	80.52
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 800 g/ha	79.14	81.48	83.59
Clodinafop propargyl 15% WP @ 400 g/ha	63.84	66.69	63.40
Carfentrazone-ethyl 40% DF @ 50 g/ha	39.22	45.91	42.44
Carfentrazone ethyl 20% + Sulfosulfuron 25% WG @ 100 g/ha	55.77	62.10	60.63
Clodinafop propargyl 15% + Metsulfuron Methyl 1% WP @ 400 g/ha	61.75	68.17	66.94
Weed free	100.00	100.00	100.00
Hand weeding @ 15 and 30 DAS	73.60	50.27	45.75
Weedy check	-	-	-
SE m+	5.641	5.695	0.750
CD 5%	16.758	16.920	2.227

Table 6. Chenopodium album control efficacy (%) after spraying of herbicides

Treatment	30 DAA	45 DAA	60 DAA
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 300 g/ha	69.19	74.05	75.48
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 400 g/ha	81.87	85.12	85.97
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 500 g/ha	85.04	85.86	87.80
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 800 g/ha	86.44	88.28	89.64
Clodinafop propargyl 15% WP @ 400 g/ha	35.04	45.30	46.56
Carfentrazone-ethyl 40% DF @ 50 g/ha	72.89	78.05	78.89
Carfentrazone ethyl 20% + Sulfosulfuron 25% WG @ 100 g/ha	58.63	62.88	65.84
Clodinafop propargyl 15% + Metsulfuron Methyl 1% WP @ 400 g/ha	31.51	39.35	41.05
Weed free	100.00	100.00	100.00
Hand weeding @ 15 and 30 DAS	82.57	40.28	38.32
Weedy check	-	-	-
SE m+	5.102	4.929	0.863
CD 5%	15.156	14.642	2.565

1. At 45 days after herbicide application, the weed-free plot exhibited the highest weed control efficiency (100%) [28].
2. Similarly, at 60 days after application, the weed-free plot maintained the highest weed control efficiency [28]. Carfentrazone ethyl 5% + clodinafop propargyl 15% DF at 800 kg/ha (89.10%, 83.59%, 89.64%, and 92.15%) [29], 500 kg/ha (88.35%, 80.52%, 87.80%, and 90.08%) [29], and 400 kg/ha (84.98%, 80.34%, 85.97%, and 87.79%) [29] also showed significant weed control efficiency. Furthermore, Carfentrazone ethyl 20% + Sulfosulfuron 25% WP and Clodinafop propargyl 15% WP were effective against monocot weeds, while Carentrazone ethyl 40% DF demonstrated effectiveness against dicot weeds [29]. These findings are supported by studies conducted by [32,34,35].

3.2 Growth and Yield Parameters

Plant height at harvest was recorded (Table 7). The highest plant height (82.13 cm) was observed in the weed-free plot [28]. This finding aligns with the study conducted by [36]. Among the herbicide treatments, Carfentrazone ethyl 5% + clodinafop propargyl 15% DF at 400 kg/ha resulted in a significant maximum plant height [28].

The significant maximum number of grains per ear head (52.17) was recorded with the application of Carfentrazone ethyl 5% + clodinafop propargyl 15% DF at 500 kg/ha,

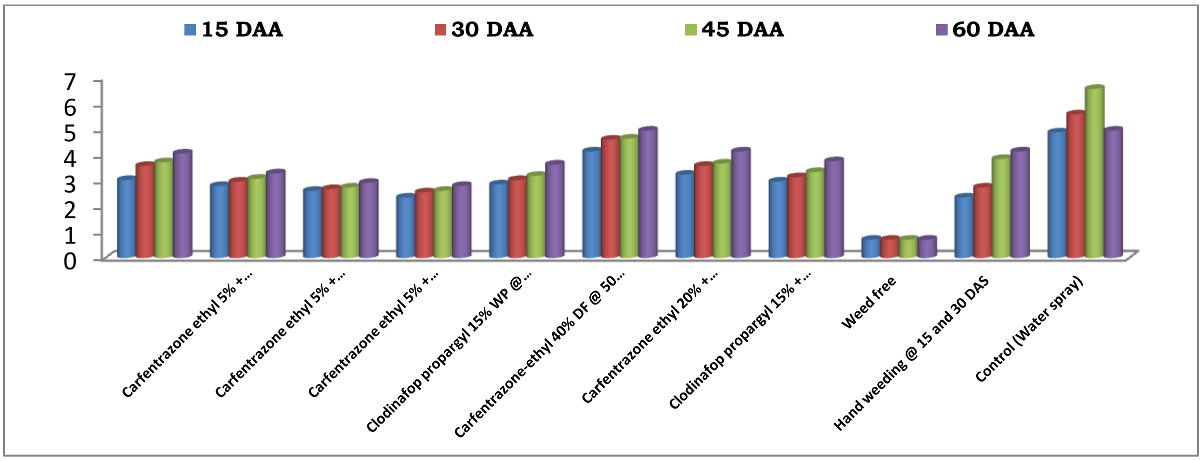

Fig. 1. *Phalaris minor* density/m^2 after spraying of herbicides

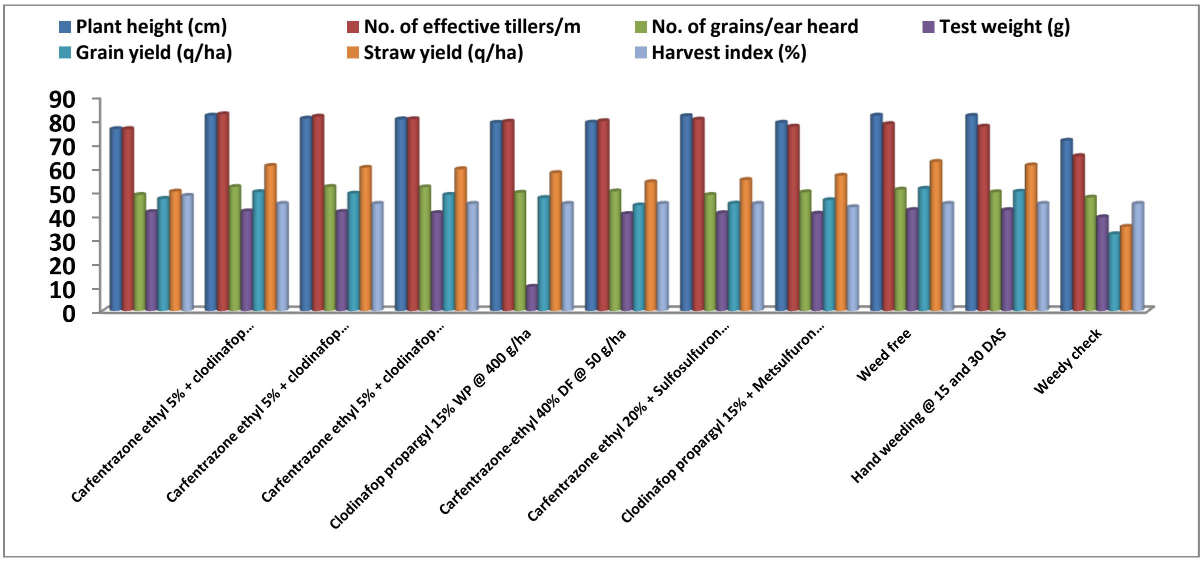

Fig. 2. Effect of herbicides on yield parameter, Grain yield of wheat

Table 7. Effect of herbicides on yield parameter, Grain yield of wheat

Treatment	Plant height (cm)	Grain yield (q/ha)	Straw yield (q/ha)
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 300 g/ha	76.47	47.17	50.22
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 400 g/ha	82.13	49.99	60.98
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 500 g/ha	80.88	49.36	60.21
Carfentrazone ethyl 5% + clodinafop propargyl 15% DF @ 800 g/ha	80.59	48.86	59.60
Clodinafop propargyl 15% WP @ 400 g/ha	79.13	47.52	57.97
Carfentrazone-ethyl 40% DF @ 50 g/ha	79.22	44.40	54.16
Carfentrazone ethyl 20% + Sulfosulfuron 25% WG @ 100 g/ha	81.94	45.15	55.08
Clodinafop propargyl 15% + Metsulfuron Methyl 1% WP @ 400 g/ha	79.15	46.60	56.85
SE m+	1.081	0.540	0.85
CD 5%	3.211	1.603	2.41

followed closely by Carfentrazone ethyl 5% + clodinafop propargyl 15% DF at 400 kg/ha (52.13) and Carfentrazone ethyl 5% + clodinafop propargyl 15% DF at 800 kg/ha (51.98) [28]. On the other hand, the weedy check plot exhibited a significantly minimum number of grains per ear head (47.69) [28]. These findings are consistent with the studies conducted by [37,38,39].

4. CONCLUSION

The research study investigated the effectiveness of various herbicides in controlling weeds and improving yield in wheat crops. The major findings of the study are as follows:

1. Plant Height: The tested herbicides did not significantly increase plant height. However, manual weeding resulted in numerically higher plant height compared to the unseeded treatment. The treatment with Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF @ 400g/ha showed the highest plant height of 82.13cm.
2. Grain Yield: The application of Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF herbicide led to improved yield attributes in wheat crops. The treatment with Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF @ 400g/ha resulted in the maximum grain yield. Manual weeding also recorded higher yield attributes compared to herbicidal treatments.
3. Weed Control Efficiency: The herbicides demonstrated effective weed control efficiency, with Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF treatments showing the highest efficacy. Weed-free plots exhibited the highest weed control efficiency, followed by the Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF treatments.
4. Weed Dry Matter: Weed-free and manual weeding treatments resulted in significantly lower weed dry matter compared to herbicide treatments. The application of herbicides showed a greater impact on reducing weed growth.

Based on the findings of this study, there are several potential future directions for further research:

1. Optimize Herbicide Application: Investigate the optimal dosage and timing of herbicide application to further enhance weed control efficiency and minimize potential adverse effects on crop growth and development.
2. Weed Resistance Management: Explore strategies to prevent or manage weed resistance to herbicides, particularly in the case of Carfentrazone ethyl 5% + Clodinafop propargyl 15% DF, to ensure its long-term effectiveness.
3. Integrated Weed Management: Evaluate the integration of herbicide treatments with other weed management practices, such as cultural methods, crop rotation, and the use of cover crops, to develop more sustainable and holistic weed management strategies.
4. Economic Analysis: Conduct a comprehensive economic analysis to assess the cost-effectiveness of herbicide treatments and their impact on overall crop profitability.
5. Environmental Impact Assessment: Assess the potential environmental impacts of herbicide application on soil, water quality, and non-target organisms,

and explore alternative approaches to minimize these impacts.

By addressing these future aspects, further advancements can be made in weed control strategies for wheat crops, leading to improved yields and sustainable agricultural practices.

CONFERENCE DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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