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Evaluating the bio-efficacy of a novel herbicide (Prosulfocarb) on weed control, with a focus on *Phalaris minor*, in wheat

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Abstract
A field experiment was conducted during rabi season of 2023-24 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to Evaluating the Bio-efficacy of a Novel Herbicide (Prosulfocarb) on Weed Control, with a Focus on *Phalaris minor*, in Wheat. The soil was normal in pH of 7.66, electrical conductivity (EC) of 0.23 dSm^{-1}, organic carbon content of 0.40%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 215.90, 19.25, and 148.40 kg ha^{-1}, respectively. The experiment was laid out during Rabi season of 2023-24. The experiment consisted of 8 treatment combinations, was laid out in Randomized Block Design (RBD) with three replications.

Keywords: Bioherbicide, wheat, prosulfocarb

Introduction

The Indo-Gangetic Plains (IGP) make up the Indian Green Revolution region, which makes up approximately 15% of the nation's total land area. About half of the food grains needed to feed 40% of the nation's population are produced there. One of the largest areas of fertile, deep-seated alluvium soil in the world, these plains are ideal for double and triple cropping (Gangwar *et al.*, 2006) [1]. In the IGP, cash crops such as cotton, sugarcane, and potatoes are grown along with important crops like rice, maize, pearl millet, and sorghum in the Kharif season and wheat, barley, chickpea, and mustard in the rabi season.

The poaceae family's wheat (*Tritium aestivum* L.) is the most significant grain crop in terms of both its historical significance and its use as a food source for humans. About one billion people in 43 countries around the world rely on wheat as a stable food source. Roughly 20% of the total calories in food that humans need come from it. Approximately 220 million hectares of wheat are grown worldwide. which is located in developing nations for the most part. China, India, the United States of America, Russia, France, Canada, Germany, Turkey, Australia, and Ukraine are the principal producers of wheat. In terms of production and area, wheat is only surpassed by rice in India. Belonging to the Poaceae family, wheat is thought to have originated in South-West Asia.

Starch (60–68%), protein (11–12%), fat (1.5–2.0%), cellulose (2.0–2.5%), minerals (1.8%), and vitamins are all present in wheat grain. Unlike other cereals, wheat is special because it contains gluten protein, which gives leavened dough the ability to rise by forming tiny gas cells, allowing bakers to create light breads. In India, chapatis, paranthas, and poories are the main dishes made with whole meal wheat, or atta. Along with breads, cakes, cookies, crackers, pancakes, noodles, piecrust, ice cream cones, pizza, bulgur, and other baby foods, it is also used in many other recipes.

With production of 28.5, 15.73, and 11.23 MT, respectively, Uttar Pradesh, Punjab, and Haryana are India's top three wheat-producing states. While Punjab has the highest productivity (4462 kg/ha), followed by Haryana (4390 kg/ha) and U.P. (4351 kg/ha), the U.P. ranked first in percentage share of wheat production (35.39%), followed by Haryana (13.45%) and Punjab

(19.80%). (2018, Anonymous). One of the most dangerous weeds in the rice-wheat cropping system is *Phalaris minor*, which can cause up to 100% of crop losses, as reported by Singh and Singh (2002) [3]. In India, weeds significantly reduce agricultural productivity; yearly losses in monetary terms total around Rs. 1650 crores (Jat 2017) [6]. Weed is more harmful to agriculture than insects, pests, and diseases combined, but because it causes hidden losses in crop productivity, farmers have not given it much thought (Rao, 2001) [1].

Without a doubt, one of the main biotic obstacles to raising wheat production is weeds. A higher yield can only be achieved by controlling weeds, especially in the early stages of crop establishment. Furthermore, given the wide variety of weed flora seen in the field, using a single herbicide might not provide an effective control. Multiple weed control and nutrient management strategies are required for improved yield. In order to delay herbicide resistance and lower the herbicide load on the agro-ecosystem, effective weed control frequently necessitates a combination of cultural, mechanical, and chemical control measures (Rao *et al*., 2007 and Verma *et al*., 2015) [10, 11]. One such approach is the integrated weed management approach.

New herbicide molecules like clodinafop propargyl, fenoxaprop-p-ethyl, Iodosulfuron- methyl sodium and mesosulfuron-methyl was very effective for weed control (Baghestani *et al*. 2008 and Barros *et al*., 2009) [7, 8], Kumar *et al*., (2011) [13], Singh *et al*., (2012) [9] and Malik *et al*. (2013) [12] and Chitband *et al*., (2013) [14] reported the tank mixture of clodinafop + metsulfuron, mesosulfuron-methyl + Iodosulfuron-methyl-sodium and clodinafop + metsulfuron with and without surfactant provided excellent control of *Phalaris minor*, *Avena fatua*, *Chenopodium album*, *Melilotus* spp., *Medicago denticulata*, *Vicia sativa*, *Rumex* spp., *Anagallis arvensis*, *Coronopus didymus*, *Lathyrus aphaca*, *Polygonum plebeium*, sedges and many other weeds with higher grain yield of wheat.

Avena fatua, *Avena leudoviciana*, *Phalaris minor*, *Poa annua*, and other common broad-leaf weeds are among the many annual grassy weeds that are said to be heavily infested in wheat. According to Inderjit.

Herbicide resistance in *P. minor* was brought about by continuous use of herbicides such as isoproturon, which also caused weed shifts (Malik *et al*., 2013 and Kumar, 2014) [12, 15]. Second, 2, 4-D has been shown to be very effective at controlling broad-leaved weeds in wheat; however, if it is not applied correctly, it can cause deformity of the ears.

In order to provide an alternative to the current recommendations for weed control in wheat crops, this involved testing new molecules and their combinations (Verma *et al*., 2008) [11]. It was suggested to use sulfosulfuron and clodinafop as substitute herbicides to combat *Phalaris minor* that is resistant to isoproturon. However, reports of resistance to these herbicides have also surfaced (Dhawan *et al*., 2009 and Kewat, 2014) [17, 16], making the hunt for novel herbicide molecules necessary for effective weed control. In addition to being affordable and environmentally friendly, technologies such as the use of herbicides and cultural practices as part of an effective weed management program, such as higher seed rates, mulching, mechanical weeding, tillage practices, time and number of irrigations, etc., play a significant role in weed suppression (Sharma and Singh, 2011) [18]. Among the various herbicidal treatments, metsulfuron + sulfosulfuron had the greatest weed control efficiency (91.5%). (2010, Khokhar and Nepalia) [19].

Materials and Methods

A field experiment was conducted during rabi season of 2022-23 on loamy sand of in the rural area of Kanpur district of Mandhana, located 10 km from Kanpur in Uttar Pradesh to Evaluating the Bio-efficacy of a Novel Herbicide (Prosulfocarb) on Weed Control, with a Focus on *Phalaris minor*, in Wheat. pH of 7.66, EC of 0.23 dSm^{-1}, organic carbon content of 0.40%, and available nutrient levels of nitrogen (N), phosphorus (P), and potassium (K) at 215.90, 19.25, and 148.40 kg ha^{-1}, respectively, were all within normal limits for the soil. Eight treatment combinations made up the experiment, which had three replications and a Randomized Block Design (RBD). T_1 Prosulfocarb 80 EC (PE) 1600 ml/hac, T_2 Prosulfocarb 80 EC (PE) 2000 ml/hac^1, T_3 Prosulfocarb 80 EC (PE) 3000 ml/hac T_4 Salfosulfuron @ 30 gm a.i./hac, T_5 Clodinafop + Metsulfuron (60 + 4) @ 64 g a.i. ha^{-1}, T_6 Sulfosulfuron + Metsulfuron (30 + 2) @ 32 g a.i. ha^{-1}, T_7 Weedy check T_8 Weed free data were gathered on five plants chosen from each plot.

Results and Discussion

Plant growth Studies

Number of tiller/m2

At every stage of crop growth, weed-free treatments lasting up to 60 days produced the most tiller relative to the other treatments; nevertheless, prosulfocarb at 1600 ml and 2000 ml/ha produced noticeably more tiller per m2. At every stage of crop growth, a significantly lower number of tillers was observed with weedy check compared to the remaining treatments. At every stage of crop growth, all herbicide treatments result in a noticeably higher number of tillers than weedy check. The greatest number of tillers, however, was observed with salfosalfuron + metsulfuron 30 + 4 g a.i./ha, followed by clodinopop + metsulfuron, sulfosulfuron, and prosulfocarb alone 3000ml a.i./ha. At every stage of crop growth, prosufocar @ 2000 ml a.i. and prosufocarb @ 1600 ml a.i./ha. The maximum number of tillers was produced by the prosulfocarb treatment that sprayed at 3000 ml, followed by 2000 ml and 1600 ml/ha at all stages of crop growth. Increased weed competition with crops resulting from increased weed population and dry weight of weeds led to low nutrient availability for crops and fewer tillers. A comparable increase in the quantity of crop tillers was noted by Bibi *et al*. (2008) [20].

Plant height

The tallest plant that was not significantly weed-free at 30 days was measured at 60 days, after which a pre-emergence prosufocarb spray at a rate of 3000 ml/ha was applied. Application of prosulfocarb at 2000 ml/ha was found to be a slightly higher plant height among the pre-emergence herbicides, followed by prosulfocarb at 3000 ml/ha and prosulfocarb at 1600 ml/ha.

Comparing weed-free plants up to 60 days to salfosulfuron at 30 g a.i. /ha and all three formulations at 60, 90, and harvesting stages, the tallest plant was found to be substantially reduced. Prosulfocarb at the rate of 2000 ml & prosulfocarb 1600 ml at 60 days, 90 days, and harvesting stage recorded significantly more plant height than sulfosulfuron + metsulfuron @ (60 + 4) herbicide treatment application. Pre-emergence spraying with 2000 ml/ha of prosulfocarb showed a non-significantly higher height among the prosulfocarb treatment, followed by 3000 ml/ha. Meena and Singh (2011) [21] both reported higher crop growth values.

Dry matter accumulation

Over the course of the treatment, weed-free up to 60 days resulted in a noticeably higher dry matter accumulation than the other treatments at every stage of crop growth. The application of salfosalfuron + metsulfuron (60 + 4) g a. i./ha as a post-emergence herbicide treatment recorded the highest dry matter accumulation at all stages of crop growth, but it was not as effective as the other treatments. With prosulfocarb treatment, the highest dry matter accumulation was observed at 3000 ml/ha. At all stages of crop growth, as post-emergence, followed by @ 2000 ml /ha and 1600 ml /ha.

As a result, weed free for up to 60 days produced significantly higher dry matter accumulation than the other treatments at every stage of crop growth, while remaining on par with salfosulfuron + metsulfosulfuron (30 + 4) g.a. i./ha. reported a similarly higher value for the crop's dry matter accumulation.

Leaf area index

At 30, 60, and 90 days, respectively, the treatment with weed free for up to 60 days recorded significantly higher values (1.70, 5.90, 5.85) than the rest of the treatment during every stage of crop growth. At every stage of crop growth, the difference between weed free up to 60 days and sulfosulfuron + metsulfuron @ (30 + 4) g. a. i. /ha was found to be non-significant. The post-emergence herbicide treatment of sulfosulfuron + metsulfuron produced a maximum leaf area compared to the other treatments, but it was not as effective as clodinopop + metsulfuron at any stage of crop growth. The prosulfocarb treatment that produced the highest leaf area index was the post-emergence spray, which applied 3000 ml/ha of prosulfocarb, followed by 2000 ml/ha and 1600 ml/ha of prosulfocarb. When compared to the other treatments, the weedy check treatment had the noticeably lowest leaf area index value.

The leaf area index was considerably higher during the 60-day weed-free treatment period. This was due to the crop being kept free of weeds for 60 days; therefore, there was no competition between the crop and the weeds for 60 days, which increased the crop's availability of light, space, and plant nutrients and produced higher growth attributes. Likewise, effective weed control.

Table 1: Number of tillers affected by different weed management treatment

Treatment	Number of tiller			
	30 DAS	60 DAS	90 DAS	At harvest
Prosulfocarb 80 EC (PE) 1600 ml.a.i./ha	199	356	399	396
Prosulfocarb 80 EC (PE) 2000 ml.a.i./ha	203	368	413	409
Prosulfocarb 80 EC (PE) 3000 ml.a.i./ha	212	378	425	420
Salfoslfuron @ 25 g.a.i./ha (POE)	214	383	430	425
Clodinopop + Metsulfuron @ 60 g + 4 g a.i./ha(POE)	226	391	438	434
Sulfosulfuron + Metsulfuron @ 30 g + 4 a.i./ha (POE)	220	398	446	442
Weed free up to 60 DAS	224	424	476.60	471
Weedy check till maturity	188	221	248	246
SEm±	7.50	15.98	19.41	19.76
CD (P=0.05)	22.74	48.46	58.88	59.94

Table 2: Plant height are affected by different weed management treatment

Treatment	Plant height (cm)			
	30 DAS	60 DAS	90 DAS	At harvest
Prosulfocarb 80 EC (PE) 1600 ml.a.i./ha	25.60	60.00	80.30	78.60
Prosulfocarb 80 EC (PE) 2000 ml.a.i./ha	26.10	63.80	85.70	84.00
Prosulfocarb 80 EC (PE) 3000 ml.a.i./ha	26.00	62.20	83.50	81.00
Salfoslfuron @ 25 g.a.i./ha (POE)	23.10	64.10	86.00	84.30
Clodinopop + Metsulfuron @ 60 g + 4 g a.i./ha(POE)	22.95	66.60	89.40	87.60
Sulfosulfuron + Metsulfuron @ 30 g + 4 a.i./ha (POE)	23.16	68.40	91.08	90.00
Weed free up to 60 DAS	26.40	70.30	94.40	92.50
Weedy check till maturity	22.25	57.20	75.60	73.90
SEm±	1.11	2.07	2.50	2.90
CD (P=0.05)	3.37	6.26	7.59	8.79

Table 3: Dry matter accumulation (gm-2) are affected by different weed management treatment.

Treatment	Dry Matter Accumulation			
	30 DAS	60 DAS	90 DAS	At harvest
Prosulfocarb 80 EC (PE) 1600 ml.a.i./ha	53.90	390.00	653.20	796.60
Prosulfocarb 80 EC (PE) 2000 ml.a.i./ha	55.20	446.00	743.00	905.60
Prosulfocarb 80 EC (PE) 3000 ml.a.i./ha	57.60	470.00	783.00	954.80
Salfoslfuron @ 25 g.a.i./ha (POE)	58.10	475.0	790.00	964.10
Clodinopop + Metsulfuron @ 60 g + 4 g a.i./ha(POE)	59.00	490.0	815.00	998.70
Sulfosulfuron + Metsulfuron @ 30 g + 4 a.i./ha (POE)	68.00	558.00	905.0	1135.20
Weed free up to 60 DAS	71.59	590.00	950.00	1168.60
Weedy check till maturity	52.00	285.0	475.00	580.60
SEm±	2.37	20.10	25.48	37.37
CD (P=0.05)	7.18	60.97	77.29	113.34

Table 4: Leaf area index are affected by Different weed management treatment.

Treatment	Leaf area Index		
	30 DAS	60 DAS	90 DAS
Prosulfocarb 80 EC (PE) 1600 ml.a.i./ha	1.20	3.92	3.33
Prosulfocarb 80 EC (PE) 2000 ml.a.i./ha	1.29	4.80	4.10
Prosulfocarb 80 EC (PE) 3000 ml.a.i./ha	1.31	4.75	4.05
Salfoslfuron @ 25 g.a.i./ha (POE)	1.45	4.80	4.10
Clodinopop + Metsulfuron @ 60 g + 4 g a.i./ha (POE)	1.48	4.82	5.07
Sulfosulfuron + Metsulfuron @ 30 g + 4 a.i./ha (POE)	1.52	5.38	5.47
Weed free up to 60 DAS	1.70	5.90	5.85
Weedy check till maturity	1.30	2.90	2.50
SEm±	0.06	0.19	0.16
CD (P=0.05)	0.19	0.57	0.40

Conclusion

Weed-free methods were found to be the most successful in controlling weeds. Sulfosulfuron + Metsulfuron (30 + 4) gm.a.i./ha was found to be the most effective herbicide for controlling weeds after emergence. Compared to the other treatments, Sulfosulfuron + Metsulfuron (30 + 4) gm.a.i./ha was found to be appropriate for wheat growth and yield.

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