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On-Farm Study on the Efficacy of Weed Management Treatments on Wheat under Irrigated Agro-Ecosystem of Jharkhand, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An on-farm trial was conducted during *rabi* (winter) seasons of 2019-20 and 2020-21 at the farmers' field. To test the OFT on weed management technology in wheat developed by the Bihar Agricultural University, Sabour, Bhagalpur. The efficacy of post-emergence application (PoE) of metsulfuron-methyl @ 4 g/ha, 2, 4-D ethyl ester 0.75 kg/ha followed by (*fb*) one manual hand weeding at 45 days after sowing (DAS) and 2, 4-D ethyl ester @ 0.75 kg /ha in managing weeds and improving productivity and economics of irrigated wheat was studied in comparison with the farmer's practice (one hand weeding at 40 DAS). The metsulfuron methyl @ 4g/ha PoE had significantly reduced the density of broad-leaved weeds (BLWs) and sedges and resulted in higher grain yield (34.4%), gross returns (INR 97.6×10^3/ha), net returns (INR 50.1× 10^3/ha), benefit: cost ratio (2.05), economic efficiency (INR 385.9/day/ha) and production efficiency (28.8 kg/ha/day) in comparison to farmer's practice. Thus, it may be concluded metsulfuron methyl @ 4g/ha PoE is effective and economically feasible practice in wheat of tribal farming community under the irrigated agro-ecosystem of Jharkhand.

Keywords: Economics; herbicides; on-farm study; metsulfuron-methyl; weed management; wheat.

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the second most important cereal crop after rice and widely cultivated in ~30 million ha (14% global area) to produce 99.7 million tonnes of wheat (13.6% of world production) with a record average productivity of 3371 kg/ha [1]. In Jharkhand, it is cultivated over an area of 0.194 million ha with a total production of 0.385 million tonnes. The average yield (1988 kg/ha) of wheat [1] is far below than its potential, i.e., 4.73 tonnes/ha [2]. The crop productivity of wheat in Jharkhand state is very low due to crop-weed competition, application of high seeding rate; very low seed replacement rate (SRR), nutrient deficiencies, infestation of insect-pests and diseases. Among these, infestation of weeds in wheat is one of the major problems faced by the farmers. The initial high soil moisture leads to severe infestation of grassy, broad-leaved weeds and sedges. Globally yield reductions in wheat due to weeds are 14.3% or even more [3,4]. Among different weed species, infestation by little seed canary grass (*Phalaris minor*) in wheat is rampant and caused depletion of 42.2 kg N, 6.5 kg P and 71.6 kg K/ha in wheat crop field [5]. Manual weeding is a common practice in this region, but it is less efficient, labour intensive, costly and often not done at right time. Hence, farmers started preferring herbicides to combat weed menace in most of wheat growing areas of India.

In Jharkhand, still, effective chemical management practices adoption is not common due to lack of the awareness and knowledge among the resource-poor farming community. Therefore, farmers are controlling the weeds in their wheat field manually, making farming more costly with reduced the net incomes. Currently, Government of India along with the State Department is implementing the program of doubling the farmer's income through adoption of the improved agricultural production techniques of which chemical weed control is a preferred practice as it involves less of the scarce and costly labour. Metsulfuron-methyl has been recommended for control of broad-leaved weeds in wheat [6,7]. It is a selective systemic herbicide absorbed through roots and foliages with rapid translocation both acropetally and basipettally as well. In susceptible plants, it inhibits the branched chain amino acid synthesis (ALS or AHAS) and interferes in biosynthesis of valine and isoleucine stopping cell division and plant growth [8,9]. This study was conducted to find out the bio-efficacy of metsulfuron-methyl in the wheat farmer's fields. To validate the suitability of the improved weed management while comparing with traditional farmer's practice.

2. MATERIALS AND METHODS

An on-farm trial was conducted during *rabi* season of 2019-20 and 2020-21 at Gunghasa, Poraiyahat Block of Godda, Jharkhand (24°41' 29.62"N and 87°11'1.5"E, a msl 87 m). Initially Participatory Rural Appraisal (PRA) was done to identify main the reasons for low wheat yield. It was found that heavy infestation by weeds, particularly *Phalaris minor, Cynodon dactylon, Cyprus rotundus, Anagalis arvensis, Convolvulus arvensis* and *Chenopodium album*, was serious constraint in Godda, Jharkhand. This experiment comprised of four treatments *viz.* farmer's practice of manual weeding at 40 days after

seeding (DAS); post-emergence application (PoE) of 2, 4-D ethyl ester 0.75 kg/ha, 2, 4-D ethyl ester 0.75 kg/ha followed one hand weeding at 45 DAS and metsulfuron-methyl 4g/ha. Experiment was carried out in randomized block design in ten farmer's field with an area of 0.1 ha for each treatment. Wheat variety *'Sabour Nirjal'* was sown by using seed rate of 100 kg/ha during the second week of November during both the years. Crop was fertilized with recommended doses of fertilizers *viz.* 120, 60, 40 kg N, P_2O_5 and K_2O/ha. Full dose of P and K and half dose of N were applied at basal application and remaining N was applied in 2 equal splits at first and second irrigation. A composite soil sample was collected and analyzed. Soil of the sites was light sandy loam in texture, with pH 7.2 and low in available N (235.4 kg/ha), medium in P (18.6 kg/ha) and K (187.2 kg/ha). Herbicides were applied with manually operated knapsack sprayer delivering a spray volume of 500 l/ha through flat-fan nozzle at 30 DAS. For weed density recorded at 80 DAS, by randomly placing a metallic quadrat of size 0.5×0.5 m at two places before and after expressed as counts/density. Original values of the weed density were square root transformed (√+0.5). Crop was harvested manually in last week of March during both the years. Average annual rainfall was 1062 mm but the crop received only 38 mm during entire growth period, as most of the annual rain occurred during monsoon season. Economics were calculated using prevailing market price of inputs. All the data on weed density and biomass were analyzed with 'Statistix 8.1' for analysis of variance (ANOVA).

3. RESULTS AND DISCUSSION

3.1 Effect on Weed

Major weed flora was observed in experimental plots include grassy weeds *viz. Phalaris minor* and *Cynodon dactylon;* broad-leaved weeds, *viz*. *Anagalis arvensis, Convolvulus arvensis* and *Chenopodium album* and the sedge *Cyprus rotundas*. Higher relative abundance were *Cynodon dactylon* followed by *Phalaris minor* and the lowest relative abundance was of *Convolvulus arvensis* followed by *Anagalis arvensis* (Table 1). Application of 2, 4-D ethyl easter 0.75 kg/ha (30 DAS) followed by hand weeding at 45 DAS were recorded lowest weed species density followed by metsulfuron methyl 4 g/ha at 30 DAS. The metsulfuron-methyl 4g /ha at 30 DAS significantly reduced density of broad leaf weed species as compared to farmer's practice but no significant effect on grassy weed and sedges (Table 2). This attributed to the inhibition of germination of weeds due to paralysis of vital metabolic process of germination, *viz.* cell-division, protein synthesis and secretion of hydrolytic enzymes and subsequently drying of susceptible weeds species [10]. Metsulfuron methyl efficacy in the control of BLWs in wheat was reported by Singh [11]. Less grassy weeds was controlled in comparison to BLWs and sedges due to nature of the weeds, high crop weed competition and herbicides modes of action [12].

3.2 Effect on Crop

Maximum wheat plant height (98.4 cm), effective tillers/meter row length (82.1), spike length (13.1cm), grains/spike (32), 1000-grain weight (39.1 g) were recorded with metsulfuron-methyl 4g/ha at 30 DAS (Table 3) and was found statistically significant more effective than 2,4-D ethyl ester 0.75 kg *a.i*./ha at 30 DAS and farmer's practice, while being at par with 2, 4-D ethyl ester 0.75 kg/ha at 30 DAS followed by one hand weeding at 45 DAS. Metsulfuron methyl @ 4g/ha PoE recorded significantly higher mean grain (6.1, 20.4 and 34.4%) and straw yield (5.41, 18.3 and 31.21%), respectively (Table 3). This might be due to effective control of weeds, so it resulted in minimum weed-crop competition [13]. Dry matter accumulation is largely a function of photosynthetic surface, which has also more under these treatments resulting in increased biological productivity and finally dry matter accumulation [14,15]. Reduction in BLWs was accredited to reason with activity of metsulfuron methyl selectively to certain grassy and broad-leaf weeds are generally effective [16,17]. Lower yield in farmers practice's may be due to poor root growth and higher weed population could have competed with wheat crop for space, water, and nutrients, thereby adversely affecting grain and straw yields of wheat.

Metsulfuron methyl 4g/ha at 30 DAS also recorded significantly higher gross returns, net returns, benefit: cost ratio, maximum economic and production efficiency than 2, 4- D ethyl ester 0.75 kg/ha at 30 DAS followed by HW at 45 DAS, 2, 4- D ethyl ester 0.75 kg/ha at 30 DAS and farmer's practice (Table 4). Initial control of BLWs by 2, 4- D PoE *fb* HW provided favourable environment to crop for growth and development, due to least crop weed competition under irrigated conditions. Tomar *et al* [18] found that maximum gross return was observed in weed

Table 1. Relative abundance (%) of different weed species of wheat under irrigated agro-ecosystem (mean data of 2 years)

Treatments	Relative abundance (%)					
	Phalaris minor	***Cynodon dactylon***	***Cyprus rotundus***	***Chenopodium album***	***Anagalis arvessis***	***Convolvulus arvensis***
Farmers' practice (One HW at 40 DAS)	35.65	38.44	14.76	5.57	3.62	1.95
2, 4-D ethyl ester @ 0.75 kg *a.i.*/ha (30DAS)	37.85	40.00	14.46	3.08	3.38	1.23
2, 4-D ethyl ester @ 0.75 kg *a.i.*/ha (30 DAS) + HW at 45 DAS	39.48	42.44	14.02	1.85	1.48	0.74
Metsulfuron ethyl @ 4g WG/ha (30 DAS)	38.51	41.22	14.19	2.70	2.36	1.01

Table 2. Effect of weed management on species wise and total weed density in wheat under irrigated agro-ecosystem (mean data of 2 years)

Treatments	Weed density (no./m^2)							Reduction in total weed density over farmers' practice (%)
	Phalaris minor	***Cynodondactylon***	***Cyprus rotundus***	***Chenopodium album***	***Anagalis arvessis***	***Convolvulus arvensis***	**Total**	
Farmers' practice (One HW at 40 DAS)	11.34* (128)	11.77 (138)	7.31 (53)	4.53 (20)	3.67 (13)	2.74 (7)	18.96 (359)	-
2, 4-D ethyl ester 0.75 kg/ha (30 DAS)	11.11 (123)	11.42 (130)	6.89 (47)	3.24 (10)	3.39 (11)	2.12 (4)	18.04 (325)	9.47
2, 4-D ethyl ester 0.75 kg/ha (30 DAS) followed by HW at 45 DAS	10.37 (107)	10.75 (115)	6.20 (38)	2.35 (5)	2.12 (4)	1.58 (2)	16.48 (271)	24.51
Metsulfuron-ethyl 4g /ha (30 DAS)	10.70 (114)	11.07 (122)	6.52 (42)	2.92 (8)	2.74 (7)	1.87 (3)	17.22 (296)	17.55
LSD (*P* =0.05)	0.90	0.94	0. 57	0.32	0.28	0.20	1.49	-

**Data subjected to square root transformation (√X+0.5), Values in parentheses are original; HW = hand weeding; DAS = days after seeding*

Table 3. Effect of weed management on wheat growth, yield attributes and yield in irrigated agro-ecosystem (mean data of 2 years)

Treatments	Plant height (cm)	Effective tillers/hill (nos.)	Spike length (cm)	Grains/ spike (nos.)	1000–grain weight (g)	Grain yield (kg/ha)			Straw yield (kg/ha)		
						2019-20	2020-21	Mean	2019-20	2020-21	Mean
Farmers' practice (One HW at 40 DAS)	87.3	70.2	10.3	24	31.6	2675	2891	2783	4109	4439	4274
2, 4-D ethyl ester 0.75 kg/ha (30DAS)	92.1	75.5	11.5	27	34.3	2995	3219	3107	4568	4910	4739
2, 4-D ethyl ester 0.75 kg/ha (30 DAS) + HW at 45 DAS	97.2	78.0	12.5	30	37.2	3423	3629	3526	5165	5475	5320
Metsulfuron ethyl 4g/ha (30 DAS)	98.4	82.1	13.1	32	39.1	3665	3817	3741	5495	5721	5608
LSD (*P* =0.05)	5.89	4.76	0.91	2.16	2.17	242.3	259.1	250.6	368.9	394.5	381.7

Table 4. Effect of weed management on production economics of wheat under irrigated agro-ecosystem (mean data of 2 years)

Treatments	Cost of cultivation (x10^3 INR/ha)	Gross returns (x10^3 INR/ha)	Net returns (x10^3 INR/ha)	B: C	Efficiencies	
					Economic (INR/ha/day)	Production (kg/ha/day)
Farmers' practice (One HW at 40 DAS)	49.8	74.6	24.8	1.50	190.5	21.4
2, 4-D ethyl ester @ 0.75 kg/ha (30DAS)	47.5	82.0	34.5	1.73	265.2	23.9
2, 4-D ethyl ester @ 0.75 kg/ha (30 DAS)+ HW at 45 DAS	50.5	91.3	40.8	1.81	313.5	27.1
Metsulfuron-ethyl 4g/ha (30 DAS)	47.5	97.6	50.1	2.05	385.9	28.8
LSD (*P*=0.05)	4.0	5.2	2.7	0.13	20. 6	1.5

free treatment due to effective weed control. While the highest net monetary returns and B: C was recorded with metsulfuron-methyl 4 g/ha due to higher yield and comparatively lower cost of cultivation as compared to weed free treatment. Similar results were reported by Singh *et al.* [19,20], Kumar *et al.* [21] and Sahu *et al*. [22]. The lowest gross & net returns, benefit: cost ratio, economic and production efficiency was recorded in farmer's practice. This was mainly owing to significantly lower yield and poor weed management in the farmer's practice [19,23,24].

4. CONCLUSION

It may be concluded that metsulfuron-methyl 4g /ha at 30 DAS was effective in reducing weed density and improving wheat productivity and profitability under irrigated agro-ecosystem of Jharkhand. Hence, these practices may be widely popularized for improving socio-economic condition of poor farming community of the Jharkhand.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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