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RESEARCH NOTE

Evaluation of a few herbicides efficacy alone and in combination for controlling weeds in fodder oats grown for seed production

Bora Santhosh*, Gangadhar Nanda, Mukesh Kumar, Abdus Sattar and Santosh Kumar Singh

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ABSTRACT

A field study was conducted during *Rabi*, 2023-24 at Forage Research Block of APRI, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar to evaluate the efficacy of few herbicides alone and in combination for weeds management in fodder oats seed production. Eleven treatments were tested on silty loam soils using RBD, replicated thrice. The tested treatments were: pre-emergence application (PE) of pendimethalin at 750 g/ha; oxyfluorfen at 200 g/ha PE; post-emergence application (PoE) of metsulfuron-methyl at 4 g/ha; 2,4-D at 500 g/ha PoE; pendimethalin at 750 g/ha PE followed by (*fb*) metsulfuron-methyl at 4 g/ha PoE; oxyfluorfen at 200 g/ha PE *fb* metsulfuron-methyl at 4 g/ha PoE; pendimethalin at 750 g/ha PE *fb* 2,4-D at 500 g/ha PoE; oxyfluorfen at 200 g/ha PE *fb* 2,4-D PoE at 500 g/ha; manual weeding twice at 20 and 40 days after seeding (DAS), hand hoeing at 20 DAS and weedy check. The *Cynodon dactylon* density was maximum with 38% relative density amongst the infested weed flora. The manual weeding twice at 20 and 40 DAS recorded the lowest weeds density and biomass and the highest fodder oats seed yield. Among the herbicides, pendimethalin at 750 g/ha PE *fb* metsulfuron-methyl at 4 g/ha PoE reduced the weed density and biomass and recorded the highest weed control efficiency, lowest weed index, highest nutrient uptake and crude protein yield and oats seed yield. The treatment oxyfluorfen at 200 g/ha PE *fb* metsulfuron-methyl at 4 g/ha PoE recorded the highest fodder oats straw yield.

Keywords: Fodder oats, Metsulfuron-methyl, Oxyfluorfen, Pendimethalin, Weed management

Fodder oats (*Avena sativa* L.), is one of the promising *Rabi* fodder crop offering high-quality forage used as livestock feed. Weeds deplete valuable soil nutrients and weed competition significantly limits fodder oats yield and quality. Weed infestations can reduce green forage yield by up to 31.4% (Singh *et al*. 2020). Effective weed management is therefore crucial to reducing competition and enhancing productivity. Effective weed management reduces yield losses, ensuring a reliable and abundant forage harvest. Uncontrolled weed growth, by contrast, can result in greater yield losses and lower-quality forage, which can be more costly over time. Although manual weeding and hoeing can effectively manage weeds in fodder oats production, these methods are often labour-intensive and costly. Due to labour shortages, particularly during critical growth periods, manual weeding and hoeing are often impractical, making chemical control an effective alternative. Thus, herbicides usage remains one of the most common and effective methods of weed management.

Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar 848125, India

* Corresponding author email: santhoshbora49@gmail.com

Herbicide use is generally more cost-effective than mechanical or manual methods, with the most economical approach combining herbicides with manual weeding. The efficacy of herbicides, however, varies with factors such as weed species, growth stage and timing of application *etc*. In some cases, herbicides combinations broaden the spectrum of control, targeting multiple weed species. Furthermore, meeting specific purity and quality standards is necessary for certification and market access and weed management plays a critical role in meeting these standards. In seed production, the presence of weed seeds in the final product can lead to rejection or reduced marketability, making weed management essential to maintaining quality standards.

Oats are highly susceptible to diverse weed species, including broad-leaved weeds such as *Cichorium intybus*, *Chenopodium murale*, *Euphorbia hirta*, *Althaea ludwigii* and *Tribulus terrestris*, as well as narrow-leaved weeds like *Cyperus rotundus* and *Cynodon dactylon* (Singh *et al*. 2001). Weed control in forage crops is often overlooked since many farmers consider weeds as supplemental animal feed. Herbicides are central to modern weed management, enabling efficient control over large areas with lower labour requirements. Studies indicate that using a combination of different herbicides can yield higher productivity than single-herbicide applications (Kadam *et al.* 2021). This study was conducted with an objective to identify best weed management options for keeping oats fields weed-free, optimizing both fodder yield and seed quality and maximizing productivity in fodder oats seed production.

The field experiment on weed management in fodder oats seed production was conducted at Forage Research Block of APRI, Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar with silty clay loam soil. The eleven treatments comprised of: pre-emergence application (PE) of pendimethalin at 750 g/ha, oxyfluorfen at 200 g/ha PE, post-emergence application (PoE) of metsulfuron-methyl at 4 g/ha, 2,4-D at 500 g/ha PoE, pendimethalin at 750 g/ha PE followed by (*fb*) metsulfuron-methyl at 4 g/ha PoE, oxyfluorfen at 200 g/ha PE *fb* metsulfuron-methyl at 4 g/ha PoE, pendimethalin at 750 g/ha PE *fb* 2,4-D at 500 g/ha PoE, oxyfluorfen at 200 g/ha PE *fb* 2,4-D (PoE) at 500 g/ha, manual weeding twice at 20 and 40 days after seeding (DAS), hand hoeing at 20 DAS and weedy check. A randomized block design replicated thrice was used. Oats cv. JHO-822 was sown on 7th December 2023 at a spacing of 25 cm row to row by using seed rate 100 kg/ha and was harvested on 6th April 2024. The crop was fertilized with recommended rate 120-60-40 kg NPK per hectare. Nitrogen was applied in two splits 60 kg N/ha as basal application and 60 kg N/ha at active tillering stage in the form of urea. Other agronomical and plant protection measures followed as per recommendation during the crop growth. Pre-emergence herbicides were sprayed 3 days after sowing on moist soil and post-emergence herbicides were sprayed at 20 DAS. Herbicides were sprayed according to the treatment by using knapsack sprayer in 500 litres of water/ha. Quadrat (0.5 m^2) was randomly placed at two places in each plot to count density and dry weight of weeds (weed biomass) at 30, 45 and 60 DAS and at harvest. Seed and straw yield (kg/ha) were also recorded at harvest. Data recorded during the experimental period was statistically analysed as per the standard procedure and weed data transformed by square root transformation $\sqrt{x+0.5}$ and transformed data were subjected to ANOVA analysis (Gomez and Gomez 1984).

Weed infestation in the experimental field

Eleven weed species, consisting of two grass, one sedge and eight broad-leaved weeds were observed in the research field during the crop growth period. *Cynodon dactylon*, *Cyperus rotundus*, *Cannabis sativa*, *Cirsium arvense*, *Anagallis arvensis*, *Polypogon monspeliensis*, *Oxalis corniculata*, *Chenopodium album*, *Parthenium hysterophorus, Scoparia dulcis* and *Physalis minima* were the dominant weeds (**Figure 1**).

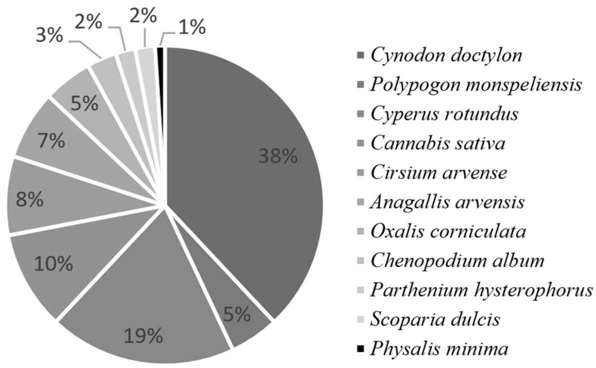

Figure 1. Relative dominance of weeds in experimental field

Weed density and biomass

Among the treatments evaluated, manual weed removal at 20 and 40 days after sowing (DAS) proved most effective in reducing weed density and biomass (**Table 1**). However, manual weeding results were statistically similar to those obtained with pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE due to suppression of grasses during initial weed growth stages by pendimethalin and then control of broad-leaved weeds (BLWs) by metsulfuron-methyl 4 g/ha PoE. The weedy check recorded the highest weed density and biomass due to the absence of weed control measures. Among the herbicides tested, metsulfuron methyl at 4 g/ha PoE effectively suppressed broad-leaved weeds, particularly *Cirsium arvense*, which remained unaffected by other herbicides. The combination of pendimethalin at 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE significantly reduced overall weed density (83.8%) and weed biomass (89.1%) compared to the weedy check at 60 DAS. Metsulfuron-methyl achieved 100% control of *Cirsium arvense*, while pendimethalin at 750 g/ha was most effective against *Chenopodium album* and showed effectiveness against *Anagallis arvensis* (Chopra *et al.* 2001). Furthermore, metsulfuron-methyl's residual effect was shown to last for over two months (Bhattacharya *et al.* 2006). Metsulfuron-methyl alone or in combination with 2,4-D Na was observed to offer excellent control of broad-leaved weeds in wheat (Pandey *et al.* 2012). Compared to 2,4-D, metsulfuron-methyl provided superior control of broad-leaved species (Singh and Ali 2004). The

Table 1. Efficacy of weed management treatments on weed density (no./m^2), weed biomass (g/m^2), weed control efficiency (WCE) and weed index (WI) in fodder oats crop grown for seed production

Treatment	Weed density				Weed biomass				WCE	WI
	Grasses	Sedges	BLWs	Total	Grasses	Sedges	BLWs	Total	60 DAS	At harvest
Pendimethalin 750 g/ha PE	2.96 (8.3)	2.58 (6.33)	4.73 (22.00)	6.08 (36.7)	1.19 (0.9)	1.12 (0.8)	1.71 (2.4)	2.14 (4.1)	80.28	20.50
Oxyfluorfen 200 g/ha PE	4.64 (21.0)	2.68 (6.7)	3.13 (9.3)	6.12 (37.0)	1.66 (2.3)	1.15 (0.8)	1.28 (1.1)	2.17 (4.2)	79.71	23.36
Metsulfuron-methyl 4 g/ha PoE	4.38 (18.7)	2.55 (6.0)	2.67 (6.7)	5.64 (31.3)	1.53 (1.8)	1.10 (0.7)	1.13 (0.8)	1.96 (3.3)	83.88	8.54
2,4-D 500 g/ha PoE	4.41 (19.0)	2.61 (6.3)	2.91 (8.0)	5.82 (33.3)	1.65 (2.2)	1.14 (0.8)	1.25 (1.1)	2.14 (4.1)	80.29	16.73
Pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE	2.85 (7.7)	2.61 (6.3)	2.54 (6.0)	4.52 (20.0)	1.18 (0.9)	1.08 (0.7)	1.09 (0.7)	1.66 (2.3)	89.17	2.69
Oxyfluorfen 200 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE	3.94 (15.0)	2.67 (6.7)	2.60 (6.3)	5.34 (28.3)	1.50 (1.7)	1.09 (0.7)	1.12 (0.7)	1.92 (3.2)	84.73	12.69
Pendimethalin 750 g/ha PE *fb* 2,4-D 500 g/ha PoE	2.90 (8.0)	2.61 (6.3)	2.86 (7.7)	4.74 (22.0)	1.19 (0.9)	1.10 (0.73	1.23 (1.0)	1.77 (2.7)	87.26	10.79
Oxyfluorfen 200 g/ha PE *fb* 2,4-D 500 g/ha PoE	3.85 (14.3)	2.54 (6.0)	2.80 (7.3)	5.31 (27.7)	1.41 (1.5)	1.12 (0.8)	1.18 (0.9)	1.91 (3.1)	84.90	9.21
Manual weeding twice at 20 and 40 DAS	2.72 (7.0)	2.47 (5.7)	2.48 (5.7)	4.32 (18.3)	1.07 (0.6)	1.03 (0.6)	1.06 (0.6)	1.52 (1.8)	91.27	0.00
Hand hoeing once at 20 DAS	3.12 (9.3)	2.59 (6.3)	3.67 (13.0)	5.38 (28.7)	1.38 (1.4)	1.13 (0.8)	1.57 (2.0)	2.16 (4.2)	79.90	18.37
Weedy check	6.92 (47.3)	3.98 (15.3)	7.84 (61.0)	11.14 (123.7)	2.90 (8.0)	1.75 (2.6)	3.28 (10.3)	4.62 (20.8)	0.00	31.91
LSD (p=0.05)	0.32	0.39	0.34	0.41	0.13	0.13	0.12	0.17	-	-

DAS = days after seeding; PE = pre-emergence application; PoE = post-emergence application; *fb* = followed by; BLWs: broad-leaved weeds

highest weed control efficiency (WCE) was recorded with manual weeding twice 20 and 40 DAS. Among herbicidal treatments, pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE recorded the highest WCE, due to reductions in both weed density and biomass. The WCE of pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE was 89.2% at 60 DAS and recorded weed index with it was 2.69 at harvest. These findings are in close agreement with the findings of Pisal and Sagarka (2013), Bhattacharya *et al.* (2006), Sharma and Chander (2006), Singh *et al.* (2019), Barikzai and Thalkar (2021) and Shubhashree *et al.* (2023).

Fodder oats yield, nutrient uptake and crude protein

The highest fodder oats seed yield was achieved with manual weeding twice at 20 and 40 DAS, which was statistically comparable to pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE (**Table 2**). These methods provided a 46.9% and 43.1% increase in seed yield, respectively, compared to the weedy plot. The highest straw yield was achieved with oxyfluorfen 200 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE, however, it was comparable to manual weeding twice at 20 and 40 DAS and pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE. Similar findings were reported by Pisal and Sagarka (2013) and Bhattacharya *et al.* (2006).

The weedy check treatment had the lowest uptake of nitrogen, phosphorus and potassium, whereas the manual weeding twice at 20 and 40 DAS resulted in the highest uptake of these nutrients. Among the herbicidal treatments pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE recorded the highest N, P and K uptake. Pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE improved total N, P and K uptake by 60.6%, 93.9% and 44.7%, respectively, compared to the weedy check. These findings are supported by studies conducted by Singh and Saha (2001) and Pisal and Sagarka (2013).

The lowest crude protein yield in both seed and straw were found in weedy check. In contrast, the highest crude protein content and yield were recorded in the treatment with manual weeding twice at 20 and 40 DAS, which was comparable to the pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE. The application of pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE significantly boosted crude protein yield, increasing it by 70% in seed and 54.3% in straw compared to the weedy check. Similar findings were reported by Singh *et al.* (2020).

Table 2. Fodder oats yield, crude protein yield and nutrient uptake as influenced by weed management strategies in fodder oats grown for seed production

Treatment	Seed yield (t/ha)	Straw yield (t/ha)	Nitrogen			Phosphorous			Potassium			Crude protein yield (kg/ha)	
			Seed	Straw	Total	Seed	Straw	Total	Seed	Straw	Total	Seed	Straw
Pendimethalin 750 g/ha PE	3.04	7.85	39.48	65.93	105.41	5.37	6.51	11.88	10.48	120.03	130.51	247	412
Oxyfluorfen 200 g/ha PE	2.93	7.82	37.76	64.91	102.67	5.10	6.21	11.31	9.75	117.51	127.25	236	406
Metsulfuron-methyl 4 g/ha PoE	3.49	8.08	47.95	75.20	123.15	7.05	7.14	14.19	13.08	124.84	137.92	300	470
2,4-D 500 g/ha PoE	3.18	8.23	43.26	70.59	113.85	5.66	7.04	12.70	11.74	125.70	137.45	270	441
Pendimethalin 750 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE	3.72	8.57	55.18	86.29	141.47	7.99	8.13	16.12	14.48	141.45	155.93	345	539
Oxyfluorfen 200 g/ha PE *fb* metsulfuron-methyl 4 g/ha PoE	3.34	8.95	46.21	82.64	128.86	6.63	8.00	14.63	11.71	146.01	157.72	289	517
Pendimethalin 750 g/ha PE *fb* 2,4-D 500 g/ha PoE	3.41	8.12	46.28	74.60	120.88	6.94	7.29	14.23	12.76	133.08	145.84	289	466
Oxyfluorfen 200 g/ha PE *fb* 2,4-D 500 g/ha PoE	3.46	8.33	50.58	75.07	125.65	7.08	6.90	13.98	12.37	127.28	139.65	316	469
Manual weeding twice at 20 and 40 DAS	3.82	8.76	59.39	94.42	153.82	8.81	9.71	18.52	15.27	161.27	176.54	371	590
Hand hoeing once at 20 DAS	3.12	7.38	42.02	69.18	111.20	6.17	6.30	12.47	11.43	118.34	129.77	262	432
Weedy check	2.60	7.25	32.42	55.70	88.11	3.97	4.34	8.31	8.04	99.69	107.73	203	348
LSD (p=0.05)	0.29	0.98	5.43	9.08	12.88	0.58	0.97	1.39	1.52	14.42	15.06	31	55

* PE = pre-emergence application; PoE = post-emergence application; *fb* = followed by

Conclusion

It may be concluded that pendimethalin at 750 g/ha PE *fb* metsulfuron-methyl at 4 g/ha PoE may be used for weed management in fodder oats grown for seed production as it recorded the lowest weed density and biomass at all the growth stages with highest weed control efficiency and lowest weed index; highest fodder oats nutrient uptake and crude protein yield and seed yield.

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