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Optimizing weed control methods to enhance seed yield and economic returns in fodder oats production

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Abstract
An experiment was laid out to study the effect of weed management practices on weed dynamics, growth, quality, fodder and seed yield of fodder oat (*Avena sativa* L.) during *rabi* season of 2022-23 and 2023-24 at the experimental field of instructional cum research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The experiment was carried out in randomized complete block design with ten treatments and three replications. The average data of two years revealed that the yield of seed was statistically paramount under treatment hand-weeding two times at 20 and 40 DAS (25.9 q ha^{-1}) and-was comparable with application of oxyfluorfen 23.5% EC 200 g ha^{-1} as pre- emergence followed by application of metsulfuron methyl 20% WP 4 g ha^{-1} as post- emergence (25.9 q ha^{-1}) in sequence, treatment application of pendimethalin 38.7% EC 750 g ha^{-1} as pre- emergence then supplication of metsulfuron methyl 20% WP 4 g ha^{-1} as post- emergence (24.0 q ha^{-1}) and hand-hoeing at 25 DAS & intra row-weeding at-35 DAS (18.7 q ha^{-1}). Higher gross rate of return (Rs.120129 ha^{-1}) was found under hand weeding twice at 20 and 40 DAS. Significantly highest net income (Rs. 92011 ha^{-1}) and B: C ratio (3.2) was recorded under sequential application of oxyfluorfen 23.5% EC 200 g ha^{-1} as pre- emergence *fb* applying metsulfuron methyl 20% WP 4 g ha^{-1} as post emergence.

Keywords: Weed management, economics, seed yield, fodder oat, herbicide, metsulfuron methyl

Introduction
Oat (*Avena sativa* L.) belongs to Poaceae family is one of the important cereals as well as fodder crop of India, commonly known as *Jaie* (Hindi). Although fodder is a smothering crop it gets affected by the presence of weed at crop space and the rise in crop weed competition hinders its growth and quality as well as the potential of seed yield while increasing the cost of cultivation involved. Hence it becomes an important aspect of investigation. And till date very less work has been done on various weed management practices for suitable and compatible herbicidal formulations for reducing the economic losses due to weeds. Some of the important weeds of oat are *Parthenium hysterophorus*, *Rumex dentatus*, *Cynodon dactylon*, *Chenopodium album*, *Cyperus iria*, *Echinochloa colona*, *Medicago denticulata* and *Melilotus alba*. Also, presently, the country faces a net deficit of 35.6% green fodder, 10.95% dry crop residues and 44% concentrate feed ingredients (IGFRI Vision, 2050). Therefore, it becomes an important cereals fodder crop of *rabi* after berseem and lucerne which can be cultivated under wide range of climatic conditions in north, central and western zones of the country and provides succulent, delicious while nutritious fodder to animals during winter season (Kumar *et al*. 2022a) [6] and seed yield for its multiplication and seed availability in the state itself to meet the demand of growing livestock population in the country.

Materials and Methods
An experiment was laid out to study effect-of weed-management-practices on weed dynamics, growth, quality-and seed-yield of fodder oat (*Avena sativa* L.) during *rabi* season of 2022-23 and 2023-24 at the experimental field of instructional cum research farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh. The soil of experimental field was sandy loam in texture, neutral in reaction (pH 7.9), low in organic carbon (0.64) and available nitrogen (167.25

kg ha^{-1}), and medium in available phosphorus (15.76 kg-ha^{-1}) and more in available potassium (323.83 kg ha^{-1}) with normal electrical conductivity (0.15 dSm^{-1}). All the meteorological parameter were suitable for plants growth and development during the two consecutive years. The crop received total rainfall of 2.54 mm and 16.18 mm during the period of experimentation in *rabi* season of year 2022-23 and 2023-24 respectively. The mean maximum temperature recorded was 28.89℃ to 36.70℃ and 24.84 to 36.86℃. Whereas, mean minimum temperature ranged between 9.24℃ to 19.86℃ and 10.39 to 20.29℃ respectively during first and second year of crop growth period. Crop received sunshine duration of 0.61 to 8.71 hr in year 2022-23 and 1.19 to 7.97 hr in year 2023-24. The experiment was carried out in randomized block design with three replications and ten treatments *viz.*, T_1: Pendimethalin 38.7% EC 750 g ha^{-1}(PE) T_2: Oxyfluorfen 23.5% EC 200 g ha^{-1} (PE), T_3: Metsulfuron methyl 20% WP 4 g ha^{-1}at 25 DAS (PoE), T_4: 2,4- D EE 58% SL 500 g ha^{-1}at 25 DAS (PoE), T_5: Pendimethalin 38.7% EC 750 g ha^{-1}(PE)+ metsulfuron methyl 20% WP 4 g ha^{-1}at 25 DAS (PoE), T_6: Oxyfluorfen 23.5% EC 200 g ha^{-1}(PE)+ metsulfuron methyl 20% WP 4 g ha^{-1}at 25 DAS (PoE), T_7: Oxyfluorfen 23.5% EC 200 g ha^{-1}(PE) + 2,4-D EE 58% SL 500 g ha^{-1}at 25 DAS (PoE), T_8: Two-hand-weeding at 20 and 40 DAS, T_9: Hand hoeing at 25 DAS + intra-row hand-weeding at 35 days after sowing, T_{10}: Weedy Check. All the recommended package and practices were followed except for the weed management methods. The crop was sown in the third week of November in both the years and harvested in March 2nd to 3rd week. The harvested crop is threshed and winnowed to collect the seeds influenced by each treatments applied and economics was calculated and analysed. Statistical analysis was done using standard procedures of analysis of variance in RBD and statistical mean differences were found by Fisher's protected least significant difference test at p<0.05. (Gomez and Gomez, 1984) [4].

Results and Discussion

Significantly maximum seed yield was recorded with treatment hand weeding twice at 20 and 40 DAS (25.5, 26.2 and 25.9 q ha^{-1} respectively) which was on par with supplication of oxyfluorfen 23.5% EC 200 g ha^{-1} as pre- emergence persuaded byapplication of metsulfuron methyl 20% WP 4 g ha^{-1} as post-emergence (25.0, 26.8 and 25.9 q ha^{-1} respectively), treatment application of pendimethalin 38.7% EC 750 g ha^{-1} as pre-emergence followed byapplication of metsulfuron methyl 20% WP 4 g ha^{-1} as post- emergence (23.7, 24.3 and 24.0 q ha^{-1} respectively) and hand hoeing at 25 DAS & intra row weeding at 35 DAS (19.3, 18.1 and 18.7 q ha^{-1} respectively) during both the years and on mean basis. The result might be due to the practical fact that, better WCE and less weed density along with betterment in yield attributes like number of panicles per square meter, panicle length, weight, filled grains, lesser number of chaffy grains and lastly the weight of 100 seed weight resulted in significantly higher seed yield. This corroborated with the findings of Tiwari *et al*. (2015) [11]; Raj *et al*. (2022) [8]. Whereas, remarkably higher straw yield was recorded under application of oxyfluorfen 23.5% EC 200 g ha^{-1} as pre- emergence *fb* application of metsulfuron methyl 20% WP 4 g ha^{-1}as post-emergence (101.8, 104.8 and 103.3 q ha^{-1} respectively during 2022-23, 2023-24 and in mean) being at par with hand weeding twice at 20 and 40 DAS (101.7, 102.6 and 102.1 q ha^{-1}respectively during 2022-23, 2023-24 and in mean), application of pendimethalin 38.7% EC 750 g ha^{-1} as pre- emergence *fb* application of metsulfuron methyl 20% WP 4 g ha^{-1} as post-emergence (100.0, 100.9 and 100.4 q ha^{-1}respectively during 2022-23, 2023-24 and in mean) and hand hoeing at 25 DAS & intra row weeding at 35 DAS (99.7, 98.3 and 99.0 q ha^{-1} respectively during 2022-23, 2023-24 and in mean). Other treatments were non- significant among themselves and least straw yield was recorded under weedy check. Harvest index is the ratio of grain to total shoot dry matter and is a measure of reproductive efficiency. The data on HI clarifies that, the highest was computed under treatment hand weeding twice at 20 and 40 DAS (20.2, 20.3 and 20.3% respectively) which was comparable to treatment applied with oxyfluorfen 23.5% EC 200 g ha^{-1} as pre- emergence *fb* application of metsulfuron methyl 20% WP 4 g ha^{-1} as post- emergence, application of pendimethalin 38.7% EC 750 g ha^{-1} as pre- emergence *fb* application of metsulfuron methyl 20% WP 4 g ha^{-1}as post- emergence and hand hoeing at 25 DAS & intra row weeding at 35 DAS. This was resulted due to better partitioning of photosynthates towards reproductive part of the plant.

Notably, highest gross monetary return was computed under treatment hand weeding twice at 20 and 40 DAS (Rs. 118605, 121653 and 120129 ha^{-1} respectively during 2022-23, 2023-24 and their mean) which was at par with treatment applied with oxyfluorfen 23.5% EC 200 g ha^{-1} as pre- emergence *fb* application of metsulfuron methyl 20% WP 4 g ha^{-1} as post-emergence at 25 DAS (Rs. 116433, 124402 and 120418 ha^{-1} respectively during 2022-23, 2023-24 and their mean) and application of pendimethalin 38.7% EC 750 g ha^{-1} as pre-emergence *fb* application of metsulfuron methyl 20% WP 4 g ha^{-1} as post- emergence (Rs. 110583, 113506 and 112045 ha^{-1} respectively during 2022-23, 2023-24 and their mean). The lowest gross monetary returns was recorded in weedy check (control) treatment because there was minimum amount of green forage yield and dry matter yield during both the years and their average. Similar results were also verified by Thakur and Barikzai (2019) [3]; Singh *et al*. (2020) [9]; Kumar and Sarkar (2020) [5] and Singh *et al*. (2019) [10]. According to net monetary returns, application of pre- emergence herbicide oxyfluorfen 23.5% EC 200 g ha^{-1} *fb* metsulfuron methyl 20% WP 4 g ha^{-1} as post- emergence bagged significantly highest net monetary return (Rs. 89026, 95695 and 92361 ha^{-1}) which was found at par with treatment hand weeding twice at 20 and 40 DAS (Rs. 85717, 86689 and 86203 ha^{-1}) and application of pendimethalin 38.7% EC 750 g ha^{-1} as pre- emergence *fb* application of metsulfuron methyl 20% WP 4 g ha^{-1}as post- emergence (Rs. 83750, 85372 and 84561 ha^{-1}) during both the years and on mean over the years. The data suggests that significantly maximum benefit cost ratio was recorded under application of oxyfluorfen 23.5% EC 200 g ha^{-1} *fb* metsulfuron methyl 20% WP 4 g ha^{-1}as post- emergence (3.2,3.3 and 3.3) and was on par with application of pendimethalin 38.7% EC 750 g ha^{-1} as pre-emergence *fb* application of metsulfuron methyl 20% WP 4 g ha^{-1} as post- emergence (3.1, 3.0 and 3.1 respectively) during 2022-23, 2023-24 and on mean basis. However, the least was under weedy check. Similar reports were stated by Meena *et al*. (2017b) [7].

Table 1: Seed, straw yield, harvest index and weed index as influenced by weed management practices on fodder oat during *rabi* 2022-23, 2023-24 and their mean

	Treatment	Seed yield (q ha^{-1})			Straw yield (q ha^{-1})			Harvest index (%)		
		2022	2023	Mean	2022	2023	Mean	2022	2023	Mean
T_1	Pendimethalin 38.7% EC 750g ha^{-1} (PE)	16.5	17.5	17.0	83.9	87.4	85.6	16.3	16.7	16.5
T_2	Oxyfluorfen 23.5% EC 200g ha^{-1} (PE)	17.6	18.6	18.1	84.8	86.8	85.8	17.2	17.6	17.4
T_3	Metsulfuron methyl 20% WP 4g ha^{-1} at 25 DAS (PoE)	20.1	21.0	20.5	88.3	88.9	88.6	18.5	19.1	18.8
T_4	2, 4- D EE 58% SL 500g ha^{-1} at 25 DAS (PoE)	15.5	16.6	16.0	80.7	81.7	81.2	16.1	16.8	16.5
T_5	Pendimethalin 38.7% EC 750g ha^{-1} (PE)+ Metsulfuron methyl 20% WP 4g ha^{-1} at 25 DAS (PoE)	23.7	24.3	24.0	100.0	100.9	100.4	19.1	19.4	19.3
T_6	Oxyfluorfen 23.5% EC 200g ha^{-1} (PE)+ Metsulfuron methyl 20% WP 4g ha^{-1} at 25 DAS PoE)	25.0	26.8	25.9	101.8	104.8	103.3	19.9	20.3	20.1
T_7	Oxyfluorfen 23.5% EC 200g ha^{-1} (PE)+ 2, 4- D EE 58% SL 500g ha^{-1} at 25 DAS (PoE)	19.0	18.5	18.8	87.6	89.5	88.6	17.9	17.1	17.5
T_8	Hand weeding twice at 20 and 40 DAS	25.5	26.2	25.9	101.7	102.6	102.1	20.2	20.3	20.3
T_9	Hand hoeing at 25 DAS & intra row weeding at 35 DAS	19.3	18.1	18.7	99.7	98.3	99.0	16.1	15.6	15.9
T_{10}	Weedy check	10.1	10.2	10.1	76.8	75.6	76.2	11.6	12.0	11.8
	SEm ±	1.59	1.29	1.00	4.20	3.47	3.03	1.34	0.85	0.74
	CD (P =0.05)	4.74	3.83	2.98	12.48	10.30	9.01	3.98	2.53	2.19

Table 2: Gross monetary return, net monetary return and B: C ratio of the experiment- II as affected by spray of nano urea and urea during *rabi* 2022-23 and 2023-24

	Treatments	GMR (Rs ha^{-1})			NMR (Rs ha^{-1})			B: C (Re. Re.$^{-1}$ invested)		
		2022-23	2023-24	Mean	2022-23	2023-24	Mean	2022-23	2023-24	Mean
T_1	Pendimethalin 38.7% EC 750g ha^{-1} (PE)	78370	83143	80757	52370	55768	54069	2.0	2.0	2.0
T_2	Oxyfliuorfen 23.5% EC 200g ha^{-1} (PE)	83105	87521	85313	56531	59572	58052	2.1	2.1	2.1
T_3	Metsulfuron methyl 20% WP 4g ha^{-1} at 25 DAS (PoE)	94046	97965	96006	69324	71868	70596	2.8	2.8	2.8
T_4	2, 4- D EE 58% SL 500g ha^{-1} at 25 DAS (PoE)	73878	78567	76222	48786	52099	50442	1.9	2.0	2.0
T_5	Pendimethalin 38.7% EC 750g ha^{-1} (PE)+ Metsulfuron methyl 20% WP 4g ha^{-1} at 25 DAS (PoE)	110583	113506	112045	83750	85247	84499	3.1	3.0	3.1
T_6	Oxyfluorfen 23.5% EC 200g ha^{-1} (PE)+ Metsulfuron methyl 20% WP 4g ha^{-1} at 25 DAS (PoE)	116433	124402	120418	89026	95570	92298	3.2	3.3	3.3
T_7	Oxyfluorfen 23.5% EC 200g ha^{-1} (PE)+ 2, 4- D EE 58% SL 500g ha^{-1} at 25 DAS (PoE)	89652	87573	88613	61875	58371	60123	2.2	2.0	2.1
T_8	Hand weeding twice at 20 and 40 DAS	118605	121653	120129	85717	86689	86203	2.6	2.5	2.5
T_9	Hand hoeing at 25 DAS+ Intra row hand weeding at 35 DAS	91915	86645	89280	62026	54931	58479	2.1	1.7	1.9
T_{10}	Weedy check	50388	50974	50681	26499	25760	26129	1.1	1.0	1.1
	SEm ±	6815	5620	4370	6815	5620	4370	0.25	0.18	0.15
	CD(P=0.05)	20247	16697	12985	20247	16697	12985	0.74	0.54	0.45

Conclusion

It was concluded that the treatment hand weeding twice at 20 and 40 DAS was found to be best in controlling weeds and producing significantly higher seed yield while stood at face value with application of oxyfluorfen 23.5% EC 200 g ha^{-1} as pre- emergence followed byapplying metsulfuron methyl 20% WP 4 g ha^{-1} as post emergence and treatment pendimethalin 38.7% EC 750 g ha^{-1} as pre- emergence *fb*application of metsulfuron methyl 20% WP 4 g ha^{-1} as post- emergence and hand hoeing at 25 DAS & intra row weeding at 35 DAS.

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