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Productivity and Profitability of Indian Mustard as affected by Integrated Weed Management

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ABSTRACT

Background: Weed infestation is a primary cause of reduced yields, with estimated losses ranging from 10-70% due to crop-weed competition in Indian mustard. Therefore, it is essential to implement effective weed control measures to optimize the crop's yield potential. A combination of herbicides with manual, culturaland mechanical approaches is desirable to achieve optimal weed control. Therefore, a field experiment was carried out to evaluate the effect of integrated weed management on the productivity and profitability of Indian mustard.

Methods: The experiment was conducted at the Agronomy Main Research Farm, College of Agriculture, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar during *rabi* season of 2021-22 and 2022-23. It consisted of eight treatments in a randomized block design (RBD) with three replications.

Result: Pendimethalin 0.75 kg ha^{-1} *fb* straw mulch 5 t ha^{-1} controlled the mixed flora of weeds which resulted in the lowest weed density, weed dry weight, weed index and highest weed control efficiency which resulted in the highest grain yield and stover yield of mustard. Pre-emergence application of pendimethalin 0.75 kg ha^{-1} *fb* straw mulch 5 t ha^{-1} registered the highest benefit-cost ratio.

Key words: Economics, Herbicides, Mustard, Weed management.

INTRODUCTION

Indian mustard [*Brassica juncea* (L.) Czern and Coss], or Raya or Laha, is a significant oilseed crop cultivated during the winter (rabi) season. Belonging to the Brassicaceae family, it is cultivated in both subtropical and tropical regions. India is one of the 3rd leading oilseed-producing countries in the world after Canada and China. Among the different oilseeds, mustard occupies an area of 6.8 million hectares with 9.1 million tonnes of total production in India (GOI, 2020) and a total area under mustard cultivation is 0.109 million hectares with a production of 0.048 million tonnes and productivity of 440 kg ha^{-1} in Odisha (Government of Odisha, 2020). In India, mustard is primarily a *rabi*-season crop, cultivated from September-October to February-March. It thrives in cool, dry conditions and requires sufficient soil moisture during growth and clear, dry weather at maturity. In Odisha, it serves as an intercrop in the rice-wheat+mustard and linseed+mustard cropping systems, with cultivation in districts like Balasore, Dhenkanal, Kandhama, Khordha, Cuttack and Sundargarh. Mustard's low production and productivity can be attributed to a range of biotic and abiotic constraints, including weed competition, inadequate and timely use of fertilizerand poor irrigation facilities. Additionally, farmers' inadequate plant protection measures and poor postharvest techniques, including inadequate marketing support, storageand processing, contribute to the issue.Indian mustard, as an irrigated crop in India, faces increased weed competition, particularly during early crop growth stages. Depending on weed flora, infestation leveland the duration of competition, yield reduction ranges from 20-30% (Punia *et al*., 2010). Under uncontrolled circumstances, yield loss can go up to 68% (Degra *et al.*, 2011).

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The magnitude of loss due to weeds depends on the type of weeds, their density and duration of competition with the crop, cultivars, soil types, type of irrigation, weed control measures adopted, cropping pattern followed and several environmental factors. Manual weeding is done 3-4 weeks after seeding and is the most popular method of controlling weeds in Indian mustard. However, the rising wages, lack of labour during peak time and high costs make it necessary to look for other options that are both technically and economically viable so that these measures can control weed infestations below the economic threshold level and

enable maximizing this crop′s yield potential (Kalita *et al.*, 2017). Weeds significantly impact crop production, especially in mustard. To minimize yield loss, timely and proper weed control is crucial. Various methods exist for effective weed management in mustard. Hand weeding twice showed the maximum control of weeds, which was significantly superior to other treatments. The two-hand weeding being at par with the herbicides coupled with hand weeding increased the pooled mean seed yield of mustard significantly by 46.3% over the weedy check (Degra *et al.*, 2011). Manual weeding, though common and effective, becomes uneconomical due to high wages and the unavailability of labour at the right time. Additionally, intra-row weeds may go uncontrolled. On the other hand, weed control by herbicides has been effective in controlling inter and intra-row weeds. Mulching has a smothering effect on weeds by restricting solar light which affects photosynthesis by weeds. It works well against some perennial weeds as well as annual weeds. Straw mulching prevents weeds from growing because it blocks light from penetrating the soil. Mulches not only help to retain soil moisture, but they also have positive impacts like reducing excessive temperature fluctuations and evaporation, which results in more soil moisture being stored (Jat *et al.*, 2017). During the rabi season, certain weeds appear early, while others emerge at later stage of crop growth. In such situations, the sequential use of herbicides with other methods is crucial for effective weed control. The optimal weed control may be achieved by combining herbicides with manual, culturaland mechanical approaches. Hence, this experiment was planned to study the effect of integrated weed management methods in mustard.

MATERIALS AND METHODS

A field experiment was carried out at the Agronomy Main Research Farm, College of Agriculture, Orissa University of Agriculture and Technology (OUAT), Bhubaneswar, during *rabi* season of 2021-22 and 2022-23. The experimental soil was sandy loam in texture, slightly acidic (pH= 5.86), low in organic carbon content, low in available nitrogen and phosphorousand medium in available potassium. The mean maximum and minimum atmospheric temperatures during the cropping season of *Rabi* 2021-22 and 2022-23 were 28.3 and 18.0°C, respectively. A total rainfall of 184.3 mm was received during the crop-growing season. The mean relative humidity for morning and evening was 91% and 63%, respectively. Similarly, the mean bright sunshine hour was 4.9 hr/day. In general, all-weather parameters were suitable for the growth of mustard. The experiment was laid out in randomized block design (RBD) consisting of eight treatments and three replications, *viz*. T_1: Pendimethalin 0.75 kg ha^{-1} as pre-emergence (PE), T_2: Pendimethalin 0.75 kg ha^{-1} as PE *fb* straw mulch 5 t ha^{-1}, T_3: Mechanical weeding at 20 DAS,T_4: Manual weeding at 20 DAS,T_5: Manual and Mechanical weeding at 20 and 40 DAS,T_6: Straw mulching 10 tha^{-1}at 7 DAS, T_7: Weed-free 4 weedings at 20, 40, 60 and 80 DASand T_8: Weed check. The crop was sown on 25th October 2021 and 22nd October 2022 and harvested on 6th February 2022 and 4th February 2023, respectively. The soil of the experimental site was sandy clay loam with medium status of available nitrogen, phosphorus and potassium content. Standard procedures were followed for the observations and statistical analysis of data.

RESULTS AND DISCUSSION

Effect on weed flora

Theexperimental field was infested mainly with 16 different types of weeds. The most problematic and dominating grass, sedge and broad-leaved weeds found in the experimental plot were *Cynodon dactylon* (11.74%), *Cyperus iria* (5.2%)and *Cleome viscose* (27.86%), respectively.

Effect on weed density and dry weight

At all stages of crop growth, weed-free plot (4 weeding at 20, 40, 60 and 80 DAS) produced minimum weed density, followed by pendimethalin 0.75 kg ha^{-1} as PE *fb* straw mulch 5 t ha^{-1} (Table 1). At 20 and 40 DAS, pendimethalin 0.75 kg ha^{-1} as PE *fb* straw mulch 5 t ha^{-1}, straw mulching 10 t ha^{-1}

Table 1: Effect of weed management practices on total weed density (Pooled over 2 years).

Treatments	Weed density (No. m^{-2})		Weed dry weight (g m^{-2})	
	20 DAS	40 DAS	20 DAS	40 DAS
Pendimethalin 0.75 kg ha^{-1} as PE	3.39 (11.00)	3.71 (13.33)	1.74	1.85
Pendimethalin 0.75 kg ha^{-1}as PE *fb* straw mulch 5 t ha^{-1}	3.29 (10.33)	3.23 (9.67)	1.58	0.84
Mechanical weeding at 20 DAS	10.05 (100.67)	5.33 (28.00)	10.18	2.61
Manual weeding at 20 DAS	10.27 (105.24)	6.24 (38.67)	11.24	4.73
Manual and Mechanical weeding (20 and 40 DAS)	9.67 (93.00)	4.34 (16.00)	7.36	1.83
Straw mulching 10 t ha^{-1} at 7 DAS	3.34 (10.67)	3.29 (10.67)	2.10	0.98
Weed-free (4 weeding at 20, 40, 60 and 80 DAS)	2.90 (8.00)	2.26 (4.67)	1.26	0.73
Weedy check	10.70 (114.00)	8.66 (74.67)	15.22	7.54
SEm(±)	0.12	0.24	0.28	0.21
CD at 5%	0.34	0.71	0.82	0.61

Data are square root transformed $\sqrt{(x+0.5)}$ and figures in parenthesis are the original value.

at 7 DAS and pendimethalin 0.75 kg ha^{-1} as PE produced significantly lower weed density. This might be due to effective weed control by pre-emergence application of herbicide and weed smothering effect of straw mulch during the early stages of crop growth. Among other treatments, manual and mechanical weeding at 20 and 40 DAS resulted in lower weed density, while the weedy check consistently exhibited the highest weed density (114.00 m^{-2} and 74.76 m^{-2} at 20 and 40 DAS, respectively) throughout crop growth stages. Pre-emergence application of pendimethalin, either solely or combined with straw mulching, consistently showed the least weed density at each growth stage. Similar findings were reported by Shekhawat *et al*., (2012), Raj *et al.* (2020) and Chishi*et al.* (2021).

At 20 DAS, the weed-free plot provided the lowest weed dry weight (1.26 gm^{-2}) followed by pendimethalin 0.75 kg ha^{-1} as PE *fb* straw mulch 5 t ha^{-1} (1.58 gm^{-2}), which were at par with pendimethalin 0.75 kg ha^{-1} as PE (1.74 gm^{-2}) (Table 1). At 40 DAS also, the weed-free plot recorded the lowest weed dry weight (0.73 gm^{-2}) which was at par with pendimethalin 0.75 kg ha^{-1} *fb* Straw mulch 5 t ha^{-1} (0.84 gm^{-2}) and straw mulching 10 t ha^{-1} at 7 DAS (0.98 g m^{-2}). Maximum weed biomass was observed in the weedy check at all stages of growth. At 20 and 40 DAS, the weed biomass obtained from the weedy check (15.22 and 7.54 gm^{-2} at 20 and 40 DAS, respectively) was significantly higher than other weed control treatments. The weedy check, where no weed control measures were implemented, exhibited increased weed growth and consequently higher weed biomass. However, the application of the herbicide pendimethalin and straw mulching resulted in weed suppression, leading to reduced weed biomass in the field. Similar results were supported by Shekawat *et al.* (2012) and Raj *et al.* (2020) and Patel *et al.* (2020).

Effect on weed control efficiency and weed index

A perusal of the data presented in Table 2 revealed that at 40 DAS, weed control efficiency was highest in 4-weedings plot (90.32%) followed by pendimethalin 0.75 kg ha^{-1} as PE *fb* straw mulch 5 t ha^{-1} (88.86%) and straw mulching 10 t ha^{-1} at 7 DAS (87%). But at20 DAS, pendimethalin 0.75 kg ha^{-1} as PE recorded higher WCE than straw mulching 10 t ha^{-1} at 7 DAS which might be due to more effective weed control during the early stages of crop growth by pre-emergence application of pendimethalin.Similar findingswereobserved by Pandey *et al*., (2019). Manual weeding at 20 DAS produced the lowest weed control efficiency at all stages of crop growth. The highest weed index was observed in the weedy check (56.75%) followed by manual weeding at 20 DAS (36.29%). The lowest weed index was observed in pendimethalin 0.75 kg ha^{-1} as PE *fb* Straw mulch 5 t ha^{-1} (8.24%) indicating its superiority over other treatments.

Effect on yield

Maximum grain yield was obtained from weed-free plot (1233 kg ha^{-1}) (Table 3). Among different weed control treatments, pendimethalin 0.75 kg ha^{-1} as PE *fb* straw mulch 5 t ha^{-1} produced the highest grain yield (1131 kg ha^{-1})

Table 2: Effect of weed management practices on weed control efficiency (WCE) and weed index (WI) (pooled over 2 years).

Treatments	Weed control efficiency (%)		Weed index (%)
	20 DAS	40 DAS	
Pendimethalin 0.75 kg ha^{-1} as PE	88.57	75.46	23.72
Pendimethalin 0.75 kg ha^{-1}as PE *fb* straw mulch 5 t ha^{-1}	89.62	88.86	8.24
Mechanical weeding at 20 DAS	33.11	65.38	27.45
Manual weeding at 20 DAS	26.15	37.27	36.29
Manual and mechanical weeding (20 and 40 DAS)	51.64	75.73	24.85
Straw mulching 10 t ha^{-1} at 7 DAS	86.20	87.00	21.85
Weed-free (4 weeding at 20, 40, 60 and80 DAS)	91.72	90.32	0.00
Weedy check	0.00	0.00	56.75

Table 3: Effect of weed management practices on grain yield, stover yield and B: C ratio (pooled over 2 years).

Treatments	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	B: C
Pendimethalin 0.75 kg ha^{-1} as PE	940	2069	1.89
Pendimethalin 0.75 kg ha^{-1}as PE *fb* straw mulch 5 t ha^{-1}	1131	2303	1.96
Mechanical weeding at 20 DAS	895	2024	1.74
Manual weeding at 20 DAS	785	1834	1.24
Manual and mechanical weeding (20 and 40 DAS)	927	2229	1.40
Straw mulching 10 t ha^{-1} at 7 DAS	964	1989	1.58
Weed-free (4 weeding at 20, 40, 60 and80 DAS)	1233	2406	1.40
Weedy check	533	1347	1.11
SEm(±)	6.74	26.33	1.89
CD at 5%	19.73	77.03	1.96

which was significantly higher than straw mulching 10 t ha^{-1} at 7 DAS (964 $kgha^{-1}$). The lowest grain yield was obtained from the weedy check plot (533 kg ha^{-1}). In treatments where pre-emergence herbicide was applied or straw mulching was done, weed growth was reduced, so the crop plant had better growth and yield. Similar results were supported by Kumar *et al.*, (2012), Bamboriya *et al.*, (2017) and Bijarnia *et al.* (2017). Maximum stover yield was recorded from weed-free plot (2406 kg ha^{-1}) (Table 3). Among various weed management treatments, the highest stover yield was obtained from pendimethalin0.75 kg ha^{-1} as PE *fb* straw mulch 5 t ha^{-1} (2303 kg ha^{-1}) which was statistically at par with straw mulching 10 t ha^{-1} at 7 DAS (2229 kg ha^{-1}). Stover yield was lowest in the weedy check (1347 kg ha^{-1}).

Economics

Production economics is the main deciding factor for the adoption of a technology by the farmers. New technology aims at reducing the cost of cultivation with increasing yield, net return and B: C ratio.The highest benefit-to-cost ratio was found under pendimethalin 0.75 kg ha^{-1} as PE *fb* straw mulch 5 t ha^{-1} (1.96) followed by pendimethalin 0.75 kg ha^{-1} as PE (1.89) (Table 3). Weedy check recorded the minimum value of 1.11. These findings conform with Singh *et al.*, (2002), Degra *et al.* (2011) and Raj *et al.* (2020). Despite the weed-free plot yielding the highest in terms of both yield and gross returns, the B:C Ratio waslow. This wasdue to the high cost of manpower involved.

CONCLUSION

The application of pendimethalin 0.75 kg ha^{-1} *fb* straw mulch 5 tha^{-1} was found to be the best treatment, followed by pendimethalin 0.75 kg ha^{-1} as PE for optimum weed management, resulting in higher productivity and a higher B:C ratio in rabi mustard under East and South Eastern Plain Zones of Odisha, India.

Conflict of interest

All authors declared that there is no conflict of interest.

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