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Study of integrated weed management practices on growth, yield and economics of Indian mustard (*Brassica juncea* L.)

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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 Study of integrated weed management practices on growth, yield and economics of Indian mustard (*Brassica juncea* L.). The soil was normal in pH of 7.66, electrical conductivity (EC) of 0.25 dSm^{-1}, organic carbon content of 0.41%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 215.70, 19.57, and 148.50 kg ha^{-1}, respectively. The experiment was laid out during Rabi season of 2023-24. The experiment consisted of 12 treatment combinations, was laid out in Randomized Block Design (RBD) with three replications.

Keywords: Herbicides, mustard, moisture

Introduction
In the region, rapeseed is referred to as sarson, toria, and yellow toria, while Indian mustard, or *Brassica juncea* (L.) Czern & Coss., is called rai, raya, laha, and raiya. Its tender, green plants are used to make a vegetable dish known as "Sarson ka Saag." In northern India, people use oil for cooking and frying in order to consume it. The entire seed is used as a condiment in pickle recipes, to enhance the flavor of curries and vegetable ghee, and to make hair oil, lubricating oil, medicines, and tanning products. Mustard seeds have an oil content that ranges from 37 to 49% (Bhowmik *et al*., 2014) [1].

Brassica juncea is a member of the Cruciferae (Brassicaceae) family. Presently, the family comprises 338 genera and 3709 species (Warwick *et al*., 2006) [2], and it is among the top ten economically significant plant families (Rich, 1991) [3].

Indian mustard is a common spice for seasoning food in addition to being a significant source of oil. According to Thiyam *et al*. (2006) [4], Indian mustard has the following nutritional value per 100 g (3.5): 4.51 g of carbohydrates, 1.41 g of sugar, 2.0 g of dietary fiber, 0.47 g of fat, and 2.56 g of protein. It is also a good source of phenolic antioxidants, such as sinapic acid and sinapine. Rapeseed is cultivated to produce biodiesel, vegetable oil for human consumption, and animal feed. In northern India, these crops are sown in the months of October and November because they require a cool growing season and consistent, moderate temperatures (Das *et al*., 2009) [5].

After the United States, China, and Brazil, the edible oil industry in India is the fourth largest in the world. India holds a significant position in the global edible oil market, accounting for approximately 7% of production, 12% of consumption, and 20% of imports during the 2016–17 period (USDA 2018). India holds a significant position as the world's third-largest producer of oilseeds, following China and Canada. In India, mustard is the second most important crop for edible oil seeds, right after groundnuts. Grown on 5.98 and 6.23 m ha in India, its productivity is 1410 and 1499 kg ha^{-1}, and its output is 8.43 and 9.34 mt. Nonetheless, the majority of the rapeseed-mustard production occurred in the states of Uttar Pradesh in the years 2017–18 and 2018–19, covering 0.68 and 0.75 mha with yields of 0.95 and 1.12 mt and yields of 1392 and

1483 kg ha^{-1}. As a result, it has a significant portion of our nation's mustard production (11.21 and 11.96%) and area (11.36 and 12.08%). Nevertheless, Gujarat had the highest area (0.22 and 0.20 mha), production (0.40 and 0.34 mt), productivity (1808 and 1745 kg ha^{-1}) and productivity of Gujarat (2.21 and 2.37 mha), and production (3.54 and 4.08 mt) [6]. In contrast, Rajasthan had the highest productivity (1602 and 1720 kg ha^{-1}).

The world's largest producers of oilseeds are brassica species, which are followed in size by sunflower (*Helianthus annuus* L.) and peanuts (*Arachis hypogaea* L.) (Shekhawat *et al*., 2012). The two most significant oilseed crops in the Indian subcontinent are rapeseed (*Brassica napus* L.) and Indian mustard (*Brassica juncea* L. Czern. & Coss.) (Saharan and Mehta, 2002) [8]. Its production is greatly aided by seven Indian states, including Gujarat, Rajasthan, Madhya Pradesh, Uttar Pradesh, Haryana, West Bengal, and Assam (Doddabhimappa *et al*., 2010) [9, 10].

A crop is sprayed with pre-emergence herbicide one or two days after it is sown. Pre-emergence herbicides are preferred more due to their longer half-lives and higher efficiency. Additionally, unlike manual weeding, it doesn't harm the crop plant mechanically. Furthermore, because the weeds are eliminated even within the row—a weed's tendency to escape mechanical control due to its morphological resemblance to the crop—the control is more successful. The type of weed flora infesting the crop, the time of application, the use of the ideal herbicide dose, and the appropriate nozzle—such as a flood jet or flat fan—all play a role in effective weed control. Broad-spectrum weed control can be achieved by using post-emergence herbicides alone or in combination (Choudhary *et al*. 2018) [11].

Mulch is a layer of materials kept or applied to the soil's surface that provides protection. Plastic mulch sheets, straw, leaves, and crop leftovers are among the materials used to make mulch. Mulching the soil's surface can physically suppress weed emergence or stop weed seeds from germinating, but it is ineffective against weeds that have already become established. It also moderates soil irrigations in addition to stopping weed germination (Dubey, 2018) [12]. Mulching can reduce weed growth by 30 to 85%, depending mainly on the type of mulch used (Choudhary *et al*. 2018) [11].

Materials and Methods

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 Study of integrated weed management practices on growth, yield and economics of Indian mustard (*Brassica juncea* L.). The soil was normal in pH of 7.66, electrical conductivity (EC) of 0.25 dSm^{-1}, organic carbon content of 0.41%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 215.70, 19.57, and 148.50 kg ha^{-1}, respectively. The experiment was laid out during Rabi season of 2023-24. The experiment consisted of 12 treatment combinations, was laid out in Randomized Block Design (RBD) with three replications. T_1Pendimethalin (PE) @ 750 g ha^{-1},T_2Isoproturon (POE) @ 1000 g ha^{-1}, T_3 Pendimethalin (PE) @ 750 g ha^{-1} + Hand weeding at 40 DAS, T_4Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40 DAS, T_5Pendimethalin (PE) @ 750 g ha^{-1} + Paddy straw mulch @ 6 t ha^{-1} at 2-3 DAS, T_6Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 6 t ha^{-1} at 2-3 DAS, T_7 Metribuzin (PE) @ 150 g ha^{-1},T_8Metribuzin (PE) @ 150 g ha^{-1} + Hand weeding at 40 DAS,T_9Metribuzin (PE) @ 100 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3 DAS,T_{10}Paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS, T_{11}Hand weeding at 20 and 40 DAS, T_{12}Weedy checkdata were gathered on five plants chosen from each plot.

Results and Discussion

Yield attributes and yields

Number of siliquae plant^{-1}

The highest values of siliquae plant-1 (287 and 293) at harvest with two hand weeding treatments (20 and 40 DAS) were associated with T_{11}, which was statistically comparable to T_{10}, T_9, T_5, and T_6 and significantly better than the remaining treatments (T_8, T_3, T_4, T_7, T_1, T_2, and T_{12}). Nonetheless, the weedy check had a noticeably lower value of number of siliquae plant-1 (183).

Length of siliquae (cm)

Notably, two hand weeding treatments (20 and 40 DAS) T_{11} treatments produced the longest siliquae (7.17), which was followed by paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS (T_{10}). It was discovered to be statistically comparable to T_{10}, T_9, T_5, and T_6, but significantly better than the other treatments. According to Dixit and Gautam (2012), Gupta *et al*. 2019, Pandey *et al*. 2019, Singh *et al*. 2020, and Kumar S.T. 2020, the smallest siliquae was measured at 5.49 cm in weedy check plots [12, 13, 14, 15, & 16].

Number of seeds siliquae^{-1}

It is clear from the data that after receiving paddy straw mulch @ 8 t ha^{-1} at 2-3 DAS (T_{10}), which was statistically equivalent to T_9, T_5, and T_6 treatment, two hand weeding (20 and 40 DAS) T_{11} treatments had a significantly higher number of seeds siliquae-1 (12.10). Nevertheless, under weedy check, the minimum number of seeds siliquae-1 is significantly lower (9.26).

Test weight (g)

Table 1 displays the test weight data that was collected in relation to the different treatments. Herbicides, mulching, and hand weeding did not significantly affect the 1000 seed weight (g). Comparing the weedy check (4.41) to the maximum test weight (1000 seed weight, 4.86 T_{11} treatment), Metribuzin (PE), @ 150 g ha^{-1} + Paddy straw mulch, @ 8 t ha^{-1} at 2-3 DAS (T_{10}), and Paddy straw mulch, @ 6 t ha^{-1} at 2-3 DAS T_9 treatment, all clearly show that the maximum test weight was recorded higher.

Seed yield (q ha^{-1})

Following two hand weeding sessions (20 and 40 DAS), T_{11} treatments yielded the highest seed yield (20.31 q ha^{-1}), which was statistically comparable to T_{10}, T_9, T_5, and T_6 over. However, under weedy control, the lowest seed yield (13.03 and 13.82 q ha^{-1}) was noted. Under the weedy check, the lowest seed and stover yields were observed. In addition, Yadav *et al*. (2013), Singh *et al*. (2020), and Kumar S. T. (2020) reported results that were similar [17, 15 & 16].

Stover yield (q ha^{-1})

Amply demonstrated the substantial impact of weed management techniques on the stover yield. The results of two hand weeding treatments (20 and 40 DAS) on T_{11} produced the highest stover yield (53.64 q ha^{-1}), which was comparable to T_{10}, T_9, T_5, and T_6 in both years. Nevertheless, under weedy control, the minimum stover yield (36.07 q ha^{-1}) was noted. Low growth and yield-attributing characteristics result in minimum seed and straw yields (Chauhan *et al*. 2005, Mukherjee, 2014, Singh *et al*. 2020, and Kumar S. T. 2020) [18, 19, 15, & 16].

Harvest index (%)

Information on how herbicides, mulching, and hand weeding have affected the harvest index. In addition to chemical treatments, two manual weeding sessions (20 and 40 DAS) with T_{11} treatments yielded the highest harvest index (27.46%), followed by T_9, T_5, and T_6 treatments. The paddy straw mulch @ 8 t ha^{-1} at 2- 3 DAS with T_{10} treatment (27.28%) was the next highest harvest index. The weedy check category had the lowest harvest index (26.54%).

Table 1: Effect of various weed management practices on number of siliquae, length of siliquae, number of seeds $siliquae^{-1}$ and test wt in mustard crop

Treatments	No. of siliquae/plant	Length of siliquae (cm)	No. of seeds/siliquae	Test weight (g)
T_1-Pendimethalin (PE) @ 750 g ha^{-1}	229	6.21	10.51	4.48
T_2-Isoproturon (POE) @ 1000 g ha^{-1} at 20 DAS	220	6.15	10.46	4.43
T_3-Pendimethalin (PE) @ 750 g ha^{-1} + Hand weeding at 40 DAS	250	6.28	10.64	4.59
T_4-Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40 DAS	243	6.25	10.60	4.57
T_5-Pendimethalin (PE) @ 750 g ha^{-1} + Paddy straw mulch @ 6 t ha^{-1} at 2-3 DAS	275	6.88	11.39	4.74
T_6-Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 6 t ha^{-1} at 2-3 DAS	270	6.79	10.92	4.72
T_7-Metribuzin (PE) @ 150 g ha^{-1}	236	6.23	10.57	4.54
T_8-Metribuzin (PE) @ 150 g ha^{-1} + Hand weeding at 40 DAS	253	6.30	10.66	4.64
T_9-Metribuzin (PE) @ 150 g ha^{-1} + Paddy straw mulch @ 6 t ha^{-1} at 2-3 DAS	278	7.09	11.48	4.76
T_{10}-Paddy straw mulch @ 8 t ha^{-1} at 2-3 DAS	281	7.12	11.65	4.81
T_{11}-Hand weeding at 20 and 40 DAS	287	7.17	12.10	4.86
T_{12}-Weedy check	183	5.49	9.26	4.41
SEM±	11.26	0.29	0.48	0.11
CD (P=0.05)	33.03	0.86	1.41	NS

Table 2: Effect of various weed management practices on seed yield (q ha^{-1}), stover yield (q ha^{-1}) and harvest index (%) of mustard

Treatments	Seed yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
T_1-Pendimethalin (PE) @ 750 g ha^{-1}	15.97	43.74	26.75
T_2-Isoproturon (POE) @ 1000 g ha^{-1} at 20 DAS	14.72	40.54	26.64
T_3-Pendimethalin (PE) @ 750 g ha^{-1} + Hand weeding at 40 DAS	16.34	45.09	26.60
T_4-Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40 DAS	16.25	44.72	26.65
T_5-Pendimethalin (PE) @ 750 g ha^{-1} + Paddy straw mulch @ 6 t ha^{-1} at 2-3 DAS	18.15	49.04	27.01
T_6-Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 6 t ha^{-1} at 2-3 DAS	18.08	47.82	27.43
T_7-Metribuzin (PE) @ 150 g ha^{-1}	16.24	44.59	26.70
T_8-Metribuzin (PE) @ 150 g ha^{-1} + Hand weeding at 40 DAS	16.53	45.32	26.73
T_9-Metribuzin (PE) @ 150 g ha^{-1} + Paddy straw mulch @ 6 t ha^{-1} at 2-3 DAS	18.56	50.03	27.06
T_{10}-Paddy straw mulch @ 8 t ha^{-1} at 2-3 DAS	19.73	52.60	27.28
T_{11}-Hand weeding at 20 and 40 DAS	20.31	53.64	27.46
T_{12}-Weedy check	13.03	36.07	26.54
SEM±	0.77	2.20	-
CD (P=0.05)	2.28	6.47	-

Conclusion

It was discovered that two-hand weeding (20 and 40 DAS) was more successful in raising mustard yield and yield-related characteristics. While T_{10} treatment (applied @ 8 t ha^{-1} at 2-3 Das) was found to be more effective than other weed management techniques in terms of increasing mustard yield and yield attributes.

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