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Effect of integrated weed control practices on growth parameters and yield attributes of Indian mustard in clay loam soils of Nagpur in Maharashtra

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Abstract
A field trial was carried out on effect of integrated weed management practices on growth and yield of Indian mustard during the *rabi* season of 2020-21 at Mahurzari farm, Nagpur, Maharashtra, India. The experiment was laid out in randomized block design with 7 treatments and 3 replications. The treatments consisted of T_{1}- Pendimethalin 30 EC (PE) @ 2.5 lit/ha + HW at 30 DAS, T_{2}- Propaquizafop 10 EC (PoE) @ 1 lit/ha + HW at 30 DAS, T_{3} - Oxyfluorfen 23.5 EC (PE) @ 0.5 lit/ha + HW at 30 DAS, T_{4}- Oxyfluorfen 23.5 EC (PE) @ 0.5 lit/ha + propaquizafop 10 EC (PoE) @ 1 lit/ha + WH at 40 DAS, T_{5}- Pendimethalin 30EC (PE) @ 1 lit/ha + propaquizafop 10EC (PoE) @ 1 lit/ha + WH at 40 DAS, T_{6}- Hand Weeding twice at 30 and 60 DAS and T_{7}-Weed Control. The soil of the experimental field was clay loam in texture, organic carbon, available nitrogen and phosphorus were low and potassium content medium.
Among the weed management treatments, the growth and yield parameters of Indian mustard *viz.* plant height, number of primary and secondary branches per plant, dry matter weight per plant, number of siliqua per plant, number of seeds per siliqua, 1000 seed weight, seed weight per plant, seed yield and stover yield per hectare were recorded highest with treatment T_{6}- Hand Weeding twice at 30 and 60 followed by T5, T4, T1, T3, T2, over T7.
Henceforth, on the basis of this study, it can be revealed that application of pendimethalin 30 EC (PE) + propaquizafop 10 EC (PoE) + WH at 40 DAS has a B:C ratio of 2.28 have been found suitable for achieving economic yield advantage from mustard with higher net returns followed by oxyfluorfen 23.5 EC (PE) + propaquizafop 10 EC (PoE) + WH at 40 DAS, which has a B:C ratio of 1.99 compared to other treatments.

Keywords: Indian mustard, *Brassica juncea* L., herbicides, hand weeding, interculturing

Introduction
Rai originated in China, according to Prain, Bailey, and Sinsky, and was spread to India from there. Together with India and Pakistan, China is the world's top producer of rapeseed and mustard. They produce nearly 90% of the world's entire output. Rapeseed and mustard, among the other oilseed crops grown in India, are important to the national economy since they rank second in terms of area and production behind groundnut. Among the various kinds of rapeseed and mustard grown in India, Indian mustard [*Brassica juncea* (L.) Czernj and Cosson] is the most popular. India has the world's fourth largest oilseed economy. Rapeseed and mustard are the second most widely grown oilseeds in India, accounting for 28.6% of total oilseed production, after groundnut, which accounts for 27.8% of the country's oilseed economy. The mustard-growing regions of India have a wide range of agro-climatic conditions, and various rapeseed and mustard species are grown in different parts of the nation. Mustard is a highly promising crop in India's many agro-climatic areas due to its broad resilience to severe climatic conditions and great yield potential. Mustard oil is utilised in a variety of applications, including cooking and industry. Cake, the by-product left after extracting the oil, is useful feed for cattle and can also be used as manure.
Brassica species' seed and oil have a distinct pungency. The presence of glucogide sinigrin [$C_{10}H_{16}O_9NS_2K$] causes the pungency. The percentage of oil fluctuates between 37 and 49 percent. Oil cake includes 25-30% oil, 5% nitrogen, 1.8% P_2O_5, and 1.2% K_2O. For cattle, green stems and leaves are a good supply of green feed. Young plant leaves are utilised as green vegetables because they provide sufficient sulphur and minerals in the diet. Mustard oil is used to soften leather in the tanning business.
The area and production of rapeseed and mustard in India has been steadily increasing. India is the world's leading producer of rapeseed and mustard, both in terms of area and production.

The country had a yellow revolution, with rapeseed and mustard production and productivity sky rocketing from 2.68 mt and 650 kg per ha in 1985-1986 to 6.96 mt and 1022 kg per ha in 1996-1997. Rajasthan is the leading producer of rapeseed-mustard, with Uttar Pradesh, Haryana, Madhya Pradesh, West Bengal, Gujarat, and Assam following closely behind. Orrisa and Bihar are two other states with limited production.

Weeds should be kept out of rapeseed and mustard fields for the first 45-60 days, after which weed development is suppressed by the smothering effect. Weeds are responsible for 25-35 percent of crop loss. Weeds found in mustard crops include *Chenopodium album, Lathyrus spp., Anagallis arvensis, Cynodon dactylon, Argemone mexicana,* and others. Depending on the weed infestation, one weeding and hoeing in rainfed areas and two weedings and hoeings in irrigated areas is usually sufficient. Weed competition for moisture, light, nutrients, and space is one of the key impediments to crop growth and productivity, as weed competes with the crop for moisture, light, nutrients, and space. Furthermore, they raise production costs, harbour insects, pests, and plant disease organisms, lower agricultural produce quality, and lower land prices. Mechanical hoeing and hand weeding are the most common methods of weed control. Not only that, but during peak crop growth, labour is scarce and labour costs are high due to farm labourers moving to industries for better and more secure income. The use of herbicides has better resulted in weed control, reduces the cost of cultivation and has resulted in the revolution of many conventional practices.

Weed control was improved when herbicides were used in conjunction with one or two hand weeding. When weeds were controlled with herbicides alone or in combination with hand weeding at 45 DAS, the return/rupees invested was higher than when weeds were not controlled (Ved *et al*., 2000). Pre-emergence herbicide spraying maintains the crop weed-free in the early stages, while hand weeding later in the crop growth phase helps to reduce weeding costs and keep the weed population below the economic threshold level.

Herbicides' efficiency is determined by their behaviour in relation to soil type, soil organic matter, weather conditions, and soil moisture, among other factors. As a result, it's critical to test newly released herbicides and determine the best doses for specific agro-climatic conditions in order to effectively manage weeds.

Material and Methods

The experiment was carried out to study the effect of integrated weed management practices on growth parameters and yield attributes of Indian mustard (*Brassica juncea* L.) during rabi season of 2020-21 at the Mahurzari Farm, Nagpur, Maharashtra under GH Raisoni University, Chhindwara, MP. The experimental soil was clay loam in texture, organic carbon, available nitrogen and phosphorus were low and potassium content medium. The experiment was carried out in randomized block design with 7 treatments and 3 replications. The treatments consisted of T_1- Pendimethalin 30 EC(PE) @ 2.5 lit/ha + HW at 30 DAS, T_2- Propaquizafop 10 EC (PoE) @ 1 lit/ha + HW at 30 DAS, T_3 - Oxyfluorfen 23.5 EC (PE) @ 0.5 lit/ha + HW at 30 DAS, T_4-Oxyfluorfen 23.5 EC (PE) @ 0.5 lit/ha + Propaquizafop 10 EC (PoE) @ 1 lit/ha + WH at 40 DAS, T_5- Pendimethalin 30EC (PE) @ 1 lit/ha + Propaquizafop 10EC (PoE) @ 1 lit/ha + WH at 40 DAS, T_6-Hand Weeding twice at 30 and 60 DAS and T_7-Weed Control. The experimental plot area was 14.96 m2. The sowing of mustard, variety- Sarita-333 was done on 26th November,2020 with a spacing of 40 cm x 20 cm and fertilizers used @ 80:40:40 kg N, P_2O_5. & K_2O per hectare and harvested on 8th March,2021. The crop was protected from insect-pest and diseases by spraying chemicals time to time. The crop was irrigated as per water requirement. During the crop growing period, the weekly mean rainfall was ranged from 0.0 to 10.2 mm.

Result and Discussion

Effect of different integrated weed control practices on growth parameters and yield attributes of mustard

Effect on Growth Parameters

Hand weeding (T6) produced significantly higher plant height than the other weed management methods (149.07 cm). However, it was comparable to the treatments pendimethalin 30 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS) (T5), oxyfluorfen 23.5 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS) (T4), pendimethalin 30 EC(PE) + HW (30 DAS) (T1), oxyfluorfen 23.5 EC + HW (30DAS) (T3), and propaquizafop 10 EC + HW @ 1 lit/ha (1 DAS + 30 DAS) (T2), (having plant height of 146.63, 144.7, 142.2, 140.47 and 137.60 cm), respectively. The treatment (unweeded check) (T7) had the lowest plant height, measuring 114.57 cm. Significantly increased dry weight per plant (44.05 g) was obtained by the treatment hand weeding (T6). Hand weeding (T6) resulted in a significantly higher number of primary branches per plant (6.43). However, it was comparable to other treatments, with the treatment (unweeded check) (T7) having significantly fewer primary branches (4.27). Similarly, the number of secondary branches was higher in the hand-weeded check plot and lower in the unweeded check plot.

Effect on Yield Attributes

The treatment hand weeding (T6) produced the longest siliquae (4.56 cm), which was statistically comparable to the treatments pendimethalin 30 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS) (T5), oxyfluorfen 23.5 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS) (T4), pendimethalin 30 EC(PE) + HW (30 DAS) (T1), oxyfluorfen 23.5 EC + HW (30DAS) (T3), and propaquizafop 10 EC + HW @ 1 lit/ha (1 DAS + 30 DAS) (T2), (having length of siliqua 4.43, 4.08, 4.05, 3.96 and 3.72). The smallest length of siliquae was 3.14 cm in the treatment unweeded check (T7). The treatment hand weeding (T6) had the highest number of siliquae per plant (204.51), while the treatment unweeded check (T7) had the lowest amount of siliquae (144.43). Because of the numerous treatments used in this experiment, the number of seeds per siliqua varied greatly. The treatment hand weeding (T6) had the highest number of seeds per siliqua (12.06), whereas the treatment unweeded check (T7) had the lowest number of seeds per siliqua (9.40). Hand weeding (T6) resulted in a much larger seed weight per plant (15.01 g) than the other treatments, but it remained comparable to the others. The effects of different treatments on test weight were considerable. Under hand weeding, the maximum test weight (4.33 g) was recorded. It was substantially greater than the treatments of pendimethalin 30 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS) (T5), oxyfluorfen 23.5 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS) (T4), pendimethalin 30 EC(PE) + HW (30 DAS) (T1), 30 EC(PE) + HW (30 DAS) (T1), oxyfluorfen 23.5 EC + HW (30DAS) (T3), and Propaquizafop 10 EC + HW @ 1 lit/ha (1 DAS + 30 DAS) (T2). The minimal test

weight for treatment T7 (unweeded check) was 2.96 g. The diverse weed control methods used in this experiment had a substantial impact on the yield of Indian mustard. The hand weeded (T6) showed its superiority by yielding 36.51 q per ha, which was significantly higher than the other treatments. However, statistically, it was comparable to the remaining treatments. The diverse weed control methods used in this experiment had a substantial impact on the seed output of Indian mustard. The hand weeded (T6) showed its superiority by yielding 18.55 q ha, which was substantially greater. The treatment hand weeding (T6) demonstrated its superiority by recording a substantially greater biological yield of 55.06 q per ha, whereas the treatment T7 recorded the significantly lowest biological yield (40.13 q per ha) (Unweeded check). Different treatments used in this study had a substantial impact on harvest index. Hand weeding (T6) produced a significantly higher harvest index (33.69%), which was comparable to the other treatments. The harvest index for treatment T7 (unweeded check) was substantially lower (26.99%). The number of primary branches per plant (r = 0.989**), number of secondary branches per plant (r = 0.931**), number of siliquae per plant (r = 0.978**), number of seeds per siliqua (r = 0.983**), seed weight per plant (r = 0.996**), and test weight (r = 0.998**) all showed a significant positive correlation with seed yield, indicating that these parameters have an effect on mustard seed yield.

Under the conditions of pendimethalin 30 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS), the maximum net realisation of Rs.60343 per hectare was achieved. Increased net realisation per hectare may be due to higher seed and stover yields as a result of better weed management combined with lower production costs under pendimethalin 30 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS). Pendimethalin 30 EC + propaquizafop 10 EC + WH (40DAS) has a B:C ratio of 2.28, which is higher than all other treatments, followed by oxyfluorfen 23.5 EC (PE) + propaquizafop 10 EC (PoE) + WH (40 DAS), which has a B:C ratio of 1.99.

Table 1: Effect of different weed management practices on growth and yield attributes of Indian mustard

	Growth parameters				Yield attributes at harvest								
Treatments	**Plant height (cm)**	**Dry matter per plant (g)**	**No. of primary branches**	**No. of secondary branches**	**Siliqua length (cm)**	**No. of siliqua per plant**	**No. of seeds per siliqua**	**Seed weight per plant (g)**	**Test weight (g)**	**Seed yield (q per ha)**	**Stover yield (q per hs)**	**Biological yield (q per ha)**	**Harvest index (%)**
T1	142.20	40.55	5.47	12.63	4.05	185.84	11.52	12.61	3.78	15.55	35.13	50.68	30.68
T2	137.60	37.75	5.10	11.53	3.72	175.71	10.36	11.64	3.45	13.83	32.35	46.18	29.95
T3	140.47	39.25	5.33	12.47	3.96	180.75	10.88	12.45	3.72	15.32	34.71	50.11	30.57
T4	144.70	41.84	5.87	12.77	4.08	195.85	11.63	13.04	3.86	16.05	35.07	51.12	31.40
T5	146.63	42.54	6.20	13.1	4.43	199.46	12.06	14.10	4.10	17.60	35.57	53.17	33.10
T6	149.07	44.05	6.43	13.63	4.56	204.51	12.66	15.01	4.33	18.55	36.51	55.06	33.69
T7	114.57	32.11	4.27	7.17	3.14	144.43	9.40	8.78	2.96	10.83	29.30	40.13	26.99
S.Em+	0.9049	0.515	0.179	0.324	0.197	0.869	0.183	0.261	0.089	0.258	0.267	0.301	0.339
CD (P=0.05)	2.7884	1.587	0.551	1.001	0.607	2.679	0.565	0.806	0.273	0.794	0.823	0.927	1.043

Based on the current discussion, it can be concluded that, in addition to hand weeding conditions, Pendimethalin 30 EC (PE) + Propaquizafop 10 EC (PoE) + WH (40 DAS) could be recommended to farmers for effective weed management, as it was found to be more effective in reducing weed populations (grassy, broad leaved, and sedges), and thus integrated weed management method plays crucial role in improving the weed population. Furthermore, when compared to other methods of weed control, the chemical technique is the most successful. It has also proven to be a cost-effective treatment, with higher net returns than alternative options.

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