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Study of weed management on growth and yield of Indian mustard (*Brassica juneca* L.) in Uttar Pradesh region

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Abstract
Oilseeds form a cornerstone of food security and livelihoods in South Asia, with mustard (*Brassica juncea*) serving as a vital Rabi crop across the Indo-Gangetic plains. Despite its importance, mustard suffers considerable yield losses due to intense weed competition, often accounting for 30–50% reductions under poor management. To address this, a field experiment was conducted during the 2024–25 Rabi season at the Organic Research Farm, Maharishi University of Information Technology, Uttar Pradesh, to evaluate the impact of different weed management practices. Treatments included hand weeding, herbicides such as Pendimethalin, Alachlor, and Metolachlor, and their combinations with manual weeding, compared against a weed check and stable seed bed. Observations on plant growth, yield attributes, nutrient uptake, and seed yield were analyzed using standard statistical procedures. Results revealed that integrated practices, particularly Pendimethalin at 0.75 kg/ha combined with hand weeding at 30 DAS, significantly enhanced plant height, leaf area index, siliquae per plant, and seed yield. Hand weeding alone produced the maximum seed and stover yield but was labour-intensive, while integrated treatments offered effective, sustainable, and labor-saving alternatives. The study underscores integrated weed management as a practical strategy for boosting mustard productivity and narrowing yield gaps under subtropical agro-ecologies of northern India.

Keywords: Indian mustard, weed management, herbicides, integrated weed control, crop productivity

Introduction
In South Asia, mustard is central to the tale of how oilseeds influence diets, lives, and economies. Mustard, which is mostly grown as a Rabi crop in the Indo-Gangetic plains, is used to make cooking oil, healthy oilcake for cattle, green fodder, and raw materials for the production of soaps, lubricants, and leather. Because mustard oil is minimal in saturated fat and relatively high in omega-3 fatty acids, local customs also value it for massage and hair care [1]. Rapeseed-mustard is grown on about 24.2 million hectares in 53 countries worldwide, yielding about 35 million tonnes. Asia accounts for approximately 60% of the cropped land but less than half of the world yield, indicating a large productivity difference. Yields vary greatly between regions; some claim very high productivity while others remain low. In comparison, Europe uses a much smaller land to produce significantly larger yields. The majority of Asia's rapeseed mustard crop is produced in China and India, which also control the majority of the region's land [2, 7].

India’s share is notable. Rapeseed–mustard occupies roughly 6.8–6.9 million hectares in the Rabi season and contributes a large slice of national oilseed production. Four states Haryana, Madhya Pradesh, Together, Rajasthan and Uttar Pradesh occupy over 80% of the land and generate the majority of the crop; in particular, areas like Rajasthan's Bharatpur division continue to be important producing hubs. However, yields in many Indian locations fall short of the world's top standards, indicating a significant opportunity to increase production without increasing land area. There are two types of restrictions that stand out. Weeds come first [3]. They fiercely struggle with mustard for space, light, water, nutrients, and CO2. Losses can be rather serious. When weed treatment is inadequate, yield reductions of 30–50% are often reported. Hand weeding is a time-sensitive, labour-intensive, and traditional method that works

well. Only when weeds reach a specific stage may mechanical weeding be beneficial. Herbicides have disadvantages, such as crop damage at high doses, insufficient control at low doses, a limited spectrum of activity, the potential to select resistant weed species, and health and environmental issues. However, they provide early, wide coverage and save labour. Therefore, the best course of action is integrated weed management, which combines chemical, mechanical, and cultural methods [4]. Climate and nutrition come in second. During flowering and grain filling, mustard is susceptible to temperature fluctuations; even a small amount of heat stress during these phases inhibits pollination, seed set, and grain filling, significantly reducing yields. Thus, the date of sowing and the cultivar selection are important. Micronutrients including boron, zinc, and sulphur also have a significant impact on seed quality and harvest index; zinc in particular clearly affects final yield partitioning [5,6].

Materials and Methods

The field experiment was conducted during rabi seasons of 2024-25 at organic Research farm, Maharishi University of Information Technology. Geographically, experimental site falls under the sub-tropical zone and located at $26^{\circ}47'$ N latitude, $82^{\circ}12'$ E longitude and an altitude of 113 meters above mean sea level.

Table 1: Details of Treatment

Weed management practise	configuration
W0	Weed check
W1	Handweeding 30 days
W2	Alachlor0.75 kg/ ha
W3	Pendimethalin0.75 kg/ h
W4	Pendimethalin 0.75 kg /h+handweeding(30)Days
W5	Alachlor 0.75 kg/ ha+ Hand weeding(30days)
W6	Metolachlor 0.75 kg/ ha+ hand weeding (30 days)
W7	Stableseedbed

Table 2: Particulars of herbicides used

S. No.	Common name	Chemical formulation
1	Pendimethalin	30%EC
2	Quizalofop	5%EC
3	Metribuzin	70%WP
4	Isoproturon	75%WP

Statistical analysis

The "f" test was used to assess the significance of the overall differences between the treatments. At the five percent likelihood level, a conclusion was reached. The crucial difference (CD) was calculated to determine the significance of the difference between two treatment means when the "F" value in the analysis of variance table was determined to be significant.

Results and Discussion

Weed management effects on weed population, control indices, crop growth features, yield attributes, nutrient absorption (N, P, and K), and oil content were assessed in a research conducted on *Brassica juncea* in Uttar Pradesh. In order to identify treatment-induced differences, crop and weed samples were examined, and the data were statistically evaluated. Table 3 presents the findings.

Plant height

Table 3 presents information on plant height as affected by different treatments. Plant height often grew as the crop of experimental variables advanced and peaked at maturity. Despite this, the plant height increased at a faster pace between 30 and 90 DAS. Table 3 makes it clear that weed control techniques had no effect on plant height at 30 DAS. Among the herbicidal treatments, Pendimethalin 0.75 kgh + manual weeding (30DAS) produced higher plants (23.30). However, the shortest plant (22.00 cm) was discovered in the 2024–2025 weed check (W0).

Leaf area index (LAI)

The findings are shown in Table 3. The leaf area index (LAI) of Indian mustard was measured at 30, 60, and 90 DAS and was considerably impacted by different treatments during the crop growth period. With the exception of weed check, all weed control methods yielded noticeably higher leaf area indices at 30 DAS. W4-Pendimethalin 0.75 kgh + manual weeding (30 DAS) yielded the greatest leaf area index (1.63 throughout these seasons, respectively) among the herbicides used. W1-Handweeding 30 days had the noticeably lowest leaf area index (1.27).

Number of branches plant^{-1}

Indian mustard's number of branches per plant grew up to 90 DAS before declining at the harvest stage. Table 3 presents the data on the number of branches plant^{-1} that demonstrated the impact of different weed management techniques at different phases of crop growth. The highest number of branches plant^{-1} (2.58) was seen at 30 DAS in 2024–2025 following the treatment of Pendimethalin 0.75 kgh+hand weeding (W5). However, the weed check plot had the fewest branches per plant (2.42).

Dry matter accumulation plant^{-1} (g)

Plant^{-1} dry matter accumulation rose as crop age grew and peaked at maturity. Different weed control techniques had a considerable impact on dry matter accumulation; the findings are shown in Table 3. According to the findings, dry matter accumulation rose steadily under all treatments from 30 DAS to the harvesting stage. Nonetheless, during the cropping seasons, a significant rise was noted in 30 DAS. Weed check (W1) recorded the highest dry matter accumulation (1.58 g plant^{-1} across the seasons, respectively), while hand weeding at 30 DAS during the years reported the lowest dry matter accumulation (1.51).

Days taken to 50% flowering

Table 3 makes it evident that the effects of manual weeding, mulching, and pesticides on days when blooming reached 50% were not greatly impacted. The herbicidal treatment that needed the most days for 50% blooming (58.10) in both years was alachlor 0.75 kg ha1 (W2). Early blooming by 2.2 days was noted across the seasons under weed control.

Days taken to maturity

Table 4.16 shows the information on how different weed management techniques affected the number of days needed to reach maturity. The effectiveness of different weed control techniques on days taken to maturity might not differ substantially. Alachlor 0.75 kg ha1 (W2) had the maximum documented days to maturity (118.8 over the cropping seasons, respectively). During the years, the weed check had the lowest number of days (115.5).

Number of siliquae/plant
Pendimethalin 0.75 kg/h + manual weeding (30DAS) had the highest number of siliquae plant^{-1} (281) among the chemical treatments (W4). Nevertheless, the equivalent values were discovered to be 239 throughout the seasons in weed check plots.

Length of siliqua (cm)
Notably, Pendimethalin 0.75 kgh + hand weeding (30DAS) had the longest siliqua (7.20 cm) (W4). Metribuzin (PE) @ 175 g ha^{-1} + hand weeding at 30DAS had the shortest siliqua (3.35) cm over the seasons.

Number of seeds siliqua-1
The findings clearly show that the quantity of seeds siliquae-1 (12.30) was considerably greater in Alachlor 0.75 kg ha1 (W2). During the cropping seasons, however, there is a noticeably low quantity of siliqua-1 seeds under hand weeding 30DAS (10.70).

Test weight (g)
Herbicides, mulching, and manual weeding had little effect on the weight of 1000 seeds (g). Alachlor 0.75 kg ha1 (W2), one of the herbicidal treatments, was shown to have a greater 1000 seed weight (4.75 g). In addition to chemical treatments, hand weeding for 30 days resulted in the lowest values of 1000 seed weight (4.42 g) during the course of the years.

Seed yield (q ha^{-1})
Among the several weed control methods, hand weeding for 30 days (W1) produced the highest seed production (19.55 q ha^{-1}), which was statistically comparable to W5, W6, and W4. Additionally, during the cropping seasons, the weed check and chemical treatments had the lowest seed production (14.60 q ha^{-1}).

Stover yield (q ha^{-1})
The information in Table 3 made it abundantly evident that stover output was significantly impacted by weed control techniques. -Hand weeding for 30 days (W1) produced noticeably the largest stover production (51.83 q ha^{-1}) among the herbicidal treatments. Nevertheless, the weed check had the lowest stover output (40.29 q ha^{-1}) across the years.

Harvest index (%)
statistics on the harvest index as it relates to herbicides, mulching, and manual weeding. The maximum harvest index (26.80%) was observed with an application of alachlor 0.75 kg ha1 (W2), whereas the lowest harvest index (26.6%) was reported under weed inspection.

Table 3: List of treatments and outcomes

Treatments	Plant height (cm)	Leaf area index (LAI)	Number of branches plant^{-1} of mustard	Dry matter accumulation plant^{-1} (g)	50% flowering	Days taken to maturity	Number of siliquae/Plant	Length of siliquae	Number of seed/siliquae	Test weight	Seed Yield	Stover Yield	Harvest index
W0-Weedcheck	22.00	1.33	2.51	1.58	56.50	115.5	239	6.45	10.95	4.51	14.60	40.29	26.60
W1-Handweeding30days	21.50	1.27	2.42	1.51	56.00	114.5	223	6.30	10.70	4.42	19.55	51.83	27.39
W2-Alachlor0.75kgha^{1}	23.15	1.56	2.70	1.78	58.10	118.8	284	7.25	12.30	4.75	16.50	45.07	26.80
W3-Pendimethalin 0.75kgh*a^-1	22.20	1.36	2.56	1.60	57.00	116.6	259	6.60	11.20	4.58	18.40	49.75	27.00
W4-Pendimethalin0.75kgh+ handweeding(30DAS)	23.30	1.63	2.75	1.81	58.00	118.6	281	7.20	12.25	4.70	16.40	44.84	26.78
W5-Alachlor0.75kgha^{1}+ handweeding(30 DAS)	22.30	1.38	2.58	1.62	56.90	116.4	253	6.55	11.15	4.56	15.80	43.49	26.65
W6-Metolachlor0.75kgha^{1}+ handweeding(30DAS)	21.80	1.30	2.48	1.55	56.40	115.3	232	6.40	10.90	4.48	15.40	42.49	26.60
W7-Metribuzin(PE)@175gha^{-1}+HandweedingaT$_3$0DAS	21.70	1.29	2.51	1.57	56.50	115.5	228	3.35	10.80	4.46	14.60	40.29	26.60
SEM±	0.86	0.06	0.11	0.07	2.42	2.28	4.12	0.11	0.18	0.18	0.27	1.76	-
CD(P=0.05)	NS	1.08	NS	0.20	NS	NS	11.94	0.31	0.53	NS	2.09	5.09	-

Conclusion
The current study emphasises how crucial efficient weed control is to improving Indian mustard's development, yield characteristics, and productivity in Uttar Pradesh's subtropical climate. Inadequate management of weed competition can result in significant output losses of up to 30–50% for mustard, an essential oilseed crop. The results showed that integrated methods greatly increased plant height, leaf area index, number of siliquae per plant, siliqua length, and eventually seed output, especially when Pendimethalin at 0.75 kg/ha was combined with manual weeding at 30 DAS. Herbicide-based integrated treatments offered efficient and labour-saving alternatives, even if manual weeding alone yielded the greatest seed and stover. While yield quality measures like test weight and harvest index increased under selected treatments, days to flowering and maturity were only slightly impacted. All things considered, the best sustainable strategy to close mustard production disparities without increasing cultivated area is through integrated weed control.

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