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Keshav
M.Sc. (Ag) Scholar, Agronomy, FASAI, Rama University, Kanpur-209217, India

Ravikesh Kumar Pal
Department of Agronomy, Faculty of Agriculture Science and Allied Industries, Rama University, Kanpur, Uttar Pradesh, India

Awanindra Kumar Tiwari
Scientist- Plant Protection (Entomology), Krishi Vigyan Kendra, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, India

Vikram Singh
Assistant Professor, Department of Agriculture, NIILM University, Kaithal, Haryana, India

Durgesh Kumar Maurya
Department of Agronomy, Faculty of Agriculture Science and Allied Industries, Rama University, Kanpur, Uttar Pradesh, India

Kuldeep Maurya
M.Sc. (Ag) Scholar Agril. Economics, NDUA&T Ayodhya, Uttar Pradesh, India

Corresponding Author:
Ravikesh Kumar Pal
Department of Agronomy, Faculty of Agriculture Science and Allied Industries, Rama University, Kanpur, Uttar Pradesh, India

To study the effect of integrated weed management on growth and yield on Indian mustard (*Brassica juncea* L.)

Keshav, Ravikesh Kumar Pal, Awanindra Kumar Tiwari, Vikram Singh, Durgesh Kumar Maurya and Kuldeep Maurya

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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 To study the effect of integrated weed management on growth and yield on Indian mustard (*Brassica juncea* L.)".The soil was normal in pH of 7.60, electrical conductivity (EC) of 0.25 dSm-1, organic carbon content of 0.44%, and available nutrients including nitrogen (N), phosphorus (P), and potassium (K) at levels of 216.20, 19.13, and 149.20 kg ha^{-1}, respectively. The experiment was laid out during Rabi season of 2023-24. The experiment consisted of 15 treatment combinations, was laid out in Randomized Block Design (RBD) with three replications.

Keywords: Herbicides, mustard, mulch, yield

Introduction
Breast health awareness has resulted in increasing detection of early breast cancer and Rapeseed is referred to locally as sarson, toria, and yellow toria, while mustard (*Brassica juncea* L.) 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, the oil is used for frying and cooking purposes and is consumed by humans. The entire seed is used as a condiment to flavor vegetables and curries, as well as to prepare pickles. In addition, mustard oil is utilized in the tanning, hair oil, medication, soap, and vegetable ghee preparation industries. Mustard seeds range in oil content from 37 to 49% (Bhowmik *et al*., 2014) [1]. Because it contains two essential fatty acids, linoleic and linolenic, and has the least amount of harmful saturated fatty acids of any edible oil, rapeseed-mustard oil that is available in India is superior nutritionally to many other edible oils. Erucic acid and glucosinolates are regarded as undesirable when present (Devi *et al*. 2017) [2]. High in nutrients, the seeds have 38–57% erucic acid, 5–13% linolic acid, and 27% oleic acid. The leftover oil cake from extraction is used as manure and cattle feed, and it contains 5.1% N, 1.8% P2O5, and 1.1% K2O. Because of its greater adaptability and ability to take advantage of residual moisture, this is a crop that could be grown during the winter (rabi) season (Mukherjee, 2010) [3].

After the United States, China, and Brazil, the edible oil industry in India is the fourth largest globally. India holds a significant position in the global edible oil market, contributing approximately 7% to production, 12% to consumption, and 20% to imports of edible oils between 2016 and 2017 (USDA 2018) [4]. According to Renjini and Girish (2019) [5], the amount of edible oil imported in 2000–01 was 4.3 mt, costing approximately Rs. 4320 crores. In 2015–16, that amount increased to 15 mt, costing approximately Rs. 65000 crores. India holds a significant position as the world's third-largest producer of oilseeds, following China and Canada. Rapeseed and mustard occupied nearly 36.68 million hectares worldwide in 2017–18, with a total production of 70.42 million tonnes and a productivity of 1919 kg ha–1 (DRMR, 2018) [6]. In India, mustard is the second most important crop for edible oil seeds, right after groundnuts. It has a significant impact on the nation's oil seed economy. In India, the rapeseed-mustard acreage was 6.07 mha in 2017–18, yielding 7.92 mt of production and 1304 kg ha-1 of productivity (DRMR, 2018) [6]. Still, in the 2017–18 season, Uttar Pradesh had 0.90 mha of rapeseed–mustard with 0.95 mt of production and a productivity of 1055 kg ha–1. Rajasthan, on the other hand, had the largest area (2.12 mha) and production (2.45 mt) with the lowest productivity (1152 kg ha–1), while Gujarat had the highest productivity (1373 kg ha–1) in 0.22 mha of production (0.30 mt). The largest area (0.053 mha), production (0.077 mt), and productivity (1453 kg ha-1) in U.P. were found in the Mathura district. Despite the fact that during the 1980s, the expansion of oilseed crops came at the expense of coarse grains and pulses. Thus, farmers were unable to find oilseed cultivation to be appealing (Ramasamy and Selvaraj 2002) [7].

Trianthema monogyna L., *Cyperus rotundus* L., *Cynodon dactylon* (L.) Pers., *Anagallis arvensis* L., *Melilotus indica* L., *Chenopodium murale* L., and other weeds are the most frequently found in rapeseed mustard crops. Therefore, in order to prevent competition for reserve moisture, weeds must be removed in the early stages of crop growth. Timely weed management is critical to maximizing mustard yield potential. In mustard, weed control can be achieved through mechanical and cultural means that lower the benefit-cost ratio.

To close the gap between supply and demand, crop productivity must be increased. Early on, mustard weed competition is more severe. In the first four to six weeks following sowing, crop growth in the wintertime remains sluggish. In rapeseed-mustard, the critical period of crop-weed competition is 15–40 days, and depending on the weed flora, its intensity, stage, nature, and duration of the crop-weed competition, weeds can cause an alarming decline in crop production ranging from 15–30% to a complete failure (Shekhawat *et al*., 2012) [8]. Due to their competition for light, moisture, space, plant nutrients, and other environmental requirements, weeds impede crops' ability to grow normally (Upadhyay *et al*., 2012) [9]. Currently, 25 to 30 DAS of hand weeding is sufficient to control weeds in their early stages, but manual weed management has become expensive and time-consuming due to a lack of laborers and rising wages. Hand weeding proved to be ineffective and expensive compared to the use of selective herbicides (Yadav *et al*., 1997) [10]. Through broad-spectrum weed control, the use of post-emergence herbicides alone or in combination may increase the window of opportunity for weed management (Choudhary *et al*. 2018) [11].

In addition to lowering weed pressure (Qin *et al*. 2015, Massimo *et al*. 2016) [12, 13], reducing evaporation (Pawar *et al*. 2004), increasing soil water retention capacity, and regulating soil temperature fluctuations, mulching improves water use efficiency and crop yield. Crop productivity and vegetation dynamics have benefited from organic mulching (Burkhard *et al*. 2009) [15]. Mulching also enhances soil quality by changing the soil's hydraulic conductivity, water-holding capacity, and resistance to root penetration, all of which have an impact on crop yield and growth (Mondal *et al*. 2008) [17]. Additionally, organic mulches improve crop yield by adding soil organic matter and plant nutrients (Leblanc *et al*. 2006, Teame *et al*. 2017) [, 17]. In addition to stopping weed germination, it also lowers soil temperature, requiring fewer irrigations (Dubey, 2018) [18]. To a degree of 30 to 85%, mulching reduced the growth of weeds; however, mulch composition greatly varies (Choudhary *et al*. 2018) [11].

Other mechanical weed-control techniques are equally cost-effective and efficient. Before and after planting the crop, weeds are mechanically removed in India using a variety of hand tools and implements. These consist of the inter-row cultivator, disc plough, hand chisel (khurpi), hand hoe, wheel hoe, blade harrow, country plough (bakhar), and soil turning tools. Even though inter-row weeds are successfully controlled with these weeding tools, intra-row weeds still needed to be manually removed (Dubey, 2018) [18].

Materials and techniques

A field experiment was carried out on loamy sand in the rural Kanpur district of Mandhana, which is 10 km from Kanpur in Uttar Pradesh, during the rabi season of 2022–2023. to research how integrated weed control affects Indian mustard (*Brassica juncea* L.) growth and yield. The pH of 7.60, EC of 0.25 dSm-1, organic carbon content of 0.44%, and available nutrient levels of nitrogen (N), phosphorus (P), and potassium (K) at 216.20, 19.13, and 149.20 kg ha-1, respectively, were all within normal ranges for the soil. The Rabi season of 2023–2024 is when the experiment was set up. The experiment, which had three replications and a Randomized Block Design (RBD) layout, comprised fifteen treatment combinations. T1 Pendimethalin (PE) at 1000 g ha-1, T2 Isoproturon (POE) at 1000 g ha-1 at 20 DAS, T3 Pendimethalin (PE) at 1000 g ha-1 + Hand weeding at 40 DAS, T4 Isoproturon (POE) at 1000 g ha-1 + Hand weeding at 40 DAS, T5 Pendimethalin (PE) at 1000 g ha-1 + Paddy straw mulch at 5 t ha-1 at 2-3 DAS, T6 Isoproturon (POE) at 1000 g ha-1 + Paddy straw mulch at 5 t ha-1 at 2-3 DAS, and T7 Meltribuzin (PE) @ 175 g ha-1 T9 Metribuzin (PE) @ 175 g ha-1 + Hand weeding at 40 DAS, T8 Quizalofop-ethyl (POE) @ 60 g ha-1 at 20 DAS DAS, T10 Quizalofop-ethyl (POE) @ 60 g ha-1 + Hand weeding at 40 DAS, T11 Metribuzin (PE) @ 175 g ha-1 + Paddy straw mulch @ 5 t ha-1 at 2-3 DAS, T12 Quizalofop-ethyl (POE) @ 60 g ha-1 + Paddy straw mulch @ 5 t ha-1 at 2-3 DAS, T13 Paddy straw mulch @ 10 t ha-1 at 2-3 DAS, T14 Hand weeding at 20 and 40 DAS, T15 Weedy checkdata were collected on five plants selected from each plot.

Results and Discussion

Yield attributes and yields

Data on yield attributes and yield, including harvest index (%), length of siliqua (cm), number of seeds siliqua-1, test weight (g), seed yield (q ha-1), stover yield (q ha-1) and number of siliquae plant-1, have been presented for Indian mustard due to different weed management practices.

Number of siliquae plant^{-1}

With the exception of hand weeding at 20 and 40 DAS (T14), the maximum number of siliquae plants-1 (284) was recorded under pendimethalin (PE) @ 1000 g ha-1 + hand weeding at 40 DAS (T3) and were found to be statistically comparable with T5, T9, and T14. Nonetheless, the corresponding values of 186 were discovered in weedy check plots.

Length of siliqua (cm)

With the exception of hand weeding at 20 and 40 DAS (T14), the longest siliqua (7.25 cm) was observed in pendimethalin (PE) @ 1000 g ha-1 + hand weeding at 40 DAS (T3). It was discovered, nevertheless, to be statistically comparable to T5, T9, and T14 and noticeably better than the other treatments. In weedy check plots, the smallest siliqua (5.60 cm) was observed.

Number of seeds siliqua^{-1}

The data clearly show that after hand weeding at 20 and 40 DAS (T14), which was statistically on par with T5, T9, and T14, pendimethalin (PE) @ 1000 g ha-1 + hand weeding at 40 DAS (T3) had a significantly higher number of seeds siliquae-1 (12.30). But under weedy check, the minimum number of seeds siliqua-1 was significantly lower (9.50).

Test weight (g)

Herbicides, mulching, and hand weeding did not significantly affect the 1000 seed weight (g). Pendimethalin (PE) at 1000 g ha-1 plus hand weeding at 40 DAS (T3) was the herbicidal treatment that produced the highest 1000 seed weight (4.75 g). In addition to chemical treatments, hand weeding at 20 and 40 DAS yielded higher 1000 seed weight values (4.80 g) than the weedy check (4.35 g).

Seed yield (q ha^{-1})

Pendimethalin (PE) at 1000 g ha-1 plus hand weeding at 40 DAS (T3), among other weed management techniques, recorded the highest seed yield (19.55 q ha-1) and was statistically comparable to T5, T9, and T14 over weedy check (12.90 q ha-1). In addition to chemical treatments, hand weeding at DAS 20 and 40 (T14) yielded the maximum amount of seeds (20.20 q ha-1). The application of pendimethalin (PE) @ 1000 g ha-1 + hand weeding at 40 DAS (T3) over weedy check resulted in a 51.5% increase in seed yield. Nonetheless, weedy control resulted in the minimum seed yield being recorded.

Stover yield (q ha^{-1})

The table's data made it abundantly evident that the stover yield was significantly impacted by weed management strategies. Pendimethalin (PE) @ 1000 g ha-1 + hand weeding at 40 DAS (T3) produced the highest stover yield (51.83 q ha-1) among the herbicidal treatments, comparable to T5, T9, T11, and T14. The application of pendimethalin (PE) @ 1000 g ha-1 + hand weeding at 40 DAS (T3) over weedy check resulted in a recorded increase in seed yield of (45%). In addition to chemical treatments, stover yield was significantly increased by hand weeding at 20 and 40 DAS (53.36 q ha-1). Nonetheless, the weedy check resulted in the lowest stover yield ever measured (35.82 q ha-1).

Harvest index (%)

information on how herbicides, mulching, and hand weeding have affected the harvest index. With the exception of hand weeding at 20 and 40 DAS (T14), which was followed by T5, T9, and T11, and the lowest harvest index (26.48%) under weedy check, an application of pendimethalin (PE) @ 1000 g ha-1 + hand weeding at 40 DAS (T3) recorded the highest harvest index (27.39%).

Conclusion

Pendimethalin (PE) @ 1000 g ha-1 + manual weeding at 40 DAS produced the greatest mustard seed yield (19.55 and 21.15 q ha-1). In terms of seed yield, this was statistically comparable to treatments T5 and T9 and outperformed the others. Additionally, under pendimethalin (PE) @ 1000 g ha-1 + manual weeding at 40 DAS (51.83 q ha-1), the highest stover yield of mustard was noted. Comparable statistically to T5, T9, and T11 was this finding. Under the weedy check, the lowest seed and stover yields were observed. Yadav *et al*. (2013) also reported similar results.

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