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Effect of integrated weed management on growth parameters and yield attributes of Indian mustard (*Brassica juncea* L.)

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Abstract
A field experiment was conducted with ten treatments pendimethalin (PE) @1.0kg ha^{-1}, isoproturon (POE) @1.20kg ha^{-1}, pendimethalin (PE) @1.0kg ha^{-1} +hand weeding at 45 DAS, isoproturon (POE) @1.20kg ha^{-1} +hand weeding at 45 DAS, pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5t ha^{-1}, isoproturon (POE) @1.20kg ha^{-1} +straw mulch @5tha^{-1}, straw mulch @10tha^{-1} (3 DAS), two hand weeding at 20 and 40 DAS, glyphosate @0.5 ml litre^{-1} of water at 20 and 40 DAS and weedy check respectively at Agronomy Research Farm, Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U. P.), India, during *rabi* season of the year 2016-17. The crop was infested with the divergent type of weed flora e.g. *Phalaris minor* and *Cynodon dactylon* of grassy, *Chenopodium album*, *Anagallis arvensis*, *Melilotus alba*, *Vicia hirsuta*, *Lathyrus aphaca* and *Rumex* sp. of broad-leaved and *Cyperus rotundus* of sedges group. Weed density of the different weed species and total weeds affected significantly due to different weed management practices, two hand weeding at 20 and 40 DAS *fb* pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5tha^{-1}, and straw mulch @10 tha^{-1} (3 DAS), were found more effective in reducing the nutrient uptake by weeds and maximizing crop growth parameters resulted in higher yield attributes (siliquae plant^{-1}, length of silique and seeds siliqua^{-1}) and seed yield of mustard as compared to rest of the treatments.

Keywords: Pre-emergence herbicides, post-emergence herbicides, mulching, and hand weeding

Introduction
Rapeseed-Mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm oil (*Elaeis guineensis jacq.*). But in India second major oilseed crop after groundnut, accounting nearly 25-30% of total oilseeds production. As an irrigated crop in North-Western India, Indian mustard suffers more from weed competition especially at the early stage of crop growth. Weeds cause yield reduction to the tune of 10-58% (Banga and Yadav 2001 and Malik *et al.* 2012) [1, 8] depending on the type, intensity and duration of the competition. Uncontrolled weeds reduce mustard yield by 68% as compared to weed-free conditions (Degra *et al.* 2011) [4]. Moreover, the competition of weeds with crop plant causes severe nutrition deprivation in general (Roshdy *et al.*, 2008) [12]. The most common practice of weed management in Indian mustard is manual weeding at 3-4 weeks after sowing. But, day to day increasing wages, scarcity of labor at peak periods and high-cost involvement compel to search other alternatives that are technically feasible and economically viable so that these measures can manage the weed infestations below the economic threshold level and allow harnessing the yield potential of this crop (Kalita *et al*., 2017) [5]. Weeds are regarded as one of the major negative factors of crop production loss due to competition for nutrients, moisture, light, and space which have been reported as high as 30-70% (Tewari *et al.*, 1998) [14]. Moreover, wages are shooting high these days. The yield loss in mustard can be minimized by the management of weeds at the right time and proper method. Among the various factors responsible for the low productivity of mustard, weed control is one of the most important constraints. As this crop is grown in poor soils with poor crop management practices, weed infestation is one of the major causes of low productivity (Singh, 1992) [13]. There is the number of methods available by which weeds can be managed effectively and efficiently in the mustard crop. Among them, manual weeding has been very common and effective but high wages and non-available labor at the right time further make it uneconomical, besides, there are many intra row weed which often remain uncontrolled. On the other hand, weed control by herbicides has been found effective to control, both inter and intra row weeds.

Mulching has a smothering effect on weeds by restricting solar light which affects photosynthesis by weeds. It is effective against annual weeds and some perennial weeds. Mulching with straw when applied on soil surface does not allow weeds to germinate as light does not reach the soil. Mulches not only conserve soil moisture but also impart beneficial effects like suppression of extreme fluctuation of soil temperature, reduce water loss through evaporation resulting in more stored soil moisture. Hand weeding twice showed the maximum management 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) [4]. During the *Rabi* season, some weeds emerged very early and some weeds in the later stage of crop growth. Under such conditions, the sequential application of herbicides is most important to control weeds. Thus, an integrated weed management approach is essential to control the weeds that emerged in different stages of crop growth.

Materials and Methods

The experiment was conducted during *Rabi* season 2016-17 at Agronomy Research Farm of Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh (26^0 47' N latitude, 82^0 12' E longitude and 113 meters altitude) India. The soil of the experimental field was slightly alkaline in reaction (7.9 pH), low in organic carbon (0.32%) and low in available nitrogen (136.5kg ha^{-1}), phosphorus (14.5kg ha^{-1}) and medium in potassium (248.5kg ha^{-1}). The average annual rainfall was 1073 mm and out of which about 80 percent was received by the south-west monsoon. During the experiment, the minimum and maximum temperature ranged between 4.9^0C and 37.8^0C, respectively, whereas minimum and maximum relative humidity ranged between 33 and 95.14% during the crop period. Ten treatments *Viz.* pendimethalin (PE) @1.0kg ha^{-1}, isoproturon (POE) @1.20kg ha^{-1}, pendimethalin (PE) @1.0kg ha^{-1} +hand weeding at 45 DAS, isoproturon (POE) @1.20kg ha^{-1} +hand weeding at 45 DAS, pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5tha^{-1}, isoproturon (POE) @1.20kg ha^{-1} +straw mulch @5tha^{-1}, straw mulch @10tha^{-1} (3 DAS), two hand weeding at 20 and 40 DAS, glyphosate @0.5 ml $litre^{-1}$ of water at 20 and 40 DAS and weedy check respectively in a randomized block design (RBD) with three replications. The size of the experimental plot was 14.04 m^{-2}. The seeds of mustard variety 'NDR-8501' were sown in row to row 45 cm and 15 cm in plant to plant, on October 19, 2016-17, using seed @5kg ha^{-1}. Urea, DAP, muriate of potash and sulphur were used to supply 120kg N, 60kg P_2O_5, 40kg K_2O and 40kg S ha^{-1}, respectively. Half dose of nitrogen and full dose of phosphorus potassium and sulphur were applied as basal dressing in the field at the time of sowing in furrows. Remaining half dose of nitrogen through urea was top-dressed after first irrigation. The recommended cultural practices and plant protection measures were followed to rise the healthy crop. The number of weeds was recorded from three places selected at random in each plot by using quadrant of 50 cm x 50 cm size after that the samples were dried in a hot air oven at 70±2°C for 48 hours or till a constant weight attained and then weed dry weight was recorded in gm^{-2}. The five number of plants was selected at random in each plot to take crop growth parameters and yield attributes. The herbicides were sprayed with the help of a hand-operated Knapsack sprayer fitted with flat fan nozzle using 600 liters of water ha^{-1}.

Results and Discussion

Effect on weeds

The pre-dominant weeds were noted in the experimental field was *Phalaris minor*, *Chenopodium album*, *Anagallis arvensis*, *Melilotus alba*, *Vicia hirsuta*, *Lathyrus aphaca* and *Rumex sp.* of grassy weeds and *Cyperus rotundus* of sedges group. A similar type of weed flora in the mustard crop was reported by Yadav, (2004) [15] and Bisen and Singh, (2008) [2]. All the weed management practices did not significantly influenced nutrient content in weeds over the weedy check. While nutrient uptake by weeds was significantly affected under various weed management practices. Two hand weeding at 20 and 40 DAS recorded significantly lower nutrient uptake by weeds over the rest of the treatments. After that treatment minimum nutrient uptake was recorded with pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5tha^{-1} fb straw mulch @10tha^{-1} (3 DAS) and pendimethalin (PE) @1.0kg ha^{-1} +hand weeding at 45 DAS. It might be because of the fact that the lowest quantity of dry weight of weeds was accumulated in that treatment plot. A similar type of results has been reported by Meena and Shah (2011) [9].

Table 1: Effect of integrated weed management on nutrient content in weeds as well as nutrient uptake by weed.

Symbols	Treatments	NPK content (%) in weeds			NPK uptake (kg ha^{-1}) by weeds		
		N	P	K	N	P	K
T_1	Pendimethalin (PE) @1.0kg ha^{-1}	1.59	0.31	1.35	13.59	2.65	11.54
T_2	Isoproturon (POE) @1.20kg ha^{-1}	1.45	0.29	1.29	14.31	2.86	12.73
T_3	Pendimethalin (PE) @1.0kg ha^{-1} +Hand weeding at 45 DAS	1.64	0.33	1.34	12.13	2.44	9.90
T_4	Isoproturon (POE) @1.20kg ha^{-1} +Hand weeding at 45 DAS	1.56	0.30	1.28	12.22	2.35	10.02
T_5	Pendimethalin (PE) @1.0kg ha^{-1} +Straw mulch @5tha^{-1}	1.46	0.27	1.36	9.51	1.76	8.85
T_6	Isoproturon (POE) @1.20kg ha^{-1} +Straw mulch @5tha^{-1}	1.62	0.33	1.26	13.23	2.69	10.29
T_7	Straw mulch @10tha^{-1} (3 DAS)	1.64	0.32	1.27	11.49	2.24	8.89
T_8	Two hand weeding at 20 and 40 DAS	1.65	0.27	1.26	9.13	1.49	6.96
T_9	Glyphosate @0.5 ml $litre^{-1}$ of water at 20 and 40 DAS	1.61	0.32	1.35	13.94	2.77	11.69
T_{10}	Weedy check	1.66	0.34	1.37	43.92	8.99	36.25
SEm±		0.05	0.02	0.04	0.92	0.23	0.82
CD (P=0.05)		NS	NS	NS	2.74	0.68	2.45

Effect on Crop

All weed management practices showed significant differences in plant height. Out of all the treatments, significantly tallest plants were recorded under two hand weeding at 20 and 40 DAS at all crop growth stages fb pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5tha^{-1} and pendimethalin (PE) @1.0kg ha^{-1} +hand weeding at 45 DAS due to effective management of weeds and maintenance of

favourable condition for better crop growth. Minimum plant height was recorded in weedy check which might be due to their lethal effect on crop, which is the main reason behind competition with crop and ultimately reduced the plant height at all the stages at a greater extents (Table-2). These results are in conformity by Kumar *et al*., (2012) [7] and Regar *et al*., (2007) [11]. Better growth and development of the crop under a competition-free environment with effective management practices of weeds due to different weed management practices showed an influence on the formation of higher yield attributing characters. The yield attributing characters viz. siliquae plant^{-1}, length of siliqua, seeds siliqua^{-1} and leaf area index increased with weed management practices. Two hand weeding at 20 and 40 DAS fb pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5tha^{-1}, straw mulch @10tha^{-1} (3 DAS) and pendimethalin (PE) @1.0kg ha^{-1} +hand weeding at 45 DAS recorded significantly higher yield attributes. These results are also conformity by Chauhan *et al.,* (2005) [3] and Mukherjee, (2014) [10].

Table 2: Effect of integrated weed management on plant height, leaf area index, number of siliquae plant^{-1}, length of siliqua and number of seeds siliqua^{-1}.

Symbols	Treatments	Plant height at harvest (cm)	Leaf Area Index at 90 DAS	Number of siliquae plant^{-1}	Length of siliqua (cm)	Number of seeds siliqua^{-1}
T_1	Pendimethalin (PE) @1.0kg ha^{-1}	173.12	3.54	253.97	5.63	10.75
T_2	Isoproturon (POE) @1.20kg ha^{-1}	172.02	3.44	245.48	5.51	10.57
T_3	Pendimethalin (PE) @1.0kg ha^{-1} +Hand weeding at 45 DAS	178.59	3.92	270.51	5.94	11.97
T_4	Isoproturon (POE) @1.20kg ha^{-1} +Hand weeding at 45 DAS	177.46	3.69	269.21	5.73	11.59
T_5	Pendimethalin (PE) @1.0kg ha^{-1} +Straw mulch @5tha^{-1}	182.88	4.09	275.21	6.11	12.08
T_6	Isoproturon (POE) @1.20kg ha^{-1} +Straw mulch @5tha^{-1}	176.08	3.61	257.28	6.01	10.95
T_7	Straw mulch @10tha^{-1} (3 DAS)	179.95	3.96	273.68	5.96	12.02
T_8	Two hand weeding at 20 and 40 DAS	186.11	4.16	280.86	6.12	12.32
T_9	Glyphosate @0.5 ml litre^{-1} of water at 20 and 40 DAS	164.35	3.31	235.45	5.29	9.74
T_{10}	Weedy check	151.19	2.87	213.41	5.46	9.36
SEm±		5.93	0.15	7.48	0.19	0.44
CD (P=0.05)		17.63	0.45	22.21	NS	1.31

As far as the 1000-seed weight or test weight and harvest index were concerned, it was not significantly affected due to different weed management practices (Table-3), as it is directly related to the genetic character and seed yield and stover yield of the crop or variety. However, weed-free treatments were superior treatment over other treatments. The higher seed yield is contributed by the different yield attributes. The treatments in which these attributes got better response ultimately would give more seed as well as stover yield. As the different weed management practices influenced the growth attributes and yield attributes significantly. Consequently, influenced the seed yield. In the same manner, two hand weeding at 20 and 40 DAS, pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5tha^{-1}, straw mulch @10tha^{-1} (3 DAS) and pendimethalin (PE) @1.0kg ha^{-1} +hand weeding at 45 DAS being at par recorded significantly higher seed yield over rest of the treatments (Table-3). Improvement in yield contributing characters and thereby seed yield under weed management practices may be attributed to low weed pressure. Weedy check plot had the lowest seed yield due to higher weed density and dry matter accumulation. Weed in untreated plot reduced seed yield of mustard by 49.24 percent, Kumar *et al.* (2012) [6] and Kumar and Kaur (2015) [6] had also obtained more plant height, seed yield and yield attributing characters with weed management practices over untreated plot.

Table 3: Effect of integrated weed management on seed yield, stover yield, biological yield, harvest index, and test weight.

Symbols	Treatments	Seed yield (Kg ha^{-1})	Stover yield (Kg ha^{-1})	Biological yield (Kg ha^{-1})	Harvest index (%)	Test weight (g)
T_1	Pendimethalin (PE) @1.0kg ha^{-1}	1860	5190	7050	26.38	4.58
T_2	Isoproturon (POE) @1.20kg ha^{-1}	1805	4915	6720	26.86	4.58
T_3	Pendimethalin (PE) @1.0kg ha^{-1} +Hand weeding at 45 DAS	2129	5723	7852	27.11	4.72
T_4	Isoproturon (POE) @1.20kg ha^{-1} +Hand weeding at 45 DAS	2097	5581	7678	27.31	4.66
T_5	Pendimethalin (PE) @1.0kg ha^{-1} +Straw mulch @5tha^{-1}	2263	6092	8355	27.08	4.85
T_6	Isoproturon (POE) @1.20kg ha^{-1} +Straw mulch @5tha^{-1}	2046	5505	7551	27.09	4.74
T_7	Straw mulch @10tha^{-1} (3 DAS)	2155	5761	7916	27.22	4.79
T_8	Two hand weeding at 20 and 40 DAS	2277	6158	8435	26.99	4.88
T_9	Glyphosate @0.5 ml litre^{-1} of water at 20 and 40 DAS	1459	4097	5556	26.25	4.34
T_{10}	Weedy check	1281	3587	4868	26.31	4.21
SEm±		74.71	196.34	264.44	0.78	0.18
CD (P=0.05)		221.93	583.28	785.57	NS	NS

Conclusion

The nutrient content was not significantly differ from treatment to treatment but in case of nutrient uptake, two hand weeding at 20 and 40 DAS was observed with less nutrient uptake by weeds fb pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5tha^{-1} was also noticed to absorb less nutrient uptake as compared to rest of the treatment due to less weed density and their dry weight. However, it was noticed that two-hand weeding at 20 and 40 DAS fb pendimethalin (PE) @1.0kg ha^{-1} +straw mulch @5t ha^{-1} were equally better in terms of crop growth parameters as well as yield attributes characters and then ultimately higher seed yield was observed under two hand weeding at 20 and 40 DAS fb Pendimethalin (PE)

@1.0kg ha^{-1} +Straw mulch @5tha^{-1} was found better among all treatments.

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