Int.J.Curr.Microbiol.App.Sci (2020) Special Issue-10: 271-276

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-10 pp. 271-276**
Journal homepage: http://www.ijcmas.com

Original Research Article

Integrated Weed Management in Indian Mustard (*Brassica juncea* L.)

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Keywords

Pre-emergence herbicides, Post-emergence herbicides, Mulching and hand weeding

A B S T R A C T

A field experiment was conducted at Agronomy Research Farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U. P.), India during the *Rabi season* 2016-17 to access the "Integrated weed management in Indian mustard (*Brassica juncea.* L.)". The experiment was performed with Randomized Block Design. The experiment comprised of three replications and ten treatments *viz.* pendimethalin (PE) @ 1.0 kg ha^{-1}, isoproturon (POE) @ 1.20 kg ha^{-1}, pendimethalin (PE) @ 1.0 kg ha^{-1} + hand weeding at 45 DAS, isoproturon (POE) @ 1.20 kg ha^{-1} + hand weeding at 45 DAS, pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1}, isoproturon (POE) @ 1.20 kg ha^{-1} + straw mulch @ 5 t ha^{-1}, straw mulch @ 10 t ha^{-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. Results revealed that the total weed population and their dry weight, weed index are lowest in two hands weeding at 20 and 40 DAS while, weed control efficiency is highest in two hand weeding at 20 and 40 DAS during course of investigation. However growth, yield attributes, yields, and quality increased significantly under two hand weeding at 20 and 40 DAS. On the basis of the economics of different treatments, the most economical and remunerative with maximum net returns (Rs. 69277.00 ha^{-1}) in pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1} along with maximum B:C ratio (2.07) for the mustard crop.

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 2001and Malik *et al.,* 2012) 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). Moreover, the competition of weeds with crop plant causes severe nutrition deprivation in general (Roshdy *et al.,* 2008). 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 below the economic threshold level and allow harnessing the yield potential of this crop (Kalita *et al.,* 2017). Weeds are regarded as one of the major negative factors of crop production loss due to competition for nutrients, moisture, light, and space which has been reported as high as 30-70% (Tewari *et al.,* 1998).It is costly and difficult affair as the operation coincides with the sowing of other rabi crops. Moreover, wages are shooting high these days. The yield loss in mustard can be minimized by the control 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). There is the number of methods available by which weeds can be controlled 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 remains 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 control 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). 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 carried out at the Agronomy Research Farm of the Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) India. The experiment was laid in uniform topography and well-drained soil which had invariably less fertility status and saline-alkaline condition. The soil of the experimental site was silty loam having pH 7.9, organic carbon 0.32% and 136.50, 14.50 and 248.50 kg ha^{-1} Nitrogen, Phosphorus and Potassium respectively. 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. The experiment was conducted in the Randomized Block Design consisting of ten treatments and three replications. The size of the experimental plot was 14.04 m^{-2}. Sowing of mustard was done on 19^{th}October under irrigated condition, with spacing 45 cm (row to row) and 15 cm (plant to plant) and fertilizer dose 80: 40: 20

(N: P_2O_5: K_2O Kg ha^{-1}) respectively. Variety NDR-8501 is recommended for timely sown irrigated conditions. The optimum sowing time of this variety lies between 15th October to 15th November with 120-130 days' maturity period, having average yield potential of about 20-25 q ha^{-1}. Different chemical compounds were sprayed in different quantities and at different growth stages of mustard for reducing the weed competition. The experiment involved 10 treatment combinations consisted of ; pendimethalin (PE) @ 1.0 kg ha^{-1}, isoproturon (POE) @ 1.20 kg ha^{-1}, pendimethalin (PE) @ 1.0 kg ha^{-1} + hand weeding at 45 DAS, isoproturon (POE) @ 1.20 kg ha^{-1} + hand weeding at 45 DAS, pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1}, isoproturon (POE) @ 1.20 kg ha^{-1} + straw mulch @ 5 t ha^{-1}, straw mulch @ 10 t ha^{-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 sampling time (30, 60, 90 DAS and at harvest), a quadrant of 50 × 50 cm was placed at two places in each plot to determine the density and dry weight of different weeds. Weed dry weight was recorded after drying the weed samples at 70±2°C for 48 hr. Weed control efficiency and weed index was calculated based on the data recorded at the harvest stage of mustard as per the standard formula. Weed density and Weed dry weight were square-root transformed before analysis. However, for better understanding, original values are given in parenthesis.

Results and Discussion

Total weed population, weed dry-matter, weed control efficiency and weed index

Among Integrated weed management, two hand weeding treatment resulted in minimum density of total weeds and weed dry matter at 30, 60, 90 and at harvest stage compared to rest of the treatments which were followed by glyphosate @ 0.5 ml $liter^{-1}$ of water at 20 and 40 DAS remained at par with two hand weeding, at 30 and 60 DAS, while straw mulch @ 10 t ha^{-1} (3 DAS) was at par with two hand weeding, at 90 DAS, but at harvesting stage pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1} was at par with two hand weeding this result was also found by Punia *et al.,* (2006) and Kumar *et al.,* (2012). Integrated weed management is an effective tool for weed control in mustard, which have also been observed by Mukherjee (2014).

The highest weed control efficiency at harvest stage of crop growth was recorded under two hand weeding treatment (79.06 %) closely followed by pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1} (75.36 %) while minimum weed control efficiency (62.69%) was recorded in isoproturon (POE) @ 1.20 kg ha^{-1} this results were also supported by Bamboriya *et al.,* (2016), Chauhan *et al.,* (2005) and Degra *et al.,* (2011).Thus, both these treatments provided the crop better environment for luxuriant growth and later on, the crop itself acted as smoother crop and curbed the growth of weeds beneath the crop coverage.

Weed index is the measure of the reduction in yield caused by weed infestation and directly related to weed density and weed dry matter. Two hands weeding at 20 & 40 DAS followed by pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1}(0.61%) recorded lowest weed index as compared to weed index of the weedy check was (43.47%). This was mainly due to lesser crop weed competition in integrated weed management practices as compared to weedy check within term resulted higher yield vice-versa reduce weed index.

Effect of the IWM on economics of mustard

The data related to the cost of cultivation has been presented in Table-2.The highest cost of cultivation was recorded under two hand weeding at 20 and 40 DAS (Rs.40854 ha^{-1}) followed by straw mulch @ 10 t ha^{-1} at 3 DAS (Rs.37354 ha^{-1}) and minimum cost of cultivation was recorded in weedy check (Rs.27354 ha^{-1}). The data related to gross returns has been presented in Table-2. Maximum gross returns were recorded under two hand weeding at 20 and 40 DAS (Rs.103396 ha^{-1}) followed by pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1} (Rs.102704 ha^{-1}) and minimum gross returns was recorded under weedy check (Rs.58414 ha^{-1}).The data related to net return has been presented in Table-2. Maximum net returns were recorded under pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1} (Rs.69277 ha^{-1}) followed by two hand weeding at 20 and 40 DAS (Rs.62542 ha^{-1}) and minimum net return were recorded in weedy check (Rs.31060 ha^{-1}).The data related to B:C ratio has been presented in Table-2. Maximum B:C ratio was recorded under pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1} (2.07) followed by pendimethalin (PE) @ 1.0 kg ha^{-1} (1.98) and minimum B:C ratio was recorded in weedy check (1.13).The results were also supported by Upasani *et al.*, (2017).

Table.1 Effect of integrated weed management on total weed population, weed dry weight, weed control efficiency and weed index

Symbols	Treatments	Total weeds population m^{-2}				Total weeds dry weight m^{-2} (g)				Weed control efficiency (%)	WI (%)
		30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest		
T_1	Pendimethalin (PE) @ 1.0 kg ha^{-1}	6.45 (41.22)	8.24 (67.54)	8.78 (76.68)	7.48 (55.51)	5.21 (26.66)	8.74 (75.99)	9.66 (92.87)	9.27 (85.52)	67.68	11.98
T_2	Isoproturon (POE) @ 1.20 kg ha^{-1}	8.07 (64.77)	6.98 (48.33)	8.87 (78.23)	8.04 (64.18)	6.30 (39.23)	7.90 (61.96)	10.22 (104.09)	9.96 (98.71)	62.69	18.97
T_3	Pendimethalin (PE) @ 1.0 kg ha^{-1} + Hand weeding at 45 DAS	6.55 (42.48)	5.70 (32.00)	7.82 (60.72)	6.73 (44.81)	5.26 (27.19)	6.80 (45.82)	9.47 (89.28)	8.97 (79.97)	72.04	6.49
T_4	Isoproturon (POE) @ 1.20 kg ha^{-1} + Hand weeding at 45 DAS	8.08 (63.99)	5.68 (31.82)	8.04 (64.28)	6.92 (47.44)	6.15 (37.34)	6.49 (41.66)	9.71 (93.83)	8.88 (78.37)	70.38	07.90
T_5	Pendimethalin (PE) @ 1.0 kg ha^{-1} + Straw mulch @ 5 t ha^{-1}	6.05 (36.12)	6.69 (44.26)	7.54 (56.54)	6.06 (36.24)	4.86 (23.16)	8.29 (68.25)	9.18 (83.82)	8.10 (65.19)	75.36	0.61
T_6	Isoproturon (POE) @ 1.20 kg ha^{-1} + Straw mulch @ 5 t ha^{-1}	7.47 (55.39)	6.07 (36.42)	7.69 (58.69)	7.33 (53.24)	5.95 (35.00)	7.10 (49.96)	9.49 (89.58)	9.06 (81.72)	69.11	10.14
T_7	Straw mulch @ 10 t ha^{-1} (3 DAS)	6.41 (40.69)	6.89 (47.07)	7.45 (55.12)	6.31 (39.34)	5.64 (31.39)	7.93 (62.42)	9.34 (86.88)	8.40 (70.07)	73.52	05.35
T_8	Two hand weeding at 20 and 40 DAS	5.89 (34.20)	4.11 (16.44)	6.61 (43.22)	5.46 (29.38)	4.83 (22.88)	5.11 (25.71)	7.93 (62.42)	7.47 (55.39)	79.06	00
T_9	Glyphosate @ 0.5 ml $litre^{-1}$ of water at 20 and 40 DAS	6.19 (37.93)	5.03 (24.82)	8.51 (71.97)	7.81 (60.64)	5.04 (24.94)	6.01 (35.69)	9.56 (90.93)	9.33 (86.61)	67.27	35.92
T_{10}	Weedy check	8.14 (65.88)	9.96 (98.87)	12.14 (146.99)	10.69 (113.96)	6.37 (40.12)	11.35 (128.45)	16.76 (280.59)	16.28 (264.63)	00	43.47
SEm±		0.33	0.32	0.34	0.36	0.37	0.44	0.49	0.43	-	-
CD (P=0.05)		0.99	0.95	1.01	1.09	NS	1.30	1.46	1.27	-	-

Population figure transforms to root √x+0.5 transformation actual figures are given in parenthesis

Table.2 Effect of integrated weed management on Economic analysis of various treatment combinations

Symbols	Treatments	Common cost of cultivation (Rs ha^{-1})	Treatments cost of cultivation (Rs ha^{-1})	Total cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C Ration
T_1	Pendimethalin (PE) @ 1.0 kg ha^{-1}	**27354**	**1073**	**28427**	**84780**	**56353**	**1.98**
T_2	Isoproturon (POE) @ 1.20 kg ha^{-1}	**27354**	**1539**	**28893**	**82030**	**53137**	**1.83**
T_3	Pendimethalin (PE) @ 1.0 kg ha^{-1} + Hand weeding at 45 DAS	**27354**	**7073**	**34427**	**96606**	**62179**	**1.80**
T_4	Isoproturon (POE) @ 1.20 kg ha^{-1} + Hand weeding at 45 DAS	**27354**	**7539**	**34893**	**95042**	**60149**	**1.72**
T_5	Pendimethalin (PE) @ 1.0 kg ha^{-1} + Straw mulch @ 5 t ha^{-1}	**27354**	**6073**	**33427**	**102704**	**69277**	**2.07**
T_6	Isoproturon (POE) @ 1.20 kg ha^{-1} + Straw mulch @ 5 t ha^{-1}	**27354**	**6539**	**33893**	**92850**	**58957**	**1.73**
T_7	Straw mulch @ 10 t ha^{-1} (3 DAS)	**27354**	**10000**	**37354**	**97722**	**60368**	**1.61**
T_8	Two hand weeding at 20 and 40 DAS	**27354**	**13500**	**40854**	**103396**	**62542**	**1.53**
T_9	Glyphosate @ 0.5 ml litre^{-1} of water at 20 and 40 DAS	**27354**	**1168**	**28522**	**66554**	**38032**	**1.33**
T_{10}	Weedy check	**27354**	**00**	**27354**	**58414**	**31060**	**1.13**

In conclusion, the lowest weed population and weed dry weight, and highest weed control efficiency was observed in two hand weeding at 20 and 40 DAS, while lowest weed index inpendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1}. However, it was also noticed that pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1} were equally good in terms of suppressing weed population at 60 DAS. The maximum seed yield was observed under two hand weeding at 20 and 40 DAS, but economic point of view pendimethalin (PE) @ 1.0 kg ha^{-1} + straw mulch @ 5 t ha^{-1} was found better among all treatments.

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