Annals of Plant and Soil Research 24(3):481-486 (2022)
https://doi.org/10.47815/apsr.2022.10196

Weed management practices in Indian mustard (*Brassica juncea* L.) in lower Gangetic plain Zone

DEEPAK PANDEY*, RAM PRATAP SINGH, GAJENDRA SINGH, SUDHAKAR SINGH AND PRITHVI RAJ

Department of Agronomy, A.N.D. University of Agriculture & Technology, Kumarganj, Ayodhya (Uttar Pradesh)

Received: February, 2022; Revised accepted: April. 2022

ABSTRACT

The field experiment was conducted during rabi season in 2017-18 and 2018-19 at the Agronomy Research Farm, A.N.D. University of Agriculture & Technology, Kumarganj, (Ayodhya)to find out the effect of weed management practices on productivity and economics of mustard (Brassica juncea L.). Fifteen treatments were evaluated in randomized block design with three replications. Two hand weedings at 20 and 40 DAS recorded significantly lowest population and dry weight of weeds as compared to rest of the treatments during both the years. Among the herbicides combination, pendimethalin (PE) @ 1000 g ha^{-1} applied either with hand weeding at 40 DAS or paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS recorded the lowest weed density and dry weight m^{-2} followed by metribuzin (PE) @ 175 g ha^{-1} either with hand weeding at 40 DAS or paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS. Weedy check till maturity recorded significantly highest density and dry weight of weeds as compared to rest of the treatments during both the years. Pre-emergence spray of pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS being at par with two hand weeding at 20 and 40 DAS but recorded highest values of all yield attributes and yields as compared to rest of the treatments. The increase in grain yield due to pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS was recorded to the tune of 10.4% over pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS. The yield losses due to weedy check till maturity was recorded to the tune of 58.2%, 53.3% and 43.3% as compared to two hand weeding applied at 20 and 40 DAS, pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS, and pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS, respectively. The highest net income (Rs. 57394 ha^{-1}) and B:C ratio (1.5) was recorded with pendimethalin (PE) @ 1000 g ha^{-1}+ hand weeding at 40 DAS which was followed by two hand weeding at 20 and 40 DAS with net income of Rs. 55485 ha^{-1} and B:C ratio 1.49.

Key words: Economics, mustard, WCE, yield and weed management

INTRODUCTION

Mustard (*Brassica juncea* L.) belonging to family cruciferous (syn. Brassicacae) is the third important oilseed crop grown in the world after soybean (*Glycine max*) and palm (*Elaeis guineensis* Jacq.) oil. The oil content in mustard seeds varies from 37-49 %.Indiais an important rapeseed-mustard growing country in the world,occupying the fourth position in area and production. Among the major factors responsible for low productivity of mustard, weed management is the utmost important. Weeds cause alarming reduction in crop production that range from 15–30% to complete failure of mustard crop. Weeds compete with crop plants for water, space, light and nutrients. Weeds also impairing quality of produce and various kinds of health and environmental hazards.Weed competition in mustard crop is more serious in early stages because crop gets slow growth during the first 4-8 weeks after sowing. However, the critical period for crop-weed competition is 15–40 days (Sharma *et al*., 2018). Therefore, to improve the growth and yield of mustard, timely and proper control of weeds is indispensable. The traditional practice of hand/mechanical weeding once during early stages of crop growth i.e., 25-30 days after sowing (DAS) is not sufficient because new flushes of weeds appears after every manual weeding or irrigation or winter rainfall, and most importantly they take away major portion of the nutrients and moisture from the soil. However, hand weeding in mustard is though easy but unavailability of labours at right time coupled with high wage makes it costly besides, several intra row weeds remains uncontrolled. Thus, use of herbicide may be the best option to control the complex weed flora in mustard. Hence, pre-and post emergence herbicides application or herbicides along with hand weeding may be the best alternative for

**Corresponding author email:deepakpandey.agri@gmail.com*

controlling the diverse weed flora in mustard crop. Application of pendimethalin (PE) was found effective in managing the weeds (Rao and Chauhan 2015). Hence, economical feasibility of herbicides with and without manual weeding or mulching is to be evaluated in mustard crop. Considering the above fact in view, the present experiment was planned to evaluate the economic feasibility of integration of herbicides with or without manual weeding or with mulching for mustard crop.

MATERIALS AND METHODS

The present experiment was conducted during *Rabi s*eason of 2017-18 and 2018-19 at Agronomy Research Farm Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya. The experimental soil was silty-loam in texture with pH 8.3, having low organic carbon (3.3 g kg^{-1}) and available nitrogen (137 kg ha^{-1}), medium in available phosphorus (15.2 kg ha^{-1}) and high in potassium (249 kg ha^{-1}). Fifteen weed management practices, *i.e.* T_1-Pendimethalin (PE) @ 1000 g a.i. ha^{-1} , T_2-Isoproturon (POE) @ 1000 g a.i. ha^{-1} at 20DAS, T_3-Pendimethalin (PE) @ 1000 g a.i. ha^{-1} + Hand weeding at 40DAS, T_4-Isoproturon (POE) @ 1000 g a.i. ha^{-1} + Hand weeding at 40DAS, T_5-Pendimethalin (PE) @ 1000 g a.i. ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_6-Isoproturon (POE) @ 1000 g a.i. ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_7-Metribuzin (PE) @ 175 g a.i. ha^{-1} , T_8-Quizalofop-ethyl (POE) @ 60 g a.i. ha^{-1} at 20DAS, T_9-Metribuzin (PE) @ 175 g a.i. ha^{-1} + Hand weeding at 40DAS, T_{10}-Quizalofop-ethyl (POE) @ 60 g a.i. ha^{-1} + Hand weeding at 40DAS, T_{11}-Metribuzin (PE) @ 175 g a.i. ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_{12}-Quizalofop-ethyl (POE) @ 60 g a.i. ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_{13}-Paddy straw mulch @ 10 t ha^{-1} at 2-3DAS , T_{14}-Hand weeding at 20 and 40DAS and T_{15}-Weedy check, were tested in randomized block design with three replications. The mustard variety cv. '*NDR-8501'* was sown manually at 45 cm apart rowsusing seed rate of 5 kg ha^{-1} on October, 22 during both the years. The recommended dose of nitrogen (80 kg ha^{-1}), phosphorus (40 kg P_2O_5 ha^{-1}), potassium (20 kg K_2O ha^{-1}) and sulphur (20 kg ha^{-1}) was applied. The half dose of nitrogen through urea and full dose of phosphorus by single super phosphate and potassium by muriate of potash was applied as basal. Remaining quantity of nitrogen was applied in two equal split i.e. branching and flowering. The herbicides were applied using knapsack sprayer fitted with flat fan nozzle with spray volume of 500 L ha^{-1}. The other package of practices was adopted to raise the crop as per the recommendations. The crop was irrigated twice at flowering and siliqua formation. Weed counts was recorded by placing 0.5 m^2 quadrates at two spot random in each plot and weeds pulled out were first, sun dried and thereafter kept in electric oven at temperature of 70 ± 1^{0C} for 72 h, until constant weight is attained. The weed data recorded on density and dry weight were subjected to square root transformation before analysis as $\sqrt{x}$ + 0.5. The standard statistical procedure was adopted to analyze the recorded data as per procedure advocated by Gomez and Gomez (1984). The data pertaining to yield attribute were recorded on five plant of mustard selected randomly from each plot before harvesting of the crop.

RESULTS AND DISCUSSION

Weeds

Data (Table 1) indicated that application of paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS, being *at par* with pendimethalin (PE) @ 1000 g ha^{-1} alone recorded significantly lower weed population and weed dry weight over isoproturon (POE) @ 1000 g ha^{-1}at 20 DAS, and quizalofop-ethyl (POE) @ 60 g ha^{-1} at 20 DAS during both the years of experimentation. Pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS recorded the lowest weed density(18.0 and 17.0 m^{-2}) and weed dry weight (24.6 and 23.7gm^{-2}) in respective years followed by metribuzin (PE) @ 175 g ha^{-1} + hand weeding at 40 DAS. Among the herbicides along with paddy straw mulch treatments,the lowest weed population (21.0 and 20.2 m^{-2}) and weed dry weight (28.7 and 27.8 g m^{-2}) in respective years was significantly recorded with pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS followed by metribuzin (PE) @ 175 g ha^{-1} + paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS. Two hand weeding at 20 and 40 DAS recorded significantly lowest weed population (16.0 and 15.2 m^{-2}) and weed dry weight (21.9 and 21.0 g m^{-2}), in respective years as compared to rest of the treatments. Weedy check till maturity recorded significantly highest weed population

and dry weight as compared to rest of the treatments. The lowest weed population and weed dry weight was recorded with pendimethalin (PE) @ 1000 g ha^{-1}+ paddy straw mulch @ 10 t ha^{-1}as compared to rest of the herbicide + paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS which was mainly because of efficient control of both (narrow & broad leaved weeds) due to broad spectrum control of weeds as compared to other tested herbicides. Similarly lower weed population and weed dry weight in mustard crop was recorded with pendimethalin (PE) @ 1000 g ha^{-1} (Patel *et al*. 2013)**.** Among the herbicides + hand weeding treatments, pendimethalin @ 1000 g ha^{-1} + hand weeding at 40 DAS recorded lowest weed population (18.0 and 17.2m^{-2}) and dry weight (24.6 and 23.7g m^{-2}) in respective years as compared to rest of treatments. This was mainly due to the fact that pre-emerged weeds was effectively controlled by pendimethalin and post-emerged weeds by hand weeding applied at 40 DAS. Similarly lower weed population and dry weight with pendimethalin @ 1000 g ha^{-1} + hand weeding at 40 DAS in mustard crop was reported by Lal *et al*. (2017).

Table 1: Effect of weed management practices on weed density, weed dry weight, WCE (%), WCI (%) and HEI (%) in mustard crop

Treatments	Weed population (m^{-2}) at 60 DAS		Weed dry weight (g m^{-2}) at 60 DAS		Weed control efficiency (%)		Weed control index (%)		Herbicide efficiency index (%)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1	6.52 (42.10)	6.41 (40.70)	7.61 (57.65)	7.50 (55.90)	82.3	84.0	69.6	71.1	0.82	0.91
T_2	6.67 (44.10)	6.58 (42.90)	7.79 (60.40)	7.70 (58.95)	80.5	82.4	67.7	69.3	0.70	0.79
T_3	7.65 (58.10)	7.54 (56.50)	8.93 (79.55)	8.82 (77.50)	75.4	77.7	62.1	63.9	0.35	0.43
T_4	7.04 (49.10)	6.95 (47.80)	8.22 (67.25)	8.12 (65.65)	78.0	80.1	64.9	66.6	0.55	0.64
T_5	6.21 (38.10)	6.10 (36.80)	7.25 (52.20)	7.14 (50.60)	84.8	86.5	72.4	73.9	0.93	1.03
T_6	4.30 (18.00)	4.20 (17.20)	5.01 (24.65)	4.92 (23.75)	98.5	99.0	87.4	88.1	4.11	4.64
T_7	4.63 (21.00)	4.55 (20.20)	5.40 (28.70)	5.32 (27.85)	95.8	96.6	84.6	85.4	2.57	2.82
T_8	5.78 (33.00)	5.69 (32.00)	6.75 (45.20)	6.67 (44.05)	89.8	91.2	78.0	79.2	1.27	1.41
T_9	5.05 (25.00)	4.95 (24.10)	5.89 (34.25)	5.80 (33.20)	92.4	93.4	80.8	81.8	1.74	1.93
T_{10}	4.63 (21.00)	4.54 (20.20)	5.41 (28.75)	5.32 (27.85)	96.7	97.4	85.5	86.4	2.96	3.23
T_{11}	4.85 (23.00)	4.75 (22.10)	5.65 ()31.50	5.55 (30.40)	94.2	95.1	82.8	83.7	2.12	2.35
T_{12}	5.96 (35.10)	5.87 (34.00)	6.97 (48.10)	6.87 (46.75)	87.4	88.7	75.2	76.5	1.10	1.22
T_{13}	5.43 (29.10)	5.34 (28.10)	6.34 (39.80)	6.26 (38.70)	90.7	91.9	78.9	80.1	1.44	1.60
T_{14}	4.06 (16.00)	3.96 (15.20)	4.73 (21.90)	4.63 (21.00)	99.1	99.4	94.9	95.3	0.00	0.00
T_{15}	10.02 (100.20)	10.14 (102.60)	12.14 (147.30)	12.22 (148.90)	0.0	0.0	0.0	0.0	0.00	0.00
SEM±	0.21	0.21	0.26	0.23	-	-	-	-	-	-
CD (P=0.05)	0.62	0.62	0.76	0.67	-	-	-	-	-	-

Note: Fig. in parenthesis are the original value, $\sqrt{x}$ + 0.5 transformation

T_1-Pendimethalin (PE) @ 1000 g ha^{-1}, T_2-Metribuzin (PE) @ 175 g ha^{-1}, T_3-Isoproturon (POE) @ 1000 g ha^{-1} at 20DAS, T_4-Quizalofop-ethyl (POE) @ 60 g ha^{-1} at 20DAS, T_5-Paddy straw mulch @ 10 t ha^{-1} at 2-3DAS, T_6-Pendimethalin (PE) @ 1000 g ha^{-1} + Hand weeding at 40DAS, T_7-Metribuzin (PE) @ 175 g ha^{-1} + Hand weeding at 40DAS, T_8-Isoproturon (POE) @ 1000 g ha^{-1} + Hand weeding at 40DAS, T_9-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Hand weeding at 40DAS, T_{10}-Pendimethalin (PE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_{11}-Metribuzin (PE) @ 175 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_{12}-Isoproturon (POE) @ 1000 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_{13}-Quizalofop-ethyl (POE) @ 60 g ha^{-1} + Paddy straw mulch @ 5 t ha^{-1} at 2-3DAS, T_{14}-Hand weeding at 20 and 40DAS and T_{15}-Weedy check

The results further revealed that weed control efficiency (98.4 and 99.0%), weed control index (87.4 and 88.1) and herbicide efficiency index (4.1 and 4.6 %), in respective years exhibited similar trend as in case of weed density and dry weight and being highest with pendimethalin @ 1000 g ha^{-1} + hand weeding at 40 DAS followed by pendimethalin @ 1000 g ha^{-1} + paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS. Paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS applied as alone resulted in highest weed control efficiency (84.8 and 86.5%), weed control index (72.4 and 73.9%) and herbicide efficiency index (0.93 and 1.03%) over rest of herbicide applied as alone. This was because of continuous suppression of emerging weeds by paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS.

Yield attributes and yield

Data (Table 2) revealed that yield attributes like siliqua $plant^{-1}$, length of siliqua, seeds $siliqua^{-1}$ and test weight of mustard were affected significantly due to different weed management practices during both the years. Application of paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS recorded higher value of all yield attributes followed by pendimethalin (PE) @ 1000 g ha^{-1} alone. The higher value of yield attribute with paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS was because of the fact that the mulching suppressed the emergence of weeds growth continuously resulted in higher availability of nutrients and synthesis of higher photosynthates which was translocated to reproductive parts of plant consequently improved the yield attributes of mustard crop as compared to herbicide applied alone. In general, application of herbicide with hand weeding being at par with herbicide with paddy straw mulch but recorded significantly higher values of all yields attributes as compared to rest of the treatments. However, pre-emergence application of pendimethalin @ 1000 g ha^{-1} + hand weeding at 40 DAS recorded higher values of all yield attributes as compared to pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS as reported by Bamboriya *et al*. (2016). Two hand weeding at 20 and 40 DAS being at par with pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS, and metribuzin (PE) @ 175 g ha^{-1} + hand weeding at 40 DAS but recorded significantly higher values of all yield attributes during both years of experimentation. This was because of efficient control of pre and post emerged weeds by hand weeding caused higher availability of plant nutrients enhanced the synthesis of photosynthates and its translocation to different parts of the mustard crop resulted in higher growth and yield attributes. Similarly higher values of all yield attributes with two hand weeding at 20 and 40 DAS or pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS was reported by Kumar *et al*. (2012) and Tetarwal *et al*. (2013).

Table 2:.Effect of weed management practices on yield attributing character of mustard crop

Treatments	No. of siliquae $plant^{-1}$		Length of siliquae (cm)		No. of seeds $siliquae^{-1}$		Test weight (g)	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1	239	244	6.4	7.1	10.9	11.7	4.5	5.0
T_2	232	237	6.4	7.0	10.9	11.6	4.4	5.0
T_3	223	227	6.3	6.9	10.7	11.4	4.4	4.9
T_4	228	232	6.3	6.9	10.8	11.5	4.4	4.9
T_5	246	251	6.5	7.1	11.1	11.8	4.5	5.1
T_6	284	290	7.2	7.9	12.3	13.1	4.7	5.3
T_7	278	283	7.0	7.6	11.9	12.6	4.6	5.2
T_8	259	264	6.6	7.2	11.2	11.9	4.5	5.1
T_9	268	274	6.7	7.3	11.4	12.2	4.6	5.1
T_{10}	281	287	7.2	7.8	12.2	13.0	4.7	5.2
T_{11}	273	278	6.9	7.5	11.7	12.5	4.6	5.2
T_{12}	253	258	6.5	7.1	11.1	11.8	4.5	5.1
T_{13}	265	271	6.7	7.3	11.4	12.1	4.6	5.1
T_{14}	290	296	7.3	7.9	12.4	13.1	4.8	5.3
T_{15}	186	189	5.6	6.2	9.5	10.3	4.3	4.8
SEM±	4.1	4.1	0.1	0.1	0.2	0.2	0.2	0.2
CD (P=0.05)	11.9	11.8	0.3	0.3	0.5	0.5	NS	NS

Application of paddy straw mulch @ 10 t ha^{-1} at 2-3 DAS (Table 3) recorded higher seed yield (16.20 and 17.32 q ha^{-1}) in respective years followed by pendimethalin (PE) @ 1000 g ha^{-1}, metribuzin (PE) @ 175 g ha^{-1}and quizalofop-ethyl (POE) @ 60 g ha^{-1} at 20 DAS applied alone and being lowest seed yield (14.6 and 15.7 q ha^{-1}) with isoproturon (POE) @ 1000 g ha^{-1} at 20 DAS. The higher values of yield attributes with former treatments as compared to poor values of yield attributes with later treatments was the main reason for higher yield with former treatments. The per cent increase in yield due to application ofpaddy straw mulch @ 10 t ha^{-1} at 2-3 DAS was recorded to the tune of 0.5, 2.31, 4.94 and 10.48 over pendimethalin (PE) @ 1000 g ha^{-1}, metribuzin (PE) @ 175 g ha^{-1}, quizalofop-ethyl (POE) @ 60 g ha^{-1} at 20 DAS and isoproturon (POE) @ 1000 g ha^{-1} at 20 DAS, respectively. Pre-emergence application of pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS being at par with metribuzin (PE) @ 175 g ha^{-1} + hand weeding at 40 DAS but recorded significantly higher seed (19.55 and 21.10 q ha^{-1}) and stover yield (51.8 and 53.8 q ha^{-1}) as compared to rest of the treatments except two hand weeding applied at 20 and 40 DAS. This was due to efficient control of weeds and higher availability of nutrients to mustard resulted in higher growth and yield attributes with above treatments responsible for higher yield of mustard. Among the herbicides along with paddy straw mulch treatments,pendimethalin (PE) + paddy straw mulch recorded the highest seed yield (18.40 and 19.65 q ha^{-1}) in respective years which was followed by metribuzin (PE) @ 175 g ha^{-1} + paddy straw mulch @ 5 t ha^{-1} at 2-3 DAS owing to efficient control of weeds due to continuous suppression of weed growth.

Table 3: Effect of weed management practices on yield and economics in mustard

Treatments	Seed yield (q ha^{-1})			Stover yield (q ha^{-1})		Net return (Rs ha^{-1})		B:C ratio	
	2017-18	2018-19	Mean	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
T_1	16.1	17.2	16.6	44.2	45.5	41219	51818	1.3	1.6
T_2	15.8	16.9	16.4	43.5	44.6	40764	51258	1.3	1.6
T_3	14.6	15.7	15.2	40.3	41.4	34713	44768	1.1	1.4
T_4	15.4	16.5	15.9	42.5	43.6	38072	48407	1.2	1.5
T_5	16.2	17.3	16.7	44.5	45.7	32747	43225	0.8	1.1
T_6	19.5	21.2	20.3	51.8	53.8	50537	64251	1.3	1.6
T_7	18.0	19.2	18.6	48.7	50.3	44624	56301	1.2	1.5
T_8	16.5	17.6	17.1	45.1	46.4	37269	47988	0.9	1.3
T_9	17.2	18.4	17.8	46.7	48.3	40132	51423	1.1	1.3
T_{10}	18.4	19.6	19.0	49.7	51.3	46521	58318	1.3	1.5
T_{11}	17.6	18.8	18.2	47.8	50.2	43832	55722	1.2	1.5
T_{12}	16.4	17.5	16.9	44.8	46.2	37823	48515	1.0	1.3
T_{13}	16.8	18.0	17.4	45.7	47.3	39332	50392	1.1	1.4
T_{14}	20.2	21.8	21.0	53.2	55.3	48525	62446	1.1	1.4
T_{15}	12.9	13.6	13.3	35.8	36.8	27817	35598	0.9	1.1
SEM±	0.7	0.7	0.7	1.7	1.6	-	-	-	-
CD (P=0.05)	2.1	2.0	2.1	5.1	4.8	-	-	-	-

Two hand weeding applied at 20 and 40 DAS recorded 3.1 and 10.4% higher seed yield over pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS, and pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 5 t ha^{-1} at 2-3 DAS, respectively. The increase in seed yield due to pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS over pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 5 t ha^{-1} at 2-3 DAS was recorded to the tune of 10.4%. Weed check till maturity reduced the seed yield by 58.2, 53.3 and 43.3% as compared to two hand weeding applied at 20 and 40 DAS, pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS and pendimethalin (PE) @ 1000 g ha^{-1} + paddy straw mulch @ 5 t ha^{-1} at 2-3 DAS, respectively. The higher yield either with two hand weeding applied at 20 and 40 DAS or pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS was mainly attributed to efficient control of weeds, higher availability of nutrients, high growth of crop and synthesis of more photosynthesis which transferred to sink resulted in higher values of yield attributes and

seed yield. Similar higher seed and stover yield with two hand weeding applied at 20 and 40 DAS or pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS was reported by Yadav *et al*. (2013).

Economics

Application of pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS (Table 3) recorded highest net income (Rs.50537 and 64251 ha^{-1}) and B: C ratio (1.33 and 1.69) followed by two hand weeding applied at 20 and 40 DASwith net income (Rs.48525 and 62446 ha^{-1}) and B: C ratio (1.13 and 1.45), in respective years. However, the lowest net income (27817 and 35518 ha^{-1}) and B: C ratio (0.9 and 1.15) in respective years was registered under weedy check till maturity treatments. The higher net income and B: C ratio with pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS as compared to two hand weeding applied at 20 and 40 DAS was mainly because of lower cost incurred and proportionally more increase in yield with former treatments as compared to higher cost incurred and proportionally lower increase in yield with the later treatment. Weedy check till maturity however, recorded the lowest net income and B: C ratio because of lower grain and stover yield and high cost incurred.

Hence, it may be concluded that keeping the scarcity of labour and their higher wages, application of pendimethalin (PE) @ 1000 g ha^{-1} + hand weeding at 40 DAS should be applied to control the weed effectively as well as to obtain higher net income and B: C ratio.

REFERENCES

Bamboriya, S.D., Kaushik, M.K., Bamboriya, S.D. and Tiwari, R.C. (2016) Weed dynamics and weed control efficiency under different weed management practices for increased productivity of mustard. *Indian Journal of Weed Science* **48**(4): 458–459.

Gomez, K.A. and Gomez. A.A. (1984) Statistical Procedure for Agriculture Research. Second Edition. John with and Sons Inc. New York.

Kumar, S., Kumar, A., Rana, S.S., Chander, N. and Angiras, N.N. (2012) Integrated weed management in mustard (*Brassica juncea* L.). *Indian Journal of Weed Science***44**:139-143.

Lal, S., Kewat, M.L. and Suryavanshi, T. (2017) Weed indices as influenced by propaquizafop and imazethapyr mixture in soybean. *Internationl Journal of Current Microbiology and Applied Sci*ences **6**(8): 3109-3115.

Rao, A.N. and Chauhan, B.S. (2015) Weeds and weed management in India - A Review. pp. 87–118. In: Proceedings of Weed Science in the Asian Pacific Region. *Indian Society of Weed Science* Hyderabad, India.

Sharma, A.R., Yaduraju ,N.T. and Das, T.K. (2018) Weed management in Indian Agriculture: current scenario and way forward. *Indian Farming* **68**(11): 03-08.

Patel, H.B., Patel, G.N., Ali, S., Patel, D.M. and Patel, N.H. (2013) Effect of integrated weed management on growth, yield and weed parameters in mustard. *Crop Research* **46** (1-3): 109-114.

Tetarwal, J.P., Ram, B.M.D.S. and Tomar, S.S. (2013) Effect of moisture conservation and sulphar sources on productivity and water use efficiency of Indian mustard under rainfed conditions.*Indian Journal of Agronomy* **58**(2):231-236.

Yadav, D.B., Punia, S.S. and Mehta, A. (2013) Weed flora of mustard in Hisar, Biennial Conference of Indian Society of Weed Science on "*Recent Advances in Weed Science Research*". 25-26, Indira Gandhi Krishi Vishwavidyalaya, Raipur (Chhattisgarh).