www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(4): 131-135

www.thepharmajournal.com
Received: 02-02-2021
Accepted: 30-03-2021

Prithvi Raj
Ph.D., Scholar, Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Gajendra Singh
Professor, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Rishav Raj
P.G. Scholar, Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Ajay Kumar
P.G. Scholar, Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Deepak Pandey
Department of Agronomy, Chandra Bhanu Gupta Agriculture Post Graduate College Bakshi Ka Talab, Lucknow, Uttar Pradesh, India

Ravikesh Kumar Pal
Ph.D., Scholar, Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Corresponding Author:
Prithvi Raj
Ph.D., Scholar, Department of Agronomy, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Influence of integrated weed management on growth attributes and quality of Indian mustard (*Brassica juncea* L.)

Prithvi Raj, Gajendra Singh, Rishav Raj, Ajay Kumar, Deepak Pandey and Ravikesh Kumar Pal

Abstract
A field experiment was conducted at the Agronomy Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.), India, during the *Rabi* season 2016-17 to access the "Influence of integrated weed management on growth attributes and quality of Indian mustard (*Brassica juncea* L.)**".** The experiment comprised of ten treatments *viz.* pendimethalin (PE) 1.0 kg/ha, isoproturon (POE) 1.20 kg/ha, pendimethalin (PE) 1.0 kg/ha + hand weeding at 45 DAS, isoproturon (POE) 1.20 kg/ha + hand weeding at 45 DAS, pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha, isoproturon (POE) 1.20 kg/ha + straw mulch 5 t/ha, straw mulch 10 t/ha (3 DAS), two hand weeding at 20 and 40 DAS, glyphosate 0.5 ml/liter of water at 20 and 40 DAS and weedy check respectively with three replication was conducted in Randomized Block Design. The results revealed that two hand weeding at 20 and 40 DAS was at par with pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha and gave higher plant height (181.39, 176.17 cm), with higher dry matter accumulation in g/plant (56.89, 54.18) respectively. Among of all treatments recorded highest number of primary and secondary branches/plant in two hand weeding at 20 and 40 DAS was at par with pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha (9.73, 9.71) and (21.93, 21.48) respectively. And also nutrient content, nutrient uptake, leaf area index as well as oil content and oil yield was found higher in two hand weeding at 20 and 40 DAS while at par with pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ ha. Based on all the observations recorded, two hand weeding at 20 and 40 DAS *fb* pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha has performed better in all parameters amongst all the integrated weed managements practices.

Keywords: Post-emergence herbicides, pre-emergence herbicides, primary and secondary branches, nutrient content and uptake in mustard

Introduction
Among oilseeds, mustard occupies second position after soybean in India. Indian mustard is cultivated in 6.12 m ha area with the annual production of 9.25 mt and average productivity of 1.51 t/ha. In Uttar Pradesh, the area occupied under rapeseed and mustard is 0.75 m ha with the annual production 1.12 mt and average productivity of 1.48 t/ha (Anonymous 2019) [1]. Major states producing mustard are Rajasthan, Punjab, Haryana, Uttar Pradesh, Bihar, Madhya Pradesh, West Bengal and Gujarat. Rajasthan ranks first in both area and production of mustard. Among oilseed *Brassica* species, *Brassica juncea* covered major area which contributes about 80% of the total rapeseed-mustard grown in the country. Its seed contains 37 to 49% oil, besides edible oil, it provides cake for feeding animal and manure, which contains about 4.9% nitrogen, 2.5% phosphorus and 1.5% potash. Weed management is one of the most important agronomic factors that affect the yield of Indian mustard (*Brassica juncea* L.). India is ranked third in production of rapeseed-mustard after Canada and China. Rapeseed-Mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm oil (*Elaeis guineensis jacq*.). As an irrigated crop in North-Western India, Indian mustard suffers more from weed competition specially at the early stage of crop growth. Weeds cause yield reduction to the tune of 10-58% (Banga and Yadav 2001, Malik *et al.* 2012) [3, 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) [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 has been reported as high as 30-70% (Tewari *et al.* 1998) [15]. Management of weed in mustard through manually is effective, but due to high wages of labor and their availability at right time makes it uneconomical.

Besides intra row weeds remain uncontrolled. However management of weeds through herbicides is effective and it managed both intra and inter row weeds. Hence, there is an urgent need to find out the alternative method of weed management which is technically feasible and economically viable so that these measures can manage the weeds below the economic threshold level and allow harnessing the yield potential of this crop (Kalita *et al*. 2017) [6]. The yield loss in mustard can be minimized by manage of weeds at the right time with proper method. Among the various factors responsible for the low productivity of mustard, weed management 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]. 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 manage 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.

Research efforts so far indicate that no any single practice for weed management in Indian mustard crop is economically effective. Hand weeding has been a traditional and effective but economically unfeasible method of weed management in mustard. So, it is imperative to find out the alternative methods for effective weed management for mustard crop to realize maximum yields. Thus, weed management with herbicides by integration of mulching practices may increase the productivity of crops by decreasing the weed density and nutrient removal by the weeds. Hence, the present experiment was planned to find out the effective and economical weed management practices for mustard crop.

Material and Methods

The experiment was carried out at the Agronomy Research Farm of the Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) India. The soil of the experimental site was silty loam having pH 7.9, organic carbon 0.32%, low in available nitrogen (136.50 kg/ha), medium in phosphorus (14.50 kg/ha) and potassium (248.50 kg/ha). The average annual rainfall was 1073 mm and out of which about 80% was received by the south-west monsoon. During the experiment, the minimum and maximum temperature ranged between 4.9 and 37.8^{0}C, 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 with ten treatments comprising *viz.* pendimethalin (PE) 1.0 kg/ha, isoproturon (POE) 1.20 kg/ha, pendimethalin (PE) 1.0 kg/ha + hand weeding at 45 DAS, isoproturon (POE) 1.20 kg/ha + hand weeding at 45 DAS, pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha, isoproturon (POE) 1.20 kg/ha + straw mulch 5 t/ha, straw mulch 10 t/ha (3 DAS), two hand weeding at 20 and 40 DAS, glyphosate 0.5 ml/liter of water at 20 and 40 DAS and weedy check respectively and replicated three times. Sowing of mustard was done on 19th October under irrigated condition. Variety *'NDR-8501'* was sown using 5 kg/ha with spacing 45 cm apart rows to maintain the optimum plant population, at 15 days of sowing thinning was done and plant to plant distance was maintain 15 cm. Before sowing, the seeds were treated with the fungicides dithane M-45 2.0 g/kg seed, for 30 minutes to control soil and seed borne diseases. A dose of fertilizer 80 kg nitrogen, 40 kg phosphorus, 20 kg potassium per hectare was applied. Straw mulch was applied as per the treatments in inter row spacing and irrigation was applied as per requirement of crop during the experimentation. Herbicides were applied as per the treatments with the help of knapsack sprayer and flat-fan nozzle and also used hoods for glyphosate spray with volume 600 liters water/ha. The observation of growth characters was collected at (30, 60, 90 DAS and at harvest), the plant height, number of primary and secondary branches, leaf area index was recorded as five tagged randomly in each net plot. Plant sample recorded for dry weight was first sun dry and thereafter kept in electric oven at 70±2°C for 48 hr to attain constant weight. Nitrogen content was estimated by using micro-kjeldahl distillation method, phosphorus by vanado-molybdo-phosphoric acid yellow colour method, potassium by flame photometer method.

Result and Discussion

Plant height and dry matter accumulation

Plant height (cm) and dry matter accumulation (g/plant) recorded at 30, 60 and 90 DAS of crop are presented in **(Table 1)**, plant height and dry matter accumulation of crop was increased progressively with increase in duration of mustard and reached maximum at 90 DAS and thereafter a slow increase in growth was obtained at harvest. The plant height and dry matter accumulation by crop was significantly influenced by various integrated weed management practices. Two hand weeding at 20 and 40 DAS being at par with pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha and straw mulch 10 t/ha (3 DAS), but recorded significantly maximum plant height and dry matter accumulation over weedy check plot at all stage of crop growth. The minimum plant height and lowest dry matter accumulation by crop was recorded in weedy check plot at all stage of crop growth. Higher plant height and dry matter accumulation with two hand weeding might be due to efficient control of weeds and higher availability of nutrient to crop resulted vigorous growth and development of the plant. On other hand, reduction in uptake of nutrients by crop in weedy check and low in synthesis of growth regulators, which caused reduction in the vegetative growth of crop. Such type results were also reported by Kumar *et al*. (2012), Regar *et al*. (2007) and Tetarwal *et al.* (2013) [7, 10, 14].

Primary and secondary branches

Number of primary and secondary branches are count on 30, 60, 90 DAS and at harvest stage are presented in **(Table 2)**, number of primary branches/plant influenced significantly at 60, 90 DAS and at harvest stage, and being maximum in two hand weeding at 20 and 40 DAS but at par with pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha and straw mulch 10 t/ha (3 DAS). While the minimum number of primary and secondary branches were recorded in weedy check plot. Efficient management of weeds and higher availability of nutrient under two hand weeding and pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha resulted good growth in term of maximum number of primary and

secondary branches/plant. The results are in conformity with Tetarwal *et al.* (2013) [14].

Leaf area index, days taken to 50% flowering, days taken to maturity, oil content and oil yield

Maximum leaf area index at 30 and 60 DAS was recorded with two hand weeding applied at 20 and 40 DAS as compare to rest of treatment however being at par with pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha, straw mulch 10 t/ha (3 DAS) and pendimethalin (PE) 1.0 kg/ha + hand weeding at 45 DAS (Table 3). The minimum leaf area index was recorded in weedy check treatment. It might be due to taller plants with profuse branching having higher number of leaves/plant which resulted increase in number and area of leaves *vis-a-vis*. In addition, integrated weed management practices adequate which favored the nitrogen uptake and nutrient utilization towards protein which favored vertical (plant height) and lateral (branching) growth of the plant and ultimately increased the number and area of leaves and leaf area index. Such type of results was also reported by Sarangi *et al.* (2010) [11].

The oil content (%) in seed was not affected significantly with integrated weed management practices. However the maximum oil content in seed was found with two hand weeding at 20 and 40 DAS, and being lowest in weedy check plot (Table 3). The higher availability of nutrient under all integrated weed management practices as compared to weedy check treatment resulted into development bold seed caused more oil content (%). The results are in conformity with Sharma and Singh (2003) [12].

Maximum seed yield of mustard are recorded with two hand weeding at 20 and 40 DAS as compare to rest of the treatment except applied pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha and straw mulch 10 t/ha (3 DAS) (Table 3). This might be due to adequate nutrient availability and efficient manage of weed resulted less competition of weeds consequently higher growth parameters and yield attributes. The increase in yield was further attributed to better translocation of photosynthates from source to sink due to higher uptake of N, P and K which are responsible for quick and easy translocation of photosynthates. Contrary to this, higher crop weed competetion nutrients, light, space and moisture in weedy check resulted into poor growth and yield attributing characters and lower grain yield. Such type of results was also reported by Chauhan *et al.* (2005) and Mukherjee, (2014) [4, 9].

Nutrient content and their uptake by mustard

Nitrogen, phosphorus and potassium content (%) were not influenced significantly due to various integrated weed management practices. However, the highest content of nitrogen, phosphorus and potassium (NPK) was recorded with two hand weeding at 20 and 40 DAS as compare to rest of the integrated weed management practices (Table 4). The uptake of nitrogen, phosphorus and potassium was influenced significantly due to various integrated weed management practices. Significantly the highest uptake of all the three nutrients (NPK) was recorded with two hand weeding at 20 and 40 DAS as compare to rest of the treatment however being at par with pendimethalin (PE) 1.0 kg/ha + straw mulch 5 t/ha and straw mulch 10 t/ha (3 DAS) the higher uptake with above treatment was mainly due to higher grain yield as uptake of nutrient is function of nutrient content multiplied by yield of respective treatment. The minimum uptake of (NPK) was recorded in the treatment with weedy check plot. The results are in conformity with Weisu *et al*. (2014).

Table 1: Effect of integrated weed management practices on plant height and dry matter accumulation

Symbols	Treatments	Plant height (cm)			Dry matter accumulation/plant (g)			
		30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	At harvest
T_1	Pendimethalin (PE) 1.0 kg/ha	15.37	127.7	169.30	1.45	16.26	40.68	44.02
T_2	Isoproturon (POE) 1.20 kg/ha	13.67	125.23	166.59	1.43	16.06	37.83	42.26
T_3	Pendimethalin (PE) 1.0 kg/ha + Hand weeding at 45 DAS	14.74	135.28	173.23	1.66	18.13	44.88	49.78
T_4	Isoproturon (POE) 1.20 kg/ha + Hand weeding at 45 DAS	14.82	132.44	171.76	1.51	17.87	42.09	47.14
T_5	Pendimethalin (PE) 1.0 kg/ha + Straw mulch 5 t/ha	15.46	140.41	176.17	1.79	20.06	48.25	54.18
T_6	Isoproturon (POE) 1.20 kg/ha + Straw mulch 5 t/ha	14.91	130.33	169.11	1.54	16.47	41.64	46.75
T_7	Straw mulch 10 t/ha (3 DAS)	15.18	136.63	174.67	1.81	19.13	46.88	52.81
T_8	Two hand weeding at 20 and 40 DAS	16.43	144.23	181.39	1.88	20.12	50.99	56.89
T_9	Glyphosate 0.5 ml/litre of water at 20 and 40 DAS	13.16	119.82	161.12	1.36	15.08	36.92	38.79
T_{10}	Weedy check	12.89	114.78	145.12	1.27	9.21	20.79	32.73
S.Em±		0.59	5.03	5.44	0.06	0.59	1.42	1.38
CD (P=0.05)		1.74	14.94	16.18	0.18	1.75	4.22	4.15

PE = Pre-emergence application, POE = Post-emergence application, DAS = Days after sowing

Table 2: Effect of integrated weed management practices on number of primary and secondary branches

Symbols	Treatments	Number of primary branches/plant				Number of secondary branches/plant		
		30 DAS	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1	Pendimethalin (PE) 1.0 kg/ha	2.39	6.76	7.48	7.89	13.00	17.31	18.81
T_2	Isoproturon (POE) 1.20 kg/ha	2.64	6.58	7.46	7.75	13.03	16.99	18.53
T_3	Pendimethalin (PE) 1.0 kg/ha + Hand weeding at 45 DAS	2.43	7.62	8.38	8.73	14.68	18.56	20.27
T_4	Isoproturon (POE) 1.20 kg/ha + Hand weeding at 45 DAS	2.52	7.18	7.94	8.18	13.29	17.39	19.72
T_5	Pendimethalin (PE) 1.0 kg/ha + Straw mulch 5 t/ha	3.05	8.68	9.49	9.71	15.17	19.11	21.48
T_6	Isoproturon (POE) 1.20 kg/ha + Straw mulch 5 t/ha	2.95	6.79	7.55	7.91	14.06	17.97	19.57
T_7	Straw mulch 10 t/ha (3 DAS)	2.30	8.43	9.37	9.46	14.82	18.84	20.32
T_8	Two hand weeding at 20 and 40 DAS	3.04	8.73	9.48	9.73	15.18	19.28	21.93
T_9	Glyphosate 0.5 ml/litre of water at 20 and 40 DAS	2.35	6.20	7.39	7.65	12.48	16.59	18.42
T_{10}	Weedy check	2.37	5.92	6.77	6.88	10.47	13.48	15.29
S.Em±		0.19	0.26	0.31	0.30	0.48	0.63	0.71

CD (P=0.05)	NS	0.79	0.91	0.89	1.44	1.87	2.11

PE = Pre-emergence application, POE = Post-emergence application, DAS = Days after sowing

Table 3: Effect of integrated weed management practices on leaf area index, days taken to flowering, maturity, oil content and oil yield

Symbols	Treatments	Leaf area index		Days taken to 50% flowering	Days taken to maturity	Oil content (%)	Oil yield (Kg/ha)
		30 DAS	60 DAS				
T_1	Pendimethalin (PE) 1.0 kg/ha	1.39	3.91	56.11	117.38	36.68	682.24
T_2	Isoproturon (POE) 1.20 kg/ha	1.37	3.71	55.22	115.78	36.83	664.78
T_3	Pendimethalin (PE) 1.0 kg/ha + Hand weeding at 45 DAS	1.53	4.14	55.56	116.68	36.56	778.36
T_4	Isoproturon (POE) 1.20 kg/ha + Hand weeding at 45 DAS	1.45	3.93	55.77	117.23	37.16	779.24
T_5	Pendimethalin (PE) 1.0 kg/ha + Straw mulch 5 t/ha	1.63	4.31	57.31	117.47	37.41	846.58
T_6	Isoproturon (POE) 1.20 kg/ha + Straw mulch 5 t/ha	1.43	3.94	56.73	117.29	36.84	753.74
T_7	Straw mulch 10 t/ha (3 DAS)	1.58	4.21	57.21	117.15	37.23	802.30
T_8	Two hand weeding at 20 and 40 DAS	1.65	4.51	58.41	118.74	37.68	857.97
T_9	Glyphosate 0.5 ml/litre of water at 20 and 40 DAS	1.32	3.58	55.98	115.37	36.01	525.38
T_{10}	Weedy check	1.28	3.12	55.01	114.47	35.39	453.34
S.Em±		0.05	0.14	1.70	3.02	1.37	24.44
CD (P=0.05)		0.16	0.42	NS	NS	NS	72.61

PE = Pre-emergence application, POE = Post-emergence application, DAS = Days after sowing

Table 4: Effect of integrated weed management practices on nutrient content and their uptake by mustard

Treatments symbols	NPK content (%)						NPK uptake (Kg/ha)								
	N Content (%)		P Content (%)		K Content (%)		N uptake			P uptake			K uptake		
	Seed	Stover	Seed	Stover	Seed	Stover	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
T_1	2.12	0.57	0.91	0.41	1.66	0.65	39.43	29.58	69.01	16.92	20.15	37.07	30.87	33.73	64.60
T_2	2.07	0.55	0.89	0.40	1.64	0.61	37.36	27.03	64.39	16.06	19.66	35.72	29.60	29.98	59.58
T_3	2.14	0.64	0.88	0.41	1.61	0.59	45.56	36.62	82.18	18.73	23.46	42.19	34.27	33.76	68.03
T_4	2.02	0.64	0.93	0.44	1.65	0.60	42.35	35.71	78.06	19.50	24.55	44.05	34.06	33.48	67.54
T_5	2.19	0.65	0.94	0.42	1.62	0.65	49.55	39.59	89.14	21.27	25.58	46.85	36.66	39.59	76.25
T_6	2.05	0.63	0.92	0.43	1.63	0.66	41.94	34.68	76.62	18.82	23.67	43.59	33.34	36.33	69.67
T_7	2.23	0.65	0.93	0.44	1.66	0.66	48.05	37.44	85.49	20.04	25.34	45.38	35.77	38.02	73.79
T_8	2.25	0.66	0.95	0.45	1.67	0.67	51.23	40.64	91.25	21.63	27.71	48.10	38.02	41.25	77.81
T_9	2.01	0.62	0.89	0.42	1.62	0.63	29.32	25.40	54.72	12.98	17.20	30.18	23.63	25.81	49.44
T_{10}	1.98	0.51	0.86	0.39	1.59	0.57	25.36	18.29	43.65	11.01	13.98	24.99	20.36	20.44	40.80
S.Em±	0.12	0.03	0.02	0.02	0.02	0.02	1.89	1.09	-	0.64	0.83	-	0.78	1.12	-
CD (P=0.05)	NS	NS	NS	NS	NS	NS	5.62	3.26	-	1.90	2.47	-	2.33	3.35	-

Conclusion

It is concluded from the above results that two hand weeding at 20 and 40 DAS or pre-emergence spray of pendimethalin 1.0 kg/ha + straw mulch 5 t/ha should be applied for effective management of weeds highest growth, plant height, plant dry matter accumulation, number of primary and secondary branches, leaf area index with highest nutrient uptake by mustard under irrigated condition.

References

1. Anonymous. Agriculture Statistics at a Glance. Department of Agriculture, Cooperation & Farmers Welfare, GOI 2019.
2. Bamboriya SD, Kaushik MK, Bamboriya SD, Tiwari RC. Weed dynamics and weed control efficiency under different weed management practices for increased productivity of mustard. Indian Journal of Weed Science 2016;48(4):458-459.
3. Banga RS, Yadav A. Evaluation of herbicides against complex weed flora in Indian mustard. Haryana Journal of Agronomy 2001;17:48-51.
4. Chauhan YS, Bhargava MK, Jain VK. Weed management in Indian mustard. Indian Journal of Agronomy 2005;50:149-151.
5. Degra ML, Pareek BL, Shivran RK, Jat RD. Integrated weed management in Indian mustard and its residual effect on succeeding fodder pearl millet. Indian Journal of Weed Science 2011;43(1&2):73-76.
6. Kalita S, Mundra SL, Solanki NS, Sharma NK. Weed management and nitrogen application for improved yield of mustard. Indian Journal of Weed Science 2017;49(1):85-87.
7. Kumar S, Kumar A, Rana SS, Chander N, Angiras NN. Integrated weed management in mustard (*Brassica juncea* L.). Indian Journal of Weed Science 2012;44:139-143.
8. Malik RS, Yadav A, Punia SS, Hooda VS, Hasija RC. Efficacy of three dinitroaniline herbicides against weeds in raya. Environment and Ecology 2012;30:787-789.
9. Mukherjee D. Influence of weed and fertilizer management on yield and nutrient uptake in mustard. Indian Journal of Weed Science 2014;46(3):251-255.
10. Rega PL, Rao SS, Joshi NL. Effect of in-situ moisture-conservation practices on productivity of rainfed Indian mustard. Indian Journal of Agronomy 2007;52(3):148-150.
11. Sarangi SK, Saikia US, Lama TD. Effect of rice straw mulching on the performance of rapeseed varieties in rice-rapeseed cropping system. Indian Journal of Agricultural Sciences 2010;80(7):603-605.
12. Sharma RP, Singh P. Effect of weed management and phosphorus levels on yield and quality of Indian mustard (*Brassica juncea* L.). Annals of Agricultural Research 2003;24(3):605-609.
13. Singh SS. Effect of fertilizer application and weed control on the yield of mustard (*Brassica juncea* L.).

Indian Journal of Agronomy 1992;37:196-198.
14. Tetarwal JP, Ram BMDS, Tomar SS. Effect of moisture conservation and sulphur sources on productivity and water use efficiency of Indian mustard under rainfed conditions. Indian Journal of Agronomy 2013;58(2):231-236.
15. Tewari AN, Rathi KS, Singh B. Weed control by herbicides in potato (*Solanum tuberosum*) intercropped with Indian mustard (*Brassica juncea L.).* Indian Journal of Agronomy 1998;43(3):407-41.