Indian Journal of Weed Science **46**(3): 251–255, 2014

Influence of weed and fertilizer managment on yield and nutrient uptake in mustard

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Received: 1 August 2014; Revised: 4 September 2014

ABSTRACT

Field investigation were carried out during winter season of 2011-12 and 2012-13 at Kalimpong (1250 m asl), to evaluate the effect of different fertilizer levels and weed management practices on density and dry matter of weeds and crop-weed completion for nutrient in Indian mustard (*Brassica juncea* (L.) Czern and Coss.). Amongst various fertility levels minimum weed density and dry matter production was recorded with the application of 150% RDF, which was found to be significantly superior to all other main plot treatments. Amongst various chemical treatments, the minimum weed density and weed dry matter production was observed with pendimethalin (0.75 kg/ha) + hand weeding (HW) at 35 DAS, and was at par with the hand weeding twice during both the years, and in second year this was statistically similar with pendimethalin (1.25 kg/ha) and alachlor (1.25 kg/ha). More seed yield was recorded with 150% RDF (2.19 t/ha) in first year and in second year more yield was associated with the 125% RDF (2.07 t/ha). Amongst various herbicidal treatments, during the first year maximum seed yield was registered with pendimethalin (1.25 kg/ha), and was at par with all the treatments except weedy check, fluchloralin (0.75 kg/ha) and pendimethalin (0.75 kg/ha), and in second year highest seed yield was recorded with the hand weeding twice, and was statistically at par with the pendimethalin (1.25 kg/ha), pendimethalin (0.75 kg/ha) + HW at 35 DAS and alachlor (1.25 kg/ha). Amongst various main plot treatments, least nutrient uptake by weed was recorded with the application of 150% RDF. Least nutrient depletion by weed was registered with the hand weeding twice during both the year of data recording, and was at par with the pendimethalin (0.75 kg/ha) + HW at 35 DAS. Economics revealed that application of 150% RDF gave maximum net return (` 19,380). However highest benefit: cost ratio (2.03) was registered with the application of 125% RDF. With sub-plot treatment highest net return (` 19,950) was observed with the hand weeding twice (` 19,950/ha), and was followed by application of pendimethalin (0.75 kg/ha) + HW at 35 DAS (` 19,850/ha). Maximum benefit: cost ratio (2.06) was recorded with the application of pendimethalin (1.25 kg/ha) and was closely followed by pendimethalin (0.75 kg/ha) + HW at 35 DAS (1.91).

Key words: Economics, Fertility levels, Herbicide, Mustard, Nutirent uptake,Weed management, Yield

Oilseeds occupy 27.5 million ha which account for 14% of total cropped area in the country with a production of 24.7 million tonnes, accounting for nearly 5% of the gross national product and 10% of the value of all the agricultural products. Rapeseed and mustard rank third in area (21%) and production (23%) after groundnut (*Arachis hypogaea* L.) and soybean (*Glycine max* L. Merr). The per hectare productivity of the rapeseed and mustard in the country is quite low (1.15 t/ha) against the world average of 1.40 t/ha (Puri and Sharma 2006). Mustard is one of the most important crop adopted by the farmers in the North eastern hill region of India. This is a potential crop in winter (*Rabi*) season due to its wider adaptability and suitability to exploit residual moisture (Mukherjee 2010). It has been estimated that yield depression in rapeseed mustard due to weed infestation varied from 20-70% depending on the composition and density of weed flora and time of their occurrence (O-Donovan *et al.* 2007).

In the past, farmers of Eastern Himalaya were bound to follow traditional weed techniques such as hand-pulling, hand-hoeing or mechanical hoeing. These techniques, besides being labour and energy intensive and weather dependent, are very difficult to apply due to shortage and high cost of labour. Application of adequate fertilizer to plant crop increases their leaf growth, which facilitates earlier shading of the soil surface and thus reduces weed seed germination (Wicks *et al.* 2012). In the past, little attention has been given to improve mustard productivity through IWM in rainfed areas of the Darjeeling hill. Therefore, the proposed study was carried out with the objective to develop suitable fertilizer and weed control technology for mustard production under terraced mid hill condition.

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MATERIALS AND METHODS

A field trial was conducted during *Rabi* winter season of 2011-12 and 2012-13 at Kalimpontg (1250 m asl), Regional Research Station (Hill Zone), Uttar Banga Krishi Viswavidyalaya, Darjeeling, West Bengal. The soil was sandy loam in texture, medium in organic carbon (0.89%), available N (283.15 kg/ha), P_2O_5 (20.31 kg/ha) and K_2O (183.29 kg/ha) content with pH 5.3. The total rainfall recorded during crop growth period was 19.3 and 15.8 mm, minimum temperature ranges from 3.9 to 11.3 and 4.9 to 16.8, and maximum temperature 19.2 to 32.6 and 16.8 to 31.3 ^{0}C during winter 2011 and 2012, respectively. The field experiment was conducted in split plot design with three replications, having 44 treatments combinations of four fertility levels *viz.*75 % RDF, 100% RDF, 125% RDF and 150% RDF in main plot and eleven weed control treatments (*viz*. weedy check, hand weeding twice (25 and 50 DAS), fluchloralin (0.75 kg/ha), fluchloralin (1.25 kg/ha), fluchloralin (0.75 kg/ha) + hand weeding (HW) at 35 DAS, pendimethalin (0.75 kg/ha), pendimethalin (1.25 kg/ha), pendimethalin (0.75 kg/ha) + HW at 35 DAS, alachlor (0.75 kg/ha), alachlor (1.25 kg/ha) and alachlor (0.75 kg/ha) + HW at 35 DAS. Fluchloralin was applied one day prior to sowing of the crop and incorporated immediately into the soil to a depth of 5 cm, while pendimethalin and alachlor were applied three days after sowing. Herbicide were applied through a manually operated foot sprayer with flat fan nozzle using 800 liter water/ha.

The recommended dose of fertilizer (RDF) was 60:40:40 kg N, P_2O_5 and K_2O/ha, respectively for mustard. NPK were supplied through urea, single superphosphate and muriate of potash. Full amount of phosphorus and potash and half of nitrogen was applied at the time of sowing. The remaining dose of nitrogen was top dressed at the pre-flowering stage. Two quadrates of 25 x 25 cm were placed randomly in each plot and weeds within the quadrates were removed and after drying in hot air oven (70 ± 1^{0}C for 72 hrs), weed dry weight was recorded. Mustard cultivar '*Varuna (T 59)*' was shown on 22nd October 2011 and 28th October 2012, respectively. The seed and straw yield was computed from the harvest of net plot and expressed in ha. Plant and soil samples were analyzed for uptake of nitrogen, phosphorus and potash as per standard laboratory procedures (Jackson 1973). Available phosphorous was determined by Olsen's method as outlined by Jackson (1973), using spectrophotometer (660 nm wave length). Available potassium was extracted with neutral normal ammonium acetate and the content of K in the solution was estimated by flame photometer (Jackson 1973). The experimental data were analyzed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of overall difference among treatments by the F test and conclusions were drawn at 5% probability level. Benefit: cost ratio (B: C) was obtained by dividing the gross income with cost of cultivation. The effect of treatments was evaluated on pooled analysis basis on growth, yield attributes and yields.

RESULTS AND DISCUSSION

The most dominant weed species at experimental site were *Anagallis arvensis, Chenopodium album, Convolvulus arvensis, Centella asiatica, Melilotus indica, Medicago polymorpha, Coronopus didymus, Oxalis latifolia* and *Vicia sativa*. During both the years, dicot weeds were predominant in the field. The most prominent weeds of rapeseed were recorded as *Chenopodium album, Chenopodium murale, Anagallis arvensis, Convovulus arvensis, Euphorbia heliscopia, Medicago polymorpha, Cynodon dactylon, Phalaris minor* and *Asphodalus* spp. (Bhowmik 2003). Amongst fertility levels, minimum weed density was recorded with the application of 150% RDF, during both the years (Table 1). This might be due to better growth of crop over weeds and smothering effect of crop vegetative growth over the weeds leading to suppression of weeds population greatly. All weed management treatments significantly reduced the weed density at 60 days after sowing. The minimum weed density was recorded under pendimethalin (0.75 kg/ha) + HW at 35 DAS , and was at par with the hand weeding twice, during both the years, further in second year this was statistically similar with pendimethalin (1.25 kg/ha) and alachlor (1.25 kg/ha). Maximum weed infestation was registered with the control, and was closely followed by pendimethalin (0.75 kg/ha) and alachlor (0.75 kg/ha).

Fertility levels played significant role in reducing weed dry matter production. Application of 150% RDF significantly reduced weed dry matter production during both the years. All the weed management practices significantly reduced the weed dry matter compared to weedy check (Table 1). Significantly lower weed dry matter was registered under hand weeding, pendimethalin (0.75 kg/ha) + HW at 35 DAS and alachlor (0.75 kg/ha) + HW at 35 DAS during the first year and pendimethalin (0.75 kg/ha) + HW at 35 DAS, and alachlor (0.75 kg/ha) + HW at 35 during the second year.

Application of 150 and 125% RDF registered significantly more seed yield compared to other levels of fertilizers. During first year, more seed yield was recorded with 150% RDF (2.19 t/ha) and in second year more yield was associated with the 125% RDF (2.07

Table 1. Effect of fertility levels and weed management practices on weed density and dry matter in mustard

Treatment	Weed density (no./m^2)			Weed dry matter (g/m^2)		
	2011-12	2012-13	Mean	2011-12	2012-13	Mean
Fertility levels (kg/ha)						
75% RDF	23.1 (534)	18.9 (358)	21.02 (446)	28.9	33.2	31.0
100% RDF	17.3 (300)*	19.4 (374)	18.34 (337)	25.7	27.7	26.7
125% RDF	12.6 (157)	15.4 (235)	13.96 (196)	22.3	25.0	23.7
150% RDF	9.4 (87)	11.2 (125)	10.29 (106)	21.4	20.2	20.7
LSD (P = 0.05)	0.93	1.31		1.40	1.96	
Weed management						
Control	27.0 (789)	30.3 (897)	28.71 (804)	65.3	59.1	62.2
Hand weeding (HW) twice (25 and 50 DAS)	9.6 (92)	11.1 (124)	10.40 (108)	11.3	15.3	13.2
Fluchloralin (0.75 kg/ha)	18.3 (336)	21.0 (442)	19.69 (389)	25.1	28.1	26.6
Fluchloralin (1.25 kg/ha)	16.4 (267)	19.3 (373)	17.84(320)	19.6	25.4	22.5
Fluchloralin (0.75 kg/ha) + HW at 35 DAS	11.2 (125)	16.3 (266)	13.77 (195)	13.3	19.1	16.2
Pendimethalin (0.75 kg/ha)	21.4 (456)	19.1 (365)	20.23 (410)	16.3	13.9	15.1
Pendimethalin (1.25 kg/ha)	13.4 (178)	12.4 (152)	12.86 (165)	14.6	18.4	16.5
Pendimethalin (0.75 kg/ha)+ HW at 35 DAS	10.0 (100)	11.2 (126)	10.62 (113)	12.0	9.4	10.7
Alachlor (0.75 kg/ha)	20.2 (409)	23.7 (561)	21.96 (485)	21.4	27.3	24.3
Alachlor (1.25 kg/ha)	17.3 (300)	15.2 (231)	16.28 (266)	25.3	20.1	22.7
Alachlor (0.75 kg/ha)+ HW at 35 DAS	11.1 (123)	12.7 (160)	11.88 (141)	10.3	16.4	13.3
LSD (P = 0.05)	1.23	1.69		2.91	3.03	

Data subjected to square root transformation. *Figures in parentheses are original values.

Table 2. Effect of fertility levels and weed management practices on yield and economics of mustard

Treatment	Seed yield (t/ha)			Straw yield (t/ha)			Net returns (x10^3 `/ha)			B:C ratio		
	2011-12	2012-13	Mean	2011-12	2012-13	Mean	2011-12	2012-13	Mean	2011-12	2012-13	Mean
Fertility levels (kg/ha)												
75% RDF	1.20	1.03	1.42	2.97	2.98	2.97	8.05	6.98	7.515	0.87	0.76	0.81
100% RDF	1.70	1.58	1.64	3.01	3.33	3.16	12.11	13.25	12.68	1.75	1.68	1.71
125% RDF	2.07	1.95	2.01	4.08	3.98	4.03	19.16	18.65	18.90	2.10	1.97	2.03
150% RDF	2.19	1.87	2.06	4.51	3.21	3.86	20.85	17.91	19.38	1.82	1.55	1.68
LSD (P = 0.05)	0.23	0.14		1.01	1.05							
Weed management												
Hand weeding (HW) twice (25 and 50 DAS)	2.22	2.19	2.27	4.35	3.78	3.84	20.10	19.89	19.95	1.86	1.78	1.81
Fluchloralin (0.75 kg/ha)	1.52	1.36	1.44	3.02	3.08	3.05	16.83	14.25	15.54	1.25	1.42	1.33
Fluchloralin (1.25 kg/ha)	1.86	1.71	1.78	3.69	3.52	3.60	17.33	16.89	17.11	1.23	1.96	1.59
Fluchloralin (0.75 kg/ha) + HW at 35 DAS	1.93	1.79	1.86	4.01	3.66	3.83	19.63	17.06	18.34	2.05	1.61	1.83
Pendimethalin (0.75 kg /ha)	1.62	1.73	1.67	3.26	3.18	3.52	17.44	16.96	17.25	1.55	1.30	1.42
Pendimethalin (1.25 kg /ha)	2.01	1.91	1.96	3.59	3.42	3.26	19.02	18.78	18.94	2.14	1.98	2.06
Pendimethalin (0.75 kg /ha)+ HW at 35 DAS	2.09	2.10	2.09	3.98	3.54	3.68	19.74	19.99	19.85	2.02	1.81	1.91
Alachlor (0.75 kg/ha)	1.83	1.46	1.64	3.43	3.29	3.36	17.86	14.98	16.42	1.34	1.27	1.05
Alachlor (1.25 kg/ha)	1.90	1.93	1.91	3.44	3.16	3.55	19.54	19.66	19.61	2.03	1.98	1.09
Alachlor (0.75 kg/ha)+ HW at 35 DAS	2.01	1.71	1.86	4.01	3.65	3.83	19.09	16.86	17.95	1.14	1.21	1.17
Control	0.93	0.82	0.87	2.61	2.98	2.79	6.18	5.05	5.61	0.73	0.81	0.87
LSD (P = 0.05)	0.26	0.34		0.56	0.39							

Note: Price of mustard seeds (` 103.50/kg), urea (`10.90/kg), SSP (` 14.60/kg), MOP (` 9.75/kg) and cost of labour (` 162.50 /day)

t/ha). RDF (150%) gave 45% more mean grain yield over lower fertility level (75% RDF). The higher seed yield due to higher fertility levels was because of better growth and more translocation of photosynthates from source to sink (Tripathi *et al*. 2005, Rana *et al*. 2005). All the weed control treatments significantly increased the seed yield of mustard over weedy check. During first year, maximum seed yield was registered with pendimethalin (1.25 kg/ha), and was at par with all the treatments except weedy check, fluchloralin (0.75 kg/ha) and pendimethalin (0.75 kg/ha). In second year, peak seed yield was recorded with the hand weeding twice, and was statistically at par with the pendimethalin (1.25 kg/ha), pendimethalin (0.75 kg/ha) + HW at 35 DAS and alachlor (1.25 kg/ha). Application of herbicidal treatments along with hand weeding at 35 DAS gave 32 to 68% more seed yield over weedy check. This was in conformity with the finding of O'-Donovan *et al*. (2007)

Stover yield revealed that, fertility levels gave positive response during both the years of observation. More straw yield was registered with 150% RDF in first year, and with 125% RDF in the second year. Both the treatments were at par with each other during both the years of experiment, and significantly better than other set of fertility management practices. The greater straw yield at higher fertility was attributed to increased plant height and leaf area and finally more accumulation of dry matter per plant.This greater straw yield was also concluded by Kumar (2006). Amongst various sub-plot treatments, more straw yield was recorded with hand weeding twice during both the years. However in first year, this was statistically similar with pendimethalin (0.75 kg/ha) + HW at 35 DAS and fluchloralin (0.75 kg/ha) + HW at 35 DAS, and in second year with fluchloralin (1.25 kg/ha), pendimethalin (0.75 kg/ha) + HW at 35 DAS, fluchloralin (0.75 kg/ha) + HW at 35 DAS and alachlor (0.75 kg/ha) + HW at 35 DAS. This might be due to the efficient control of weeds with lower dry matter production of weeds and higher crop growth.

Amongst fertility treatments, least nutrient uptake by weed was recorded with the application of 150% RDF. Uptake of nitrogen failed to produce any significant response during both the years of study. Uptake of phosphorous gave positive response only in first year and least nutrient uptake registered with 150% RDF. Uptake of potassium was least registered with higher fertility levels *i.e*. 150% RDF during both the years (Table 3). Among weed control treatments, maximum uptake of primary nutrients by weed was registered with the weedy check. Least nutrient uptake by weed was registered with the hand weeding twice during both the years and was at par with

Table 3. Effect of fertility levels and weed management practices on nutrient uptake by weeds and crop of mustard

Treatment	Uptake by weeds (kg/ha)						Uptake by crop (kg/ha)					
	N		P		K		N		P		K	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Fertility levels (g/ha)												
75% RDF	4.06	4.32	2.80	3.25	10.2	8.95	60.2	87.0	14.2	16.0	55.3	66.3
100% RDF	3.96	3.98	2.98	3.21	9.12	9.65	102.3	87.4	21.4	18.9	79.0	63.9
125% RDF	3.56	3.39	2.31	2.98	7.98	7.89	121.6	112.3	30.0	29.6	95.7	78.9
150% RDF	2.84	3.21	1.90	1.85	6.89	5.69	133.4	123.0	33.4	32.1	98.0	89.6
LSD (P=0.05)	NS	NS	0.12	NS	0.45	0.68	8.02	6.34	3.36	5.12	5.62	9.98
Weed management												
Hand weeding (HW) twice (25 and 50 DAS)	2.01	2.34	1.39	1.41	7.98	9.18	133.0	125.0	28.9	27.0	103.1	111.3
Fluchloralin (0.75 kg/ha)	4.98	4.10	2.36	2.98	11.1	10.1	107.6	109.3	20.0	21.9	71.2	79.3
Fluchloralin (1.25 kg/ha)	4.89	4.95	2.54	3.14	9.89	10.1	112.1	108.1	20.1	19.0	80.2	83.0
Fluchloralin (0.75 kg/ha) + HW at 35 DAS	3.91	4.11	2.11	3.01	8.91	9.06	105.6	111.9	21.6	20.1	94.0	91.1
Pendimethalin (0.75 kg/ha)	5.52	5.17	3.11	3.91	12.0	13.1	104.3	89.6	18.0	15.2	79.1	70.2
Pendimethalin (1.25 kg/ha)	3.11	3.68	2.81	2.16	9.11	10.2	123.1	116.9	26.0	21.9	89.4	82.5
Pendimethalin (0.75 kg/ha)+ HW at 35 DAS	2.51	2.98	1.55	1.59	8.06	9.01	126.8	119.1	27.0	26.9	98.2	95.0
Alachlor (0.75 kg/ha)	4.54	5.02	2.88	3.99	12.0	13.1	111.3	94.4	20.0	15.8	85.1	84.2
Alachlor (1.25 kg/ha)	3.91	4.28	2.58	2.91	10.1	11.0	114.2	107.3	21.1	21.3	90.9	91.1
Alachlor (0.75 kg/ha)+ HW at 35 DAS	3.71	3.80	1.90	3.10	9.96	10.0	120.9	116.9	25.4	19.1	96.0	94.9
Control	6.19	7.72	3.98	4.89	24.0	29.4	88.2	69.4	15.4	12.4	65.3	53.3
LSD (P = 0.05)	0.99	1.04	0.44	0.57	1.10	1.32	8.53	7.58	2.35	1.98	7.33	8.91

pendimethalin (0.75 kg/ha) + HW at 35 DAS. Uptake of phosphorus and potassium was least associated with hand weeding twice during both the years and was at par with the pendimethalin (0.75 kg/ha) + HW at 35 DAS. The removal of N, P and K by weeds were reduced significantly by various herbicidal and manual weeding treatments and it almost nil under hand weeding twice, whereas the significantly highest N,P and K uptake by weeds were recorded in the weedy check treatments (Table 3). These results confirm the finding of Kour *et al*. (2013).

Application of 150% RDF registered more nitrogen uptake during both the years. Highest uptake of phosphorus and potassium was recorded with 150% RDF and was statistically at par with the 125% RDF during both the years. These observations are in agreement with finding of Shekhawat *et al*. 2012. Among weed management practices, maximum uptake of NPK was recorded with the hand weeding twice during both the years. Application of pendimethalin (0.75 kg/ha) + HW at 35 DAS gave maximum nitrogen uptake by crops, and was at par with the pendimethalin (1.25 kg/ha) and alachlor (0.75 kg/ha) + HW at 35 DAS. Uptake of phosphorus was highest with pendimethalin (0.75 kg/ha) + HW at 35 DAS during the second year. However it was at par with the pendimethalin (1.25 kg/ha) and alachlor (0.75 kg/ha) + HW at 35 DAS during the first year. Potassium uptake was more with pendimethalin (0.75 kg/ha) + HW at 35 DAS during initial year of observation. However in second year this was at par with the fluchloralin (0.75 kg/ha) + HW at 35 DAS and alachlor (0.75 kg/ha) + HW at 35 DAS.

Application of 150% RDF gave maximum net return (` 20,850/ha) during first year while in second year, 125% RDF produced maximum net return (` 18,650/ha) (Table 2). Mean net return of two years revealed that maximum net return with 150% RDF (` 19,380). However, highest benefit: cost ratio (2.03) was registered with the application of 125% RDF. Among weed control treatments, highest net return (` 19,950) was obtained with the hand weeding twice (` 19,950/ha), followed by application of pendimethalin (0.75 kg/ha) + HW at 35 DAS (` 19,850/ha). Maximum benefit: cost ratio (2.06) was recorded with the application of pendimethalin (1.25 kg/ha) and closely followed by pendimethalin (0.75 kg/ha) + HW at 35 DAS (1.91).

Present study suggests that application of 125% RDF along with application of pendimethalin (0.75 kg/ha) + HW at 35 DAS found to be best in terms of mustard yield and nutrient uptake by weeds and crop.

REFERENCES

Amanullah MA, Sekhar S and Muthukrishnan P. 2010. Prospect and potential of chicken manure. *Asian Journal of Plant Sciences* **34**(1): 1-11.

Bhowmik TP. 2003. *Oil Seed Brassicas: Constraints and their Management*. 1st Edition, CBS publishers and Distributors, New Delhi: 254 p.

Jackson ML. 1973. *Soil Chemical Analysis*, Prentice Hall of India Pvt. Ltd., New Delhi: 498 p.

Kaur R, Sharma BC, Kumar A and Kour P. 2013. Nutrient uptake by chickpea + mustard intercropping system as influenced by weed management. *Indian Journal of Weed Science* **45**(3): 183-188.

Kumar N. 2006. *Integrated nutrient management practices in mustard (Brassica juncea L.) and its effect on the productivity of succeeding rice crop*. Ph.D. Chaudhary Charan Singh, Univerisity, Meerut.

Mukherjee D. 2010. Productivity, profitability and apparent nutrient balance under different crop sequence in mid-hill condition. *Indian Journal of Agricultural Sciences* **80**(5): 420-22.

O'-Donovan JT, Blackshaw RE, Harker KN, Clayton GW, Moyer JR, Dosdall LM, Maurice DC and Turkington TK. 2007. Integrated approaches to managing weeds in spring-sown crops in western Canada. *Crop Protection* **26**: 390-398.

Piri I and Sharma SN. 2006. Effect of levels and sources of sulphur on yield attributes, yield and quality of Indian mustard (*Brassica juncea* L.). *Indian Journal of Agronomy* **51**(3): 217-220.

Rana KS, Rana DS and Gautam RC. 2005. Influence of phosphorus, sulphur and boron on growth, yield and nutrient uptake and economics of Indian mustard (*Brassica juncea* (L.) under rainfed condition. *Indian Journal of Agronomy* **50**(4): 314-316.

Shekhawat K, Premi OP, Kandpal BK and Chauhan JS. 2012. Advances in agronomic management of Indian mustard (*Brassica juncea* (L.) Czernj. Cosson): an overview. *International Journal of Agronomy* **13**: 1-14.

Tripathi MK, Chaturvedi S, Shukla DK and Mahapatra BS. 2010. Yield performance and quality in Indian mustard (*Brassica juncea* L.) as affected by integrated nutrient management. *Indian Journal of Agronomy* **55**(2): 138-142.

Wicks GA, Burnside OC and Felton WL. 2012. Mechanical weed management, In: *Hand Book of Weed Management Systems*. (Ed. Smith AE), Marcel Dekkers, Inc., New York, USA.