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Effect of Fertilizer Placement and Weed Management Practice on Weed Dynamics and Yield of Rainfed Mustard (*Brassica juncea* L.)

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Abstract

A field experiment was carried out during winter season of 1998-99 and 1999-2000 to study the effect of method of fertilizer placement and weed management practices on weed dynamics and seed yield of mustard. Three main plot treatments with broadcasting, deep placement and side placement and eight sub-plot treatment such as weedy check, weed free, hand weeding twice (30 and 60 DAS), intercultural twice (30 and 60 DAS), pre-plant incorporation of isoproturon at 1 kg a.i./ha), pre-emergence application of isoproturon (at 1 kg a.i./ha), pre-plant incorporation isoproturon (1 kg a.i./ha) + intercultivation (once at 30 DAS) and pre-emergence application of isoproturon (1 kg a.i./ha) + intercultivation (once at 30 DAS). With regard to fertilizer placement, deep placement produced significantly lowest value of weed density and dry matter production and gave highest value of yield attributing parameters followed by side placement, which proved its distinct superiority over broadvasiting method of fertilizer application. Weed management practices proved superiority to unweeded control for yield traits. Highest values of all yield attributes were recorded with weed free treatments closely followed by isoproturon pre-emergence 1 kg a.i./ha) + interculture once at 30 DAS except in respect of seed yield/plant, where it was statistically at par to each other. Marked rise in seed and stover yield were noticed with deep placement and weed management. The maximum seed and stover yield of 14.97 and 45.45 q/ha, respectively were realized under deep fertilizer placement method and significantly superior to other placement methods. Amongst all weed management treatments, plot kept weed free throughout weed free gave maximum seed yield (14.73 q/ha) however, with integrated weed management strategy isoproturon pre-emergence 1 kg a.i./ha) + interculture once at 30 DAS produced significantly higher seed (14.03 q/ha) and stover yield (46.93 q/ha).
Key words : Fertility levels, Interculture, Mustard, Weed management, Yield.

India is blessed with favorable agro-ecological condition for the growth of wide range of cultivated perennial and annual oilseed. Among the oilseed crop, mustard is the most important winter oilseed crop of India. Sub-optimal and imbalanced use of fertilizers and severe weed infestation are the main reasons for low productivity of this crop. The importance of fertilizer nutrients is well recognized for enhancing crop yield. Since the fertilizer is important input and consititue about 55—60% of the farmers's budget, it is imperative to provide the farmers with appropriate technology which low cost and gives the remunerative price for his produce. An important aspect in the efficient fertilizer use is that of placement technique. Further, it has bean observed that weeds become serious pest of mustard crop as they interfere with the availability and utilization of inputs and reduce the mustard yield to the tune of 56% (1). Traditional practice of hoeing once during early stage or applying any selective herbicides as pre-emergence spray is not sufficient particularly in rainfed mustard as new flush of weeds appear in later stage and take away major portion of the nutrient. About 50% saving in fertilizer has been achieved through weed control in groundnut, soyabean, rice and maize (2), however, information in this regard is scanty in mustard. Therefore, this experiment was planned to study the effect of method of fertilizer placement and weed management practices in controlling weed population,growth and seed yield of mustard in this region.

Methods

This experiment was carried out during winter season of 1998-1999 and 1999-2000 at the Research Farm, Banaras Hindu University, Varanasi. The soil of

Table 1. Effect of treatments on weed population and weed dry weight (pooled data of two years). NS : Non-significant : DAS: Days after sowing.

Treatment	Monocot weed (No./m^2)		Dicot weed (No./m^2)		Total weed population (No./m^2)		Weed dry matter production (g/m)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Fertilizer Placement								
Broad casting	9.88 (97.11)	10.01 (99.70)	10.72 (114.41)	13.33 (177.19)	20.60 (423.86)	23.26 (540.52)	5.10	5.6
Deep placement	7.85 (62.70)	9.53 (90.32)	8.50 (71.75)	12.61 (158.51)	16.45 (270.10)	22.06 (486.14)	4.45	4.68
Side placement	8.58 (73.12)	9.71 (93.78)	9.26 (85.25)	12.91 (166.71)	17.84 (317.76)	22.54 (507.55)	4.69	5.05
SE ±	0.26	0.29	0.11	0.76	0.27	0.38	0.01	0.03
CD at (P = 0.05)	0.74	NS	0.33	0.47	0.76	NS	0.04	0.17
Weed Management								
Weedy check	11.40 (129.46)	18.92 (357.47)	11.12 (123.15)	26.98 (727.52)	21.52 (462.61)	49.94 (2170.23)	6.85	11.56
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71	0.71
Hand weeding twice (30 & 60 DAS)	11.08 (122.27)	7.06 (49.34)	10.84 (117.00)	8.00 (63.51)	21.92 (479.99)	15.09 (227.21)	6.80	4.27
Interculture twice (30 & 60 DAS)	11.93 (141.82)	6.68 (44.12)	11.03 (121.16)	7.49 (55.60)	22.96 (526.66)	14.18 (200.57)	6.81	4.15
Isoproturon (PP) (1 kg a.i./ha)	9.77 (94.95)	17.67 (311.73)	10.64 (112.71)	24.56 (602.69)	20.41 (416.07)	42.24 (1783.72)	4.24	6.77
Isoproturon (PE) (1 kg a.i./ha)	8.57 (72.94)	15.49 (239.44)	10.46 (108.91)	22.79 (518.88)	19.03 (361.64)	38.24 (1461.80)	4.06	6.70
Isoproturon (PP) (1 kg a.i./ha)+Interculture once at 30 DAS	9.78 (95.40)	4.5 (19.75)	10.74 (114.85)	4.54 (20.38)	20.42 (416.48)	9.05 (81.40)	4.25	3.54
Isoproturon (PE) (1 kg a.i./ha)+Interculture once at 30 DAS	8.50 (71.75)	3.96 (15.50)	10.91 (109.96)	3.95 (15.10)	19.01 (360.88)	7.92 (62.23)	4.08	3.35
SE ±	0.44	0.48	0.20	0.27	0.46	0.62	0.02	0.04
CD (P = 0.05)	1.25	1.38	0.57	0.77	1.31	1.77	0.06	0.13

the experimental site was sandy clay loam having pH 7.8, available nitrogen, phosphorus and potassium 150, 17.5 and 160.5 kg/ha, respectively (2, 3). The experiment was conducted in split-plot design with three replication. There were three main plot treatments comprising three methods of fertilizer placement (viz. broadcasting, deep placement and side placement) and eight sup-plot treatment (viz. weedy check, weed free, hand weeding twice (30 and 60 DAS), intercultural twice (intercultivation by dryland weeder and intra-row hand weeding twice at 30 and 60 DAS), pre-plant incorporation of isoproturon (1kg a.i./ha), pre-emergence application of isoproturon (1 kg a.i./ha), pre-plant incorporation isoproturon (1 kg a.i./ha) + intercultivation by dry land weeder and intra-row hand weeding (once at 30 DA) and pre-emergence application of isoproturon (1 kg a.i./ha) + intercultivation by dryland weeder and intra-row hand weeding (once at 30 DAS). The test crop mustard var Varuna was sown during first week of November and harvested during first fortnight of April during both the year. Line sowing was done with 45 cm spacing and thinning was done at 21 DAS to maintain plant to plant distance of 15 cm within the row. Full dose of nitrogen, phosphorus and potash were applied at the time of sowing. Urea, single super phosphate and murate of potash were used as source of nitrogen, phosphorus and potassium, respectively. Other crop

Table 2. Effect of treatments on weed index, weed control efficiency and yield attributes of mustard crop (pooled data of two years). DAS : Days after sowing.

Treatments	Weed control efficiency (%)		Yield attributes				
	30 DAS	60 DAS	Silique/ plant (No.)	Siliqua length (cm)	Seed/ siliqua (No.)	1000 seed weight (g)	Seed yield plant (g)
Fertilizer Placement							
Broad casting	45.57	76.67	274.67	4.59	11.94	4.49	11.94
Deep placement	44.45	83.72	468.37	5.66	12.86	5.06	17.96
Side placement	44.23	81.03	336.04	4.76	12.17	4.71	12.28
SE ±			6.56	0.03	0.05	0.02	0.28
CD (P = 0.05)			18.64	0.09	0.12	0.08	0.81
Weed Management							
Weedy check			181.61	4.31	11.03	4.16	8.35
Weed free	100.00	100.00	519.83	5.5	13.34	5.30	18.62
Hand weeding twice (30 % 60 DAS)	-	86.47	348.84	4.96	12.32	4.71	13.76
Interculture twice (30 & 60 DAS)	-	87.21	393.81	5.08	12.54	4.82	15.03
Isoproturon (PP) (1kg a.i./ha)	62.36	65.82	253.63	4.76	11.63	4.37	10.82
Isoproturon (PE) (1 kg a.i./ha)	64.32	62.52	288.74	4.86	11.91	4.52	12.07
Isoproturon (PP) (1 kg a.i./ha) +Interculture once at 30 DAS	62.17	90.71	426.23	5.21	12.77	4.99	16.11
Isoproturon (PE) (1 kg a.i./ha) +Interculture once at 30 DAS	63.61	91.70	460.87	5.34	13.01	5.12	17.01
SE ±			10.68	0.05	0.08	0.04	0.46
CD (P = 0.05)			30.45	0.14	0.24	0.13	1.33

management practices were carried out based on the recommended practices for the region. Weed samples were collected by randomly placing a 50 cm × 50 cm quadrate at tow places in each plor at monthly interval and after counting, they were kept in hot air oven at 70 ± 1C until they attained a constant weight. Seed yield was recorded and finally the data were statistically analyzed and presented.

Results and Discussion

Weed Flora

There were 16 weed species belonging to ten families found in the experimental site. The dominant weed flora were : Cynodon dactylon (L.) Pers., *Cyperus rotundus* L., *Parthenium hysterophorus* L., *Phalaris minor* Retz., *Melilotus indica* L. and *Anagslis arvensis* L.

Weed Density

The data on density of monocot weeds revealed an increasing trend from 30 to 60 DAS (Table 1). Higher density of monocot weeds was observed with broadcasting followed by side and deep placement of fertilizer during both the phenophases of crop growth. However, significant variation amongst the treatment was observed only at 30 Das of the crop. Deep placement of fertilizer showed comparatively low monocot weed and was at par with side placement 30 DAS. Weed management practices influenced the density of monocot weeds significantly. Maximum density of monocot weeds was recorded in weedy check treatment, which was significantly higher than other treatment except pre-plant incorporation of isoproturon (1 kg a.i./ha) at 60 DAS and with hand weeding and intercultural twice at 30 DAS. Pre-emergence applica-

Table 3. Effect of treatments on yield, soil moisture content and economics of mustard crop (pooled data of two years). DAS: Days after sowing.

Treatments	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)	Weed index (%)	AET (mm)	WUE (kg/ha/mm)	Net returns (Rs)	Benefit : cost ratio
Fertilizer Placement								
Broad casting	9.92	39.75	19.77	21.29	203.57	4.93	7812.32	1.38
Deep placement	14.97	45.45	24.57	16.05	196.40	7.72	13404.32	2.10
Side placement	11.18	43.46	20.33	18.80	201.03	5.61	8936.72	1.48
SE ±	0.12	0.26	0.14		0.13	0.07		
CD (P = 0.05)	0.35	0.76	0.42		0.37	0.20		
Weed Management								
Weedy check	8.47	34.38	19.60	42.67	222.62	3.82	6121.52	1.12
Weed free	14.73	47.79	23.42	-	183.89	8.03	6627.07	0.51
Hand weeding twice (30 & 60 DAS)	11.96	42.99	21.53	19.42	200.91	5.97	9693.95	1.52
Interculture twice (30 & 60 DAS)	12.58	43.80	22.13	14.99	198.18	6.35	10030.32	1.70
Isoproturon (PP) (1 kg a.i./ha)	9.92	39.87	19.77	32.29	210.43	4.76	7573.12	1.27
Isoproturon (PE) (1 kg a.i./ha)	10.95	41.50	20.74	25.77	203.60	5.38	8850.32	1.49
Isoproturon (PP) (1 kg a.i./ha) + Interculture once at 30 DAS	13.42	45.83	22.41	9.58	194.61	6.91	11587.52	1.82
Isoproturon (PE) 1 kg a.i./ha) + Interculture once at 30 DAS	14.08	46.93	22.86	5.00	188.45	7.46	12423.52	1.96
SE ±	0.22	0.43	0.24		0.21	0.12		
CD (P = 0.05)	0.58	1.24	0.68		0.61	0.32		

tion of isoproturon (1 kg a.i./ha) combined with one interculture operation by dryland weeder proved most effective in minimizing the intensity of monocot weed/m^2 during both the stage of observation, which being at par with isoproturon pre-emergence 1 kg a.i./ha 30 DAS and pre-plant incorporation along with one intercultural operation through dryland weeder plus hand weeding twice during both stage of observation.

Density of dicot weeds was affected significantly by fertilizer placement. Deep placement of fertilizer, being at par with side placement, exhibited significantly lower density of dicot weeds than broadcasting method during both the stage of observation except 30 DAS, where side placement of fertilizer was also found significantly inferior to deep placement in this respect (Table 1). Density of dicot weed/m^2 increase progressively with weedy check as well as well as sole chemical application during both the stage. The lowest density of dicot weed was observed in weed free treatment followed by pre-emergence application of isoproturon 1 kg a.i./ha) initially only and isoproturon pre-emergence (1 kg a.i./ha) plus one inturculture during both the stage of observation. Pre-emergence application of isoproturon 1 kg a.i./ha) along with one intercultural operation by dryland weeder and inter-row hand weeding, being comparable to same herbicide applied as preplant incorporation with one intercultural, proved significantly instrumental in lowering the dicot weed population at 60 DAS. However, chemical application alone either as pre-plant incorporation or pre-emergence application proved least effective in this respect.

Total weed density was affected significantly by fertilizer placement methods only at 30 DAS. Deep placement resulted in lowest total weed density and found significantly superior to other two method of placement during the both the stage of reading. Weed management practices had significantly influence on total weed density/m^2 during critical crop ontogeny. Pre-emergence application of isoproturon 1 kg a.i./ha) coupled with one intercultural operation by dryland weeder maintained comparatively lower density of weed and recorded 72.5% less weed population

than weedy check at 60 DAS. Pre-emergence as well as pre-plant incorporation of isoproturon (1 kg a.i./ha), through suppressed the weed substantially at initial 30 day stage, proved less effective and resulted in higher total weed population at later stage. Amongst chemical treatment integration of pre-emergence application of isoproturon 1 kg a.i./ha) followed by one intercultural operation by dry land weeder gave significantly lowest weed population during both the stage of study except pre-emergence application of isoproturon (1 kg a.i./ha) at 30 DAS.

Weed Dry Matter

Weed dry matter production (g/m^2) significantly influenced by all main and sub-plot treatments with the advancement of season (Table 1). Minimum weed dry matter was noticed with deep fertilizer placement method both the stage of study, which proved significantly superior to rest of the two methods. Amongst the sub-plot treatments, pre-emergence application of isoproturon (1 kg a.i./ha) combined with one intercultural operation through dryland weeder plus hand weeding proved significantly superior to rest of the treatments at all stages of observation except 30 DAS, were sole chemical application of pre-emergence resulted in similar performance with this character and recorded lowest weed dry matter. However, pre-emergence and pre-plant incorporation of isoproturon 1 kg a.i./ha) recorded statistically similar result to each other at 60 DAS, when weed regrowth occurred and occupied second position to weedy check in dry matter accumulation. Similarly, the different between hand weeding twice and interculture twice treatments remained statistically similar at 30 and 60 DAS phenophase of crop growth. Dry matter accumulation was quite high during early growth period, might be due to slow initial growth rate of mustard and heavy infestation by weeds (4).

Weed control efficiency noticed that different fertilizer placement methods did not vary much among themselves during both the stage of reading, however maximum WCE was recorded with deep placement at 60 DAS (Table 2). Amongst the weed management practices, pre- and post-emergence application of isoproturon 1 kg a.i./ha) along with one intercultural operation by dryland weeder recorded higher WCE compared to other weed management strategy.

Yield Attributes

The data on yield component of the test crop significantly influenced by fertilizer placement methods and weed management practices (Table 2). Significantly higher noumber of siliquae/plant was recorded with deep placement and was followed by side placement and broad casting methods of fertilizer placement. Similar kind of observation was recorded with other yield attributing parameter too. Weed management practices also differed significantly with respect to all the yield attributing parameter. Pre-emergence application of isoproturon 1 kg a.i./ha) coupled with one intercultural operation by dryland weeder plus intra-row hand weeding (at 30 DAS) was the best treatment and show significantly higher all yield attributing characters compared to all other weed management practices and was at par with pre plant incorporation of isoproturon 1 kg a.i. /ha) along with one intercultural operation with dry land weeder for siliqua length and seed yield/plant (g). The reduction in crop weed competition by weed management practices not only provided the crop plants with abundance of moisture, light and nutrient and space but also encouraged vigorous development of crop plant, this leads to increase the entire yield attributing parameter and ultimately affect the final economic yield of mustard crop plant (5).

Yield Component

The seed yield is the cumulative sum of all the yield components. Therefore, with better fertilizer placement and weed management the seed yield increased as all the yield components were enhanced significantly (Table 3). Maximum seed yield (14.97 q/ha) was recorded with deep placement which was significantly higher than all other fertilizer placement methods. The increase in seed yield due to deep placement was to the tune of 33.9 and 51.2% over side placement and broadcasting method, respectively. Therefore, fertilizer applied deep in the soil increased the seed yield and this was proved in the present investigation. This finding corroborates the result of other workers (1, 4). Weed management measures influenced the seed yield significantly. The highest seed yield (14.73 q/ha) was recorded with weed free treatment while lowest yield (8.47 q/ha) with weedy cheek.

Amongst all integrated weed management measures pre- emergence application of isoproturon (1 kg a.i./ha) along with one intercultural operation with dry land weeder proved significantly instrumental in increasing the seed yield (14.08 q/ha) compared to rest of the weed control treatments.

Interaction effect of fertilizer placement and weed management practices on seed yield of mustard was found to be significant (Table 4). Maximum seed yield was obtained with deep placement fertilizer integrated with hand weeding twice which was statistically at par with deep placement of fertilizer when integrate with pre-emergence application of isoproturon 1 kg a.i./ha) along with weeding by dry land weeder. These two integrated weed management methods proved significantly instrumental in enhancing the seed yield in comparison to rest of the other weed treatments at each fertilizer placement method under investigation. However, least effective treatment combination in influencing the seed yield was that where sole chemical method of weed control was followed with broadcasting method of fertilizer application.

Maximum stover yield (45.45 q/ha) was recorded with deep placement which proved significantly superior to all other fertilizer methods (Table 3). This increase in stover yield due to deep placement was to the extent of 14.3 and 13.1% respectively, over broadcasting and side placement methods. Further, with weed management measures, maximum stover yield witnessed under weed free plots (47.79 q/ha) while minimum with weedy check (8.47 q/ha). Pre-emergence application of isoproturon (1 kg a.i./ha) along with one intecultivation by dryland weeder being at par with pre-plant incorporation of isoproturon (1 kg a.i./ha) + interculture once resulted in significantly higher stover yield than weed management practices. Interaction effect of fertilizer placement methods and weed management practices found to be non-significant under present investigation.

Harvest index (%) was significantly influenced by various treatment measures either in main plot of sub-plot treatments. Higher harvest index of 24.57 was noticed with deep placement which was 24.21% higher than broadcasting and 20.8% higher than side placement, respectively. Higher value of HI was recorded in weed free treatment which, being at par with pre-emergence application of isoproturon (1 kg a.i./ha) + one interculture proved significantly superior to other weed management practices.

Table 4. Interaction effect of fertilizer placement methods and weed management practices on seed yield (q/ha) (pooled data of two years). DAS : Days after sowing.

Weed management practices	Fertilizer placement methods		
	Broad casting	Deep placement	Side placement
Weedy check	6.82	10.25	8.35
Weed free	12.58	17.83	13.78
Hand weeding twice (30 & 60 DAS)	9.43	15.54	10.93
Interculture twice (30 & 60 DAS)	10.43	15.86	11.47
Isoproturon (PE) (1 kg a.i./ha)	8.53	11.99	9.32
Isoproturon (PE) (1 kg a.i./ha)	9.18	13.52	10.16
Isoproturon (PP) (1 kg a.i./ha) + Interculture once at 30 DAS	10.79	17.18	12.28
Isoproturon (PE) (1 kg a.i./ha) + Interculture once at 30 DAS	11.48	17.59	13.17
SE ±	0.35		
CD (P = 0.05)	0.99		

Among the fertilizer placement methods, deep placement registered lowest weed index followed in order by side placement and broadcasting method. But weed management practices resulted in entirely different weed indices. Lowest index was observed with pre-emergence application of isoproturon (1 kg a.i./ha) coupled with one intercultural operation followed by isoproturon (1 kg a.i./ha) pre-plant incorporation plus one intercultivation with dry land weeder. Among weed management practices, chemical methods of weeding alone resulted in maximum values of weed index.

Soil Moisture Studies

Fertilizer placement and weed management practices significantly influenced the moisture content of soil and other parameter like actual evapotranspiration (AET) and water use efficiency (WUE) (Table 3). Deep placement of fertilizer recorded the lowest AET (196.4 mm) and WUE (7.72 kg/ha/mm) compared with rest of the technique, and significantly superior to rest of all other main plot treatment. Higher weed density and weed dry matter production under broadcasting method of fertilizer application was mainly

responsible for higher AET and lower water use by the crop resulting into lower WUE. While under deep placement method, weed density and weed dry weight was minimum which led to lower evepotranspiration loss of water from the soil surface and higher water use by the crop plants owing to deep root system which ultimately resulted into higher WUE. Similar kind of finding was reported by Regar and Rao (6).

Amongst weed management practices, weed free treatment recorded the minimum AET and WUE, and proved significantly superior to remaining weed management practices (Table 3). Pre-emergence application of isoproturon (1 kg a.i./ha) coupled with one intercultural operation registered minimum loss of moisture and which was significantly lower than rest of the treatments. WUE was maximum (3.64 kg/ha/mm) with this treatment and significantly superior to other combination. WUE was found maximum under weed free treatment followed by pre-emergence application of isoproturon (1 kg a.i./ha) along with one intercultural at 30 DAS while minimum was observed under weedy check. This was mainly due to lower weed growth and weed dry matter under these former two treatments and the water stored stored in soil profile could be utilized by the crop more efficiently lead into higher WUE.

Economics

Among fertilizer placement method, deep placement realized the maximum net return (Rs 13,404.32/ha), which was Rs 5592.00 and Rs 4467.60/ha higher than broad casting and side placement of fertilizer (Table 3). As a result of weed management practices the highest net return of Rs 12,423.52/ha was obtained with isoproturon pre-emergence (1 kg a.i./ha) + intercultue once which was Rs 6,302.00/ha higher than the weedy check. This corroborate with the earlier finding of Dixit and Gautam (2)

The maximum net return per rupee invested (B : C ratio) was obtained with deep placement (2.10). Among weed management practices highest net return per rupee invested was obtained with pre-emergence application of isoproturon (1 kg a.i./ha) coupled with one intercultural operation (1.96), while lowest under weed free condition (0.51).

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