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RESPONSE OF THREE MUSTARD GENOTYPES TO SOIL-APPLIED AND LEAF-APPLIED NUTRIENTS

FIROZ MOHAMMAD AND TAUHEED KHAN
Department of Botany, Aligarh Muslim University, Aligarh-202 002 India.
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A field experiment was conducted at Aligarh on mustard varieties Rohini, Vaibhav and Varuna grown with either 60 kg N + 20 kg P or 90 kg N + 30 kg P/ha with nitrogen being applied as (i) full basal (B), (ii) 2/3 basal + 1/3 top-dressing (T) or (iii) 2/3 basal + 1/3 foliar (F). The plants receiving full basal treatment were sprayed with deionised water (F_w). A uniform dose of 30 kg K/ha was given at the time of sowing. The top-dressing and spray treatments included application of N in two equal splits at 50 and 70 DAS. The lower dose of N and P proved insufficient for the cultivation of mustard, ruling out the possibility of fertiliser economy for this crop. However, it was established that top-dressing surpassed basal treatment while foliar spray excelled even top-dressing. Foliar spray of 30 kg N/ha on plants grown with 60 kg N and 30 kg P/ha (B_{N60P30} + F_{N30})) proved optimum for almost all growth and yield attributing parameters studied. This resulted in an increase in seed and oil yield of 11.18% and 12.13% respectively over the control, i.e. spray of water on plants receiving the officially recommended basal dose (90 kg N + 30 kg P/ha). Rohini performed best among the varieties tested, while the interaction B_{N60P30} + F_{N30} x Rohini proved optimum for most characters.

Key Words : Foliar spray, top-dressing, rapeseed-mustard.

It is well known that a considerable quantity of the fertiliser added to the soil at the time of sowing remains unutilised by crop plants (Anonymous, 1971) and thereby reduces the cost-benefit ratio. To get maximum fertiliser-use efficiency, farmers normally practise split application for the cultivation of major crops, including one or more top-dressings. It is noteworthy that foliar spray of nutrients has proved superior to top-dressing in several crops, including mustard (Barat and Das, 1962; Afridi *et al.*, 1983; Mohammad *et al.*, 1987).

However, it is also to be realised that the response to fertiliser application differs from species to species and even from variety to variety of the same species (Millikan, 1961; Langer, 1966). Moreover, new techniques could appeal to the farmer only if they help increase productivity, reduce the bill of his inputs or both. Therefore, keeping efficacy of split application of nitrogen and fertiliser economy in mind, a field experiment was conducted on three new high yielding cultivars of mustard, applying two sub-optimal doses of basal nitrogen (N) and phosphorus (P) and providing supplemental N by top-dressing or foliar spray so as to compare the efficacy of these techniques.

MATERIALS AND METHODS

A factorial randomised block design field experiment was performed in 10 sq m beds on three varieties of mustard (*Brassica juncea* L. Czern and Coss) in sandy loam soil (pH - 7.9, available N-200, P-22 and K-248 kg/ha) at the Farm of the Aligarh Muslim University, Aligarh. Two rates of N (applied as urea) and P (monocalcium superphosphate), viz. 60 kg N + 20 kg P and 90 kg N + 30 kg P/ha and three methods of N application, i.e. (i) full basal (B), (ii) 2/3 basal (B) + 1/3 top-dressing (T), and (iii) 2/3 basal (B) + 1/3 foliar (F) comprised one variant and three varieties of mustard, namely Rohini, Vaibhav and Varuna, the other. To compare the efficacy of the various methods of nutrient application, the plants receiving full nutrient dose at the time of sowing were sprayed with deionised water (F_w) simultaneously with top-dressing/foliar spray. Thus, the six treatments were divided into two sets. Set (a) included : (i) B_{N60P20} + F_w (2) B_{N40P20} + T_{N20} (3) B_{N40P20} + F_{N20} and Set (b) : (4) B_{N90P30} + F_w (5) B_{N60P30} + T_{N30}, (6) B_{N60P30} + F_{N30}. In addition, 30 kg K/ha was applied uniformly as muriate of potash at the time of sowing. The additional N was given in two equal splits; half at 50 days after sowing (DAS) when vegetative growth was vigorous and the remaining half at 70 DAS, the stage coinciding with the onset of flowering. Each treatment was replicated thrice. The seeds were sown in rows at the rate of 10 kg/ha. Weeding was done twice and thinning, once, at

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Table 1. Effect of top-dressing (T) and foliar spray (F) of N with two basal doses (B) of N and P on leaf area index and dry weight/plant in three varieties of mustard.

Varieties (v)	Treatments (t)						
	Set (a)			Set (b)			
	$B_{N60P20}+F_w$	$B_{N40P20}+T_{N20}$	$B_{N40P20}+F_{N20}$	$B_{N90P30}+F_w$	$B_{N60P30}+T_{N30}$	$B_{N60P30}+F_{N30}$	Mean
				Leaf area index			
Rohini	2.61	3.10	3.54	4.21	5.13	6.27	4.14
Vaibhav	1.92	2.08	2.64	2.96	3.66	4.42	2.94
Varuna	2.29	2.65	3.12	3.46	4.19	4.88	3.43
Mean	2.27	2.61	3.10	3.54	4.32	5.19	
C.D. at 5%	t = 0.41, v = 0.39		txv = 0.78				
				Dry weight/plant (g)			
Rohini	25.18	27.95	32.73	35.56	37.93	40.72	33.34
Vaibhav	20.84	22.09	25.71	27.90	31.79	35.51	27.31
Varuna	22.82	26.72	29.48	32.62	36.40	38.73	31.13
Mean	22.94	25.59	29.31	32.03	35.37	38.32	
C.D. at 5%	t = 0.32, v = 0.45		t x v = 0.79				

N.B. : A uniform dose of 30 kg K/ha was added at sowing.

Table 2. Effect of top-dressing (T) and foliar spray (F) of N with two basal doses (B) of N and P on the N, P and K status of plants in three varieties of mustard.

Varieties (v)	Treatments (t)						
	Set (a)			Set (b)			
	$B_{N60P20}+F_w$	$B_{N40P20}+T_{N20}$	$B_{N40P20}+F_{N20}$	$B_{N90P30}+F_w$	$B_{N60P30}+T_{N30}$	$B_{N60P30}+F_{N30}$	Mean
				Nitrogen content (%)			
Rohini	2.34	2.44	2.63	3.22	3.40	3.64	2.94
Vaibhav	1.91	2.04	2.25	2.89	3.26	3.30	2.60
Varuna	2.16	2.28	2.50	3.02	3.20	3.45	2.76
Mean	2.13	2.25	2.46	3.04	3.28	3.46	
C.D. at 5%	t = 0.21, v = 0.15		txv = 0.36				
				Phosphorus content (%)			
Rohini	0.270	0.281	0.301	0.370	0.380	0.390	0.332
Vaibhav	0.252	0.260	0.280	0.332	0.344	0.381	0.308
Varuna	0.281	0.280	0.322	0.380	0.388	0.410	0.343
Mean	0.267	0.273	0.301	0.360	0.370	0.393	
C.D. at 5%	t = 0.024, v = 0.017		t x v = 0.042				
				Potassium content (%)			
Rohini	3.53	3.60	3.73	3.08	3.11	3.21	3.37
Vaibhav	3.23	3.28	3.36	2.86	2.95	3.10	3.13
Varuna	3.30	3.35	3.55	3.05	3.10	3.19	3.25
Mean	3.35	3.41	3.54	2.99	3.05	3.16	
C.D. at 5%	t = 0.12,	v = 0.80	t x v = N.S.				

N.B.: A uniform dose of 30 kg K/ha was added at sowing.
N.S. = Non-significant.

the first weeding. The crop received two irrigations between sowing and harvesting (130 DAS). Leaf area index (LAI), dry weight/plant and leaf N, P and K contents were studied at 80 DAS.

Leaf powder was digested and assayed for its N content, using the method of Lindner (1944). For leaf P content, the following technique of Fiske and Subbarow (1925) was adopted:

5 ml of the digested leaf powder was taken in a test tube, to which 1 ml molybdic acid (2.5% ammonium molybdate in 10 N H_2SO_4) was carefully added. To this was added 0.4 ml of a solution of 1,2,4-

amino-naphthol-sulphonic acid, prepared by dissolving 500 mg in 195 ml of 15% sodium bisulphite, followed by 5 ml of 20% sodium sulphite. After 5 minutes, the optical density (O.D.) of the developed blue colour was read at 620 nm, using a blank. A standard curve was prepared using 10 dilutions of potassium dihydrogen orthophosphate (0.1-1.0 ml of 100 ppm P each diluted to 5 ml with D.D.W.) versus O.D. For preparing the stock solution of 100 ppm P, 351 mg of KH_2PO_4 was dissolved in sufficient water, to which was added 10 ml of 10 N H_2SO_4 and the final volume made upto 1 litre with D.D.W.

Potassium was estimated flame photometrically. Pods/plant, seeds/pod, hecto-litre weight and seed yield/ha were noted at harvest. Oil percentage of the harvested seeds was determined with the help of Soxhlet apparatus using petroleum ether as solvent. Oil yield/ha was calculated on the basis of seed yield and oil percentage. The data were analysed statistically using the F-test for estimating the significance of variance and values for critical difference (C.D.) at P = 0.05 were also calculated (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

The effect of the treatments, varieties and their interaction was found to be significant on almost all the parameters studied. In general, mustard showed a preference for 90 kg N (Set b) applied as full basal or 2/3 basal + 1/3 top-dressing/foliar spray, with the application to the leaves giving the best results (Tables 1-5). The salient features of the data are discussed below.

Vegetative growth : Table 1 reveals that all treatments in Set (b) proved superior to those in Set (a) with regard to LAI and dry matter production. Thus, $B_{N60P30} + F_{N30}$ increased LAI by 46.6% and dry weight/plant by 19.6% over the control for set (b), i.e. $B_{N90P30} + F_w$, which represents the optimal basal dose for the local cultivation of mustard (Mohammad *et al.*, 1985). The superiority of the treatments in Set (b) over those in Set (a) is understandable, as the quantity of N and P supplied in the latter was not sufficient for the manifestation of the full genetic potential of the crop, with regard to vegetative growth prior to the onset of flowering. The reason for this is not far to seek in view of the well established role of these nutrients in the formation and functioning of some of the most important plant metabolities, including chlorophyll and other porphyrins, coenzymes, nucleoproteins, nucleic acids, etc. (Devlin and Witham, 1986; Marschner, 1986). LAI represents the number of leaves/plant and area/leaf. As N and P are involved directly in the production and enlargement of new cells and tissues, they have a direct bearing on leaf production and expansion. The consequent larger surface area of leaves produced in Set (b) was, therefore, better equipped to harvest the radiant energy and to produce more photosynthates, as revealed by the higher dry weight of the plants in each of the three treatments of this set. Obviously, the ready availability of one of these nutrients (nitrogen) to the metabolising surface directly by foliar application at critical stages of vegetative growth (50 DAS and 70 DAS) added to its efficacy further. This is substantiated not only by the highest LAI and dry weight/plant in treatment $B_{N60P30} + F_{N30}$ but is also manifested in the parameters of reproductive growth that are discussed later. That this treatment also favoured the N, P and K status of the plants (Table 2), helping in the accumulation of 13.8% more N, 9.1% more P and 5.7% more K than the control ($B_{N90P30} + F_w$), is further proof of superior efficacy of foliar spray of nitrogen which has been demonstrated by a number of workers, including those working on mustard (Parvaiz *et al.* 1982a; Samiullah *et al.*, 1985; Mohammad *et al.*, 1987).

Reproductive growth : Flower and fruit formation and economic yield of crop plants is dependent upon their vegetative growth and on the availability and proper balance of mineral nutrients (Marschner, 1986). It has already been noted that, compared with the sub-optimal treatments in Set (a), growth and NPK content were higher in Set (b). However, in the individual sets themselves, split application of nitrogen proved superior to one-time (basal) application of the same quantity. This beneficial effect is reflected more prominently as the plants passed into the reproductive phase of growth. Thus, presumably through better partitioning of the photosynthates at the onset of flowering, more pods/plant, seeds/pod and higher hecto-litre weight were noted in (i) Set (b) than in Set (a) and (ii) in split application of N in either of the two sets (Tables 3-5). As an example, the best treatment ($B_{N60P30} + F_{N30}$) produced 63.3% and 12.6% more pods/plant, 17.9% and 5.9% more seeds/pod and 1.2% and 0.3% higher hecto-litre weight of seeds than the two controls of Set (a) and Set (b),

Table 3. Effect of top-dressing (T) and foliar spray (F) of N with two basal doses (B) of N and P on pods/plant and seeds/pod in three varieties of mustard.

Varieties (v)	Treatments (t)						
	Set (a)			Set (b)			
	$B_{N60P20}+F_w$	$B_{N40P20}+T_{N20}$	$B_{N40P20}+F_{N20}$	$B_{N90P30}+F_w$	$B_{N60P30}+T_{N30}$	$B_{N60P30}+F_{N30}$	Mean
				Pods/plant			
Rohini	255.00	280.00	302.66	372.00	394.66	410.33	335.77
Vaibhav	213.00	230.00	244.00	302.00	345.00	348.00	280.33
Varuna	233.33	252.33	280.00	343.00	356.33	387.33	308.72
Mean	233.77	254.11	275.55	339.00	365.33	381.88	
C.D. at 5%	t = 5.21, v = 3.68		txv = 9.21				
				Seeds/pod			
Rohini	11.21	11.40	11.66	12.62	13.20	13.50	12.26
Vaibhav	10.80	11.00	11.31	11.88	12.60	12.48	11.62
Varuna	11.06	11.26	11.51	12.31	12.57	13.00	11.95
Mean	11.02	11.22	11.49	12.27	12.67	12.99	
C.D. at 5%	t = 0.19,	v = 0.14	t x v = N.S.				

N.B.: A uniform dose of 30 kg K/ha was added at sowing.
N.S. = Non-significant.

Table 4. Effect of top-dressing (T) and foliar spray (F) of N with two basal doses (B) of N and P on hecto-litre weight and seed yield in three varieties of mustard.

Varieties (v)	Treatments (t)						
	Set (a)			Set (b)			
	$B_{N60P20}+F_w$	$B_{N40P20}+T_{N20}$	$B_{N40P20}+F_{N20}$	$B_{N90P30}+F_w$	$B_{N60P30}+T_{N30}$	$B_{N60P30}+F_{N30}$	Mean
				Hecto-litre weight (kg)			
Rohini	65.95	66.11	66.26	66.50	66.68	66.73	66.37
Vaibhav	64.00	64.06	64.13	64.54	64.63	64.73	64.34
Varuna	65.01	65.33	65.36	65.63	65.83	65.91	65.52
Mean	65.01	65.16	65.25	65.55	65.71	65.79	
C.D. at 5%	t = 0.08, v = 0.06		txv = 0.14				
				Seed yield (kg/ha)			
Rohini	1030.00	1085.00	1145.00	1280.00	1330.66	1413.33	1213.99
Vaibhav	883.00	950.66	998.33	1095.66	1221.66	1221.00	1061.71
Varuna	960.33	1024.00	1068.33	1189.66	1257.00	1329.66	1138.16
Mean	957.77	1019.88	1070.55	1188.44	1269.77	1321.33	
C.D. at 5%	t = 14.29, v = 13.64		t x v = 33.42				

N.B. : A uniform dose of 30 kg K/ha was added at sowing.

viz. $B_{N60P20} + F_w$ and $B_{N90P30} + F_{WS}$ respectively. As would be expected, this ultimately resulted in enhanced seed yield (Table 4). Thus, treatment $B_{N60P30} + F_{N30}$ gave 37.9% and 11.18% more seeds than $B_{N60P20} + F_w$ and $B_{N90P30} + F_w$, respectively. These data confirm the results of Mohammad *et al.* (1987) on Varuna, one of the varieties included in the present trial.

Correlation studies further confirm this proposition. It may be noted that seed yield was significantly and positively correlated with pods/plant (r = +0.992), seeds/pod (r = +0.982) and hecto-litre weight (r = +0.693). It may be pointed out that similar beneficial effect of foliar application of nitrogen on the yield performance of a few varieties of mustard (other than Rohini and Vaibhav) has been reported from this laboratory by Parvaiz *et al.* (1982a, b) and Mohammad (1992).

Oil content and oil yield : One noteworthy observation in Table 5 merits special mention here. The oil content of seeds in all (sub-optimal) treatments comprising Set (a) is slightly (albeit significantly)

Table 5. Effect of top-dressing (T) and foliar spray (F) of N with two basal doses (B) of N and P on the oil content and oil yield in three varieties of mustard.

Varieties (v)	Treatments (t)						
	Set (a)			Set (b)			
	$B_{N60P20}+F_w$	$B_{N40P20}+T_{N20}$	$B_{N40P20}+F_{N20}$	$B_{N90P30}+F_w$	$B_{N60P30}+T_{N30}$	$B_{N60P30}+F_{N30}$	Mean
				Oil content (%)			
Rohini	39.10	39.38	39.67	38.58	38.70	38.90	39.23
Vaibhav	38.91	39.17	39.45	38.46	39.06	38.81	38.97
Varuna	39.05	39.31	39.66	38.54	38.67	38.85	39.01
Mean	39.02	39.28	39.62	38.52	38.81	38.85	
C.D. at 5%	t = 0.19, v = N.S.		txv = N.S.				
				Oil yield (kg/ha)			
Rohini	402.74	427.25	455.31	493.84	514.93	549.85	473.98
Vaibhav	343.64	372.43	393.88	421.36	477.24	473.98	413.75
Varuna	375.07	402.54	423.81	458.53	486.15	516.60	443.78
Mean	373.81	400.74	424.33	457.91	492.77	513.47	
C.D. at 5%	t = 7.84, v = 5.54		t x v = 13.59				

N.B.: A uniform dose of 30 kg K/ha was added at sowing.

higher than the oil content in treatments of Set (b). The most apparent explanation for this adverse effect of the full dose of nitrogen seems to be the preferential utilisation of carbon skeletons, at the time of seed filling, toward protein synthesis rather than oil formation. This has been reported earlier for mustard grown with high basal nitrogen doses (Arora and Bhatia, 1970; Tomer *et al.*, 1992). Mohammad *et al.* (1992) have also made a similar observation for mustard variety Varuna, using supplemental foliar spray technique.

However, it may be pointed out that, comparing the top-dressing/foliar spray treatments of Set (a) and Set (b) with their respective controls, slightly higher but significant oil content values were obtained in the two treatments of each set, indicating the desirability of split application of N rather than applying the full dose at the time of sowing. This proposition is dramatically brought out on computation of oil yield/ha (Table 5), as treatment $B_{N60P30} + F_{N30}$ was found to give 37.4% and 12.13% higher oil yield than $B_{N60P20} + F_w$ and $B_{N90P30}+F_w$, respectively.

Varietal response : Considering the comparative performance of the three varieties (Rohini, Vaibhav and Varuna) with regard to growth parameters, leaf NPK concentration and yield attributes, Rohini proved best for most of the parameters studied and was followed by Varuna (Tables 1-5). Thus, seed yield, which is the deciding criterion of performance for the farmers, was 14.3% and 6.6% higher in Rohini than in Vaibhav and Varuna, respectively.

Interaction effect : Among interactions $B_{N60P30} + F_{N30}$ X Rohini out-yielded most other interactions significantly (Tables 1-5). Apparently this good performance could be traced not only to the better effect of this combination during the vegetative phase of growth as is revealed by its 41.8% and 28.4% higher LAI and 14.6 and 5.1% higher dry weight than $B_{N60P30} + F_{N30}$ X Vaibhav and $B_{N60P30} + F_{N30}$ X Varuna respectively (Table 1) but also during the reproductive phase. Thus, pods/plant were 17.9% and 5.9% more in $B_{N60P30} + F_{N30}$ X Rohini than in $B_{NN60P30} + F_{N30}$ X Vaibhav and $B_{N60P30} + F_{N30}$ X Varuna, respectively (Table 3). Even the hecto-litre weight was highest in $B_{N60P30} + F_{N30}$ X Rohini (Table 4) although the difference was marginal. It is, therefore, not surprising that these attributes contributed cumulatively to the highest seed yield in this combination noted above. The seed yield of $B_{N60P30} + F_{N30}$ X Rohini was so markedly higher than that of the other combinations that inspite of the non-significant effect of t x v on seed oil content, it out-yielded $B_{N60P30} + F_{N30}$ X Vaibhav and $B_{N60P30} + F_{N30}$ X Varuna in oil production also by 16.0% and 6.4% respectively (Table 5).

It may be of interest to add here that, in various varietal trials carried out so far, including those of Samiullah *et al.* (1983) and Mohammad *et al.* (1984), Varuna had been proving superior to other varieties tested. The emergence of Rohini as a better yielder

than Varuna is, therefore, a welcome observation, particularly in view of the chronic shortage of edible oils in our country.

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