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FERTILIZER APPLICATION STRATEGIES FOR IMPROVED YIELD AND FATTY ACID COMPOSITION OF OIL IN MUSTARD

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SUMMARY

The effect of basal N and P with and without supplemental foliar N, P and S on yield characteristics and fatty acid composition of oil of *Brassica juncea* cv. Rohini was studied in a two year field experiment. The data revealed that, of the six treatments, inclusion of N, P and S in the spray, particularly in the form of commercial grade fertilizers, had a significant ameliorating effect on all yield characteristics as well as erucic acid content of the oil. This indicates the feasibility of the technique for increased productivity of the crop as well as improved quality of oil for human consumption.

***Key words* : *Brassica juncea*, fatty acid composition, fertilizer application, seed yield.**

INTRODUCTION

Previous studies have established the superiority of supplemental leaf-applied nutrients, over conventional methods, for varied field crops, including rapeseed-mustard grown with sub-optimal basal rates of application (Wittwer and Bukovac 1969, Afridi and Wasiuddin 1979, Mohammad *et al*. 1987, Mohammad 1994, Mohammad and Khan 1997, Mohammad, 2000). Although some information about the effect of leaf-applied nutrients on mustard productivity is available, little is known on their effect on the fatty acid composition of its oil. The latter information is especially important with regard to human consumption (Downey and Rimmer 1993, Kaushik and Agnihotri 2000). The present study deals with the evaluation of the effect of foliar and/or soil application of nutrients on the productivity and oil composition of a newly developed high yielding variety of mustard.

MATERIALS AND METHODS

A field experiment was conducted for two years during the winter season at the Agriculture Farm of the Aligarh Muslim University, Aligarh, India (27°52’ N latitude, 78°51’ E longitude and 187.45 m altitude). The soil was a sandy loam with a pH 7.9 and 8.0, electrical conductivity 0.50 and 0.40 dSm^{-1}, available N 210 and 190 kg ha^{-1}, P 34.3 and 26.5 kg ha^{-1} and K 207 and 209 kg ha^{-1}, for the first and second year, respectively. Six fertilizer management treatments (Tmts), as given in Table 1, were evaluated using a simple randomized block design.

Nutrient sources for soil-applied N, P and K were commercial grade urea, monocalcium superphosphate and muriate of potash, respectively. Leaf-applied nutrients were laboratory grade urea for N (Tmts 2 through 6), sodium dihydrogen orthophosphate for P (Tmts 3 and 5), sodium sulphate for S (Tmts 4 and 5) and commercial grade monocalcium superphosphate as a single source for P and S (Tmt 6). Each treatment was replicated three times using 10 m^2 plots. Foliar treatments were applied in two equal splits at 50 days after sowing (vegetative stage) and 70 days after sowing (flowering stage).

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Table 1. Fertilizer treatments evaluated for their effects on mustard seed yield and fatty acid composition

Treatment (Tmt)	Soil-applied (kg/ha)		Leaf-applied (kg/ha)		
	N	P	N	P	S
1*	80	30	0	0	0
2	60	30	20	0	0
3	60	28	20	2	0
4	60	30	20	0	2
5	60	28	20	2	2
6**	60	28	20	2	3.4

*Optimum rates determined for the Rohini cultivar (Khan 1993). Deionized water was sprayed as part of this "Control" treatment.
**Foliar P and S supplied as inexpensive commercial grade monocalcium superphosphate (Mohammad 1994).
All treatments received a basal application of 30 kg K ha^{-1} just before sowing.

At harvest, pods per plant, seeds per pod, test weight and seed yield were measured. Oil was extracted with a Soxhlet apparatus using petroleum ether as the solvent. Oil yield was computed on the basis of oil percentage and seed yield. Methyl esters of fatty acids were prepared using procedures given by Chalvardjian (1964). Palmitic (16:0), stearic (18:0), oleic (18:1), linoleic (18:2), linolenic (18:3), eicosenoic (20:1) and erucic (22:1) acid were estimated using a Nucon 5700 Gas Chromatograph. Separation was carried out on a 1.83 m by 2 mm glass column using 10% silar (5 c.p., 80/100 gas chrom. Q). The content of each fatty acid was determined by spiking the retention times with authentic reference standards prepared as pure methyl esters of each compound and the methyl ester of total seed lipids in groundnut (*Arachis hypogaea* L.). Peak areas were calculated by triangulation.

The data were analyzed with analysis of variance (Gomez and Gomez 1984). In applying the 'F' test, errors due to treatments and replicates in the first and second year separately as well as on pool basis, were determined. When 'F' value was found to be significant at the 5 per cent level of probability, a critical difference (CD) was calculated.

RESULTS AND DISCUSSION

Perusal of Tables 2-4 shows that the data for treatments differ (P=0.05) for all yield characteristics, except seeds per pod, as well as for linolenic, eicosenoic and erucic acid content of the oil. The average of the data of the two seasons (Tables 2 and 3) revealed that spray application of N (Tmt 2) resulted in higher values for pods per plant (12.7%), test weight (1.7%), seed yield (8.5%), oil content (1.3%) and oil yield (9.8%) over the water-sprayed control (Tmt 1). This observation confirms the superiority of cumulative application of N, partly basally and partly by foliar spray, over the one time basal application of the same dose. It is noteworthy that inclusion of P and S in the supplemental nitrogenous spray (Tmts 3 and 4) proved more efficacious than Tmt 2. However, the best results were obtained when all three nutrients irrespective of their sources (Tmts 5 and 6) were sprayed together. Among Tmts 5 and 6 which were at par, Tmt 6 increased pods per plant by 31.4%, test weight by 2.9%, seed yield by 14.5%, oil content by 5.4% and oil yield by 20.3% over the control.

The observed responses to the treatments would not seem unexpected in view of the fact that the growth of a plant organ is the manifestation of cell division, expansion and differentiation, which depends, among other factors, on proper supply of mineral nutrients (Moorby and Besford 1983). These cellular activities depend upon the availability of carbon skeletons and enzymes. The involvement of P in the production of the former and of N and S in that of both is well known (Salisbury and Ross 1992). Most probably the demand of the crop for these mineral nutrients was not met fully

Table 2. Effect of basal N and P with and without supplemental foliar N, P and S on pods per plant, seeds per pod and test weight of mustard cv. Rohini

Treatment	Pods per plant			Seeds per pod			Test weight (kg /hl)		
(Tmt)	First year	Second year	Pooled mean	First year	Second year	Pooled mean	First year	Second year	Pooled mean
1	380	390	385	13.1	13.2	13.2	66.5	66.7	66.6
2	422	445	434	13.8	13.9	13.9	67.6	67.7	67.7
3	465	493	479	14.2	14.3	14.3	68.1	68.2	68.2
4	455	470	463	14.1	14.1	14.1	67.8	67.9	67.9
5	500	543	522	14.6	14.8	14.7	68.9	68.8	68.9
6	489	523	506	14.3	14.3	14.3	68.5	68.4	68.5
$CD_{(0.05)}$	17	25	18	NS	NS	NS	0.8	0.9	0.4

Table 3. Effect of basal N and P with and without supplemental foliar N, P and S on seed yield, oil content and oil yield of mustard cv. Rohini

Treatment	Seed yield (kg/ha)			Oil content (%)			Oil yield (kg/ha)		
(Tmt)	First year	Second year	Pooled mean	First year	Second year	Pooled mean	First year	Second year	Pooled mean
1	1340	1375	1358	39.0	39.1	39.1	523	538	531
2	1480	1466	1473	39.5	39.6	39.6	585	580	583
3	1504	1530	1517	39.9	39.9	39.9	599	611	605
4	1492	1505	1499	40.1	40.2	40.2	598	605	602
5	1558	1603	1581	40.8	40.9	40.9	636	655	646
6	1539	1570	1555	41.1	41.2	41.2	631	647	639
$CD_{(0.05)}$	22	37	22	0.9	0.3	0.4	15	13	12

at crucial stages of growth by the supply from the soil alone due to various edaphic factors (Kannan 1990). This was offset by the ensured availability of these nutrients, at the site of their metabolism, in the form of foliar spray. It is also well known that yield is strongly related to vegetative growth (Marschner 2002). Unpublished data of the present experiment regarding growth characteristics, including dry weight of the plants, clearly established that supplemental spray of nutrients in Tmts 2-6 resulted in higher values of these attributes. It is logical to conclude that, compared with the water-sprayed control (Tmt 1), the nutrients applied through foliage contributed abundantly to the better results obtained at harvest, noted above, particularly in Tmts 5 and 6 in which all three nutrients (N, P and S) were included. Moreover, correlation studies on pooled basis, reveal that there was a positive relationship of pods per plant ($r = 0.985$) and test weight ($r = 0.995$) with seed yield, culminating in the maximization of the latter, and confirm our earlier findings (Mohammad *et al.* 1987, Mohammad 1994).

Table 4 on fatty acid composition of the oil shows that the control (Tmt 1) gave the lowest and Tmts 3 and 4 (being at par), the highest value for linolenic acid (18:3).

Table 4. Effect of basal N and P with and without supplemental foliar N, P and S on fatty acid composition of oil in mustard cv. Rohini

Treatment (Tmt)	Fatty acid composition (%)																				
	Palmitic (16:0)			Stearic (18:0)			Oleic (18:1)			Linoleic (18:2)			Linolenic (18:3)			Eicosenoic (20:1)			Erucic (22:1)		
	First year	Second year	Pooled mean	First year	Second year	Pooled mean	First year	Second year	Pooled mean	First year	Second year	Pooled mean	First year	Second year	Pooled mean	First year	Second year	Pooled mean	First year	Second year	Pooled mean
1	3.4	3.2	3.3	1.1	0.9	1.0	20.9	21.5	21.2	13.0	12.4	12.7	8.0	8.4	8.2	10.6	10.2	10.4	42.4	42.2	42.3
2	3.2	3.1	3.2	0.9	0.8	0.9	20.0	20.4	20.2	13.8	13.4	13.6	8.5	8.9	8.7	9.5	9.2	9.4	41.0	41.6	41.3
3	3.2	3.0	3.1	1.0	0.8	0.9	19.7	19.2	19.5	14.0	13.7	13.9	8.8	9.2	9.0	9.5	9.3	9.4	41.0	41.3	41.2
4	3.4	3.3	3.4	1.2	1.0	1.1	20.5	20.7	20.6	14.2	13.9	14.1	8.8	9.3	9.1	9.6	9.4	9.5	39.3	40.3	39.8
5	3.5	3.4	3.5	1.2	1.0	1.1	20.5	21.3	20.9	14.0	13.6	13.8	8.6	9.0	8.8	10.0	9.7	9.9	38.7	40.1	39.4
6	3.5	3.4	3.5	1.2	1.0	1.1	20.3	21.1	20.7	13.9	13.6	13.8	8.4	8.9	8.7	10.1	9.7	9.9	39.1	40.4	39.8
$CD_{(0.05)}$	0.2	NS	NS	0.1	NS	NS	NS	NS	NS	NS	NS	NS	0.2	0.2	0.2	0.2	0.3	0.3	0.8	0.9	0.9

NS = Non-significant

It is noteworthy, however, that the remaining treatments (Tmts 2, 5 and 6), being equally effective, gave about 6.0% higher value than the control (Tmt 1) that received the entire quantity of N and P basally. The table also shows that the content of eicosenoic acid (20:1) which forms an intermediate link in the fatty acid chain, was highest in Tmt 1, followed closely by Tmts 5 and 6 that affected it equally. The data on erucic acid (22:1) need special consideration. Incidently, the control (Tmt 1) gave the highest value for this human-unfriendly fatty acid. The 6% decrease in its content noted in Tmts 5 and 6 is, therefore, highly desirable. These observations lend support to the postulation of Downey and Craig (1964), Canvin (1965) and Appelqvist (1968a,b) that the long chain fatty acids (eicosenoic and erucic) are formed at the expense of the smaller chain ones that include linolenic acid.

The present study therefore, confirmed our earlier findings (Mohammad *et al*. 1987, Mohammad 1994) of an ameliorating effect of supplemental spray of N, P and S on seed and oil production in rapeseed-mustard. The erucic acid content of the oil may be reduced substantially by using this technique, thus making it more suitable for human consumption. It may also be pointed out that the technique involving supplemental foliar spray may be made more cost-effective by employing commercial grade monocalcium superphosphate as source of P and S and urea, of N. Moreover, as the three nutrients are readily compatible with common insecticides, which have to be sprayed invariably at the growth stages selected in our study, the nutrients would, therefore, get almost a "free-ride" with the usual pest control measures.

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