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Variation in yield, oil and protein content of rapeseed (*Brassica campestris*) in relation to levels of nitrogen, sulphur and plant density

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ABSTRACT

A field experiment was conducted during the winter seasons of 1988–89 and 1989–90 to find the effect of different levels of nitrogen sulphur and plant density on yield, yield attributes, oil and protein content of rapeseed (*Brassica campestris* L.). Nitrogen up to 120 kg/ha increased the yield components (plant height, primary branches/plant, siliquae/m^2 and seeds/siliqua), seed and stover yields/ha and harvest index. Yield attributes, and seed and stover yields, harvest index progressively increased with the increase in level of sulphur. Lower plant density increased the plant height and branches/plant but plant density of 400,000/ha significantly increased the number of siliquae/m^2, seed and stover yields/ha and harvest index. Oil content was inversely related to the protein content in seed irrespective of different levels of nitrogen, sulphur and plant density. Increasing levels of nitrogen decreased the oil and increased the protein content in seed but sulphur and plant density increased the oil and decreased the protein content in seed.

Rapeseed (*Brassica campestris* L.) being the principal oilseed crop, plays an important role in rural economy of Bangladesh. Though it is extensively grown, its yield is very low (about 700 kg/ha). Such a low yield is the consequence of the use of a very low level of fertilization with inadequate cultural management in this crop. The soils of Bangladesh are generally deficient both in available N and S (Mazid, 1986). The beneficial effect of nitrogen on growth and yield of *Brassica* has been established by a number of research workers (Patil and Bhargava, 1987; Kumar and Gangwar, 1985; Sharma and Kumar, 1990). Grain yield can also be increased by raising plant density; however it varies with plant types (Ali *et al.*, 1990). The combined effect of N and S have important role on growth, seed and oil yields of *Brassica* (Janzen and Bettany, 1984). Many researchers also demonstrated the combined effect of N and plant density on growth and seed yield of *Brassica* species (Gangwar and Kumar, 1986; Ali *et al.*, 1990). Moreover, optimum plant density minimizes competition for nutrients, light and moisture. However, information on proper levels of N, S and plant density which can ensure optimum yield of rapeseed, are scanty in Bangladesh. Hence present experiment was conducted to assess the influence of N, S and plant density and their interactions on yield, its atributes, oil and protein content of rapeseed.

MATERIALS AND METHODS

The field experiment was conducted at Bangladesh Agricultural Institute, Dhaka, during winter season (*rabi*) of 1988–89 and 1989–90 on a medium high land, located at

Table 1. Influence of plant density, nitrogen and sulphur on yield attributes, yield of rapeseed

Treatment N (kg/ha)	Plant height (cm)		No. prim. br./plant		No. siliquae/m²		No. seed/siliqua		Seed yield (kg/ha)		
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Pooled
0	105.49	95.68	5.27	4.35	1331.17	865.56	28.90	26.70	674.54	634.79	654.67
60	110.37	101.46	6.92	6.40	1746.98	1267.08	30.52	28.99	1215.58	1011.52	1113.55
120	117.42	105.57	8.81	8.82	2280.54	1814.60	30.81	31.22	1545.71	1434.38	1490.55
180	116.40	105.61	8.72	7.68	2135.19	1486.65	31.06	30.54	1465.27	1372.75	1419.65
CD (P = 0.01)	1.45	1.00	1.28	0.82	356.67	299.30	0.88	2.05	105.39	191.21	140.55
S (kg/ha)											
0	111.68	100.56	7.52	6.58	1735.17	1215.31	30.41	30.27	1100.29	958.98	1029.64
10	101.93	101.93	7.09	6.95	1802.63	1321.54	29.53	28.95	1194.21	1149.48	1171.84
20	102.82	102.82	7.52	6.39	2005.46	1446.73	30.35	29.31	1261.38	1165.46	1213.42
30	103.00	103.00	7.59	7.32	1950.63	1450.31	31.19	28.91	1345.23	1180.52	1262.87
CD (P = 0.01)	NS	NS	NS	0.76	242.97	175.81	NS	0.95*	87.46	133.55	98.43
Plants/ha ('000)											
100	124.29	115.95	14.00	14.73	1710.48	1276.60	33.44	33.68	1244.69	1100.15	1172.42
400	115.25	107.54	7.16	6.31	2140.27	1667.13	31.20	30.91	1345.79	1269.73	1307.76
700	108.11	96.11	4.81	3.80	1856.19	1304.46	29.58	27.86	1193.27	1070.29	1131.78
1,000	102.02	88.71	3.72	2.40	1786.94	1185.71	27.57	25.00	1117.35	1014.27	1065.81
CD (P = 0.01)	1.75	2.11	0.58	0.54	122.43	115.34	0.76	1.08	22.74	75.10	50.25

Y_1, 1988–89; Y_2, 1989–90
*CD value at 5% level

23.70°N and 90.40°E with humid subtropical climate. The soil was clay loam having pH 5.6, organic carbon 0.83%, available N, P, K and S 54, 68, 93 and 16 kg/ha respectively in 30 cm-soil profile. The treatments comprised 4 levels of N (0, 60, 120 and 180 kg/ha) as main plots, 4 of S (0, 10, 20 and 30 kg/ha) as subplots and 4 of plant density (100, 400, 700 and 1,000 plants/ha as sub-subplots (4.0 m x 3.90 m) which were then replicated 3 times in split-plot design. The seeds of variety 'Sonali Sarisha' ('SS 75') which belongs to toria group of *Brassica campestris* were sown 30 cm apart in rows on 2 November in 2 subsequent years. All plots received a basal dressing of 80 kg P_2O_5 and 40 kg K_2O/ha through triple superphosphate and muriate of potash respectively. Entire quantity of S (through gypsum) and half quantity of N in the form of urea were applied before sowing and the rest half of nitrogen was top-dressed at 50% flowering stage. Uniform plant densities of 3, 12, 21 and 30 plants per linear m were established by thinning to mean distance of 33.33, 8.33 4.76 and 3.33 cm between plants in row for 4 plant densities of 100, 400, 700 and 1,000 plants/ha. The crop was irrigated twice, first at flower initiating stage [35 days after sowing (DAS)] and second after completion of siliquae setting at 64 DAS. Total precipitation received during 2 subsequent crop seasons (November to February) was 162 and 20 mm in 2 instalments respectively. One hand-weeding during 10–15 DAS and 1 spading was provided at 40 DAS, after top-dressing.

Aphids were controlled by spraying Ripcord 10 EC at 32 and 56 DAS. When 80% of the siliquae turned yellowish, an area of 6.30 m^2 from the centre of each plot was harvested at ground-level. After proper drying biological yield (seed + stover) was recorded. Threshed seeds were dried, cleaned and weighed to estimate seeds/ha.

The oil content was determined by Soxlet-extraction method (Hughes, 1969). After digestion of seed sample with H_2SO_4 in presence of K_2SO_4 + $CuSO_4$ + metalic selenium, the N (%) of seed was determined by the help of 'Technicon Autoanalyzer' and the content of protein was worked out by multiplying the N content with a conversion factor of 6.25.

RESULTS AND DISCUSSION

Effect of N

Application of N up to 120 kg/ha significantly increased the yield attributes (plant height, primary branches/plant, siliquae/m^2 and seeds/ siliqua) (Table 1). The highest number of siliquae/m^2 was at 120 kg N/ha followed by N_{180}, N_{60} and N_0 respectively. Improvement in yield components in Indian mustard with N was reported by Singh *et al.* (1985).

The improvement in plant growth and yield components reflected on seed and stover yields which increased significantly with increasing levels of N up to 120 kg/ha (Tables 1, 2). In pooled data analysis N @ 60, 120 and 180 kg/ha increased the seed yield by 70.09, 127.69 and 116.83% respectively over N_0. The harvest index was not affected due to nitrogen application. The response of seed yield to N levels was quadratic in nature. Kumar and Gangwar (1985), Singh *et al.* (1985) and Sharma and Kumar (1990) reported similar effect of N on stover and seed yields of rapeseed.

For each successive increase of N rate, there were significant increase in the protein content but it negatively affected the oil content in seed (Table 2). Higher and lower oil content of 43.03 and 40.81 were recorded at N_0 and N_{180} kg/ha during 1988–89. Thus

180 kg N/ha reduced the oil content and caused increased protein on an average of 4.89, 7.76 and 12.81% over 120, 60 and 0 kg N/ha respectively. Thus it appears that protein content increased with increasing N inputs which showed inverse relationship with oil content. Patil and Bhargava (1987) obtained similar results with N in respect of oil and protein content of *B. juncea.*

Effect of S

Sulphur significantly increased the siliquae/m^2 (Table 1). However, primary branches/plant and seeds/siliqua were significantly influenced by N only during 1989–90. Improvement in yield attributes at higher S rate contributed positively towards maximum seed and stover yields up to 30 kg S/ha. However, in pooled data analysis S @ 10–30 kg/ha gave seed yield of 13.86, 17.91 and 22.65% higher over S_0. The response showed a linear relationship between S levels and seed yield. The finding is in agreement with the finding of Singh and Gangasaran (1987). Application of S. 10–30 kg/ha did not show significant difference in harvest index (Table 2). Chaturvedi *et al.* (1988) reported positive relationship between higher harvest index and seed yield of *B. campestris.* Increasing levels of S significantly increased the oil content and consequently reduced the protein content in seed (Table 1). The increase in oil content due to 30 kg S/ha had an average 3.94% higher over S_0. Increasing level of S decreased the protein content, which showed inverse relationship with oil content in seed. Sawarkar *et al.* (1987) reported protein content of 18.84 and 17.48% and oil content from 40.46 to 45.05% in *B. juncea* with S from 0–60 kg/ha.

Effect of plant density

Increasing levels of plant density adversely affected the various yield attributes, stover and seed yields (Tables 1, 2). The maximum and minimum plant height and branches/plant were 124.29 and 102.03, 14.73 and 2.40 respectively were recorded with plant density of 10 and 100 plants/m^2 respectively. It is natural that population of more than 10 plants/m^2 competed for nutrients, space and light and therefore could not produce desirable height and number of branches/plant. Plant density at 40 plants/m^2 significantly increased the siliquae/unit area over 70, 100 and 10 plant/m^2. Naturally lower population increased and higher population decreased the number of siliquae/plant but they could not compensate with PD at 40 plants/m^2, because of optimum PD, which facilitated maximum utilization of solar energy and nutrients. Significant reduction in seeds/siliqua was observed when plants were subjected to higher plant density (Table 1).

Unlike yield attributes, the grain and stover yields were significantly higher at 400,000 plants/ha (Table 1). It indicated that the improvement in yield attributes at lower plant density was not reflected by seed and stover yields. In other words, higher plant density above 400,000 plants/ha could not influence yield attributes due to more competition for nutrients and space which failed to compensate yield. It may be concluded that 400,000 plants/ha gave substantially higher seed and stover yields, because such an optimum plant density, facilitated maximum utilization of nutrients, increase dry-matter production and yield attributes, which cumulatively resulted in higher seed yield of rapeseed. Gupta (1988) also observed significant increase and decrease of all yield attributes at lower and higher plant density, but higher yield was recorded at 44.4 plants/m^2. Plant density at different levels increased the harvest index

Table 2. Effect of plant density, nitrogen and sulphur on stover yield, harvest index, oil and protein in seed of rapeseed

Treatment (kg/ha)	Stover yield (kg/ha)		Harvest index (%)		Oil content in seed			Protein content in seed (%)		
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
0	1389.63	1520.02	32.72	29.63	43.33	41.53	42.27	19.47	20.83	20.15
60	2384.72	2294.83	33.79	30.60	42.26	41.31	41.78	21.43	21.21	21.32
120	2919.27	3022.48	35.27	32.12	41.88	40.74	41.31	22.27	21.69	21.98
180	2837.85	2934.13	34.23	31.76	40.81	39.94	40.37	23.60	22.62	23.11
CD (P = 0.01)	609.67	388.20	NS	NS	0.34	0.24	0.33	0.19	0.48	0.30
S (kg/ha)										
0	2283.00	2146.63	32.91	30.91	41.14	40.19	40.66	22.80	22.46	22.63
10	2325.29	2445.13	33.83	31.96	41.77	40.54	41.15	22.06	22.151	22.11
20	2409.96	2599.46	34.42	30.34	42.16	41.18	41.67	21.23	21.19	21.21
30	2513.23	2580.25	34.85	30.91	42.90	41.62	42.26	20.58	20.55	20.56
CD (P = 0.01)	163.08*	298.64	1.35*	NS	0.27	0.27	0.23	0.16	0.25	0.22
Plants/ha ('000)										
100	2301.69	2350.98	34.99	31.68	40.39	39.29	39.84	23.26	23.19	23.22
400	2421.50	2624.00	35.51	32.34	41.61	40.19	40.90	22.28	22.20	22.24
700	2415.67	2430.96	32.94	30.28	42.79	41.60	42.19	21.18	21.31	21.25
1,000	2392.65	2365.52	32.57	29.83	43.18	42.40	42.79	20.04	19.65	19.85
CD (P = 0.01)	85.23*	131.33	1.44	1.53	0.28	0.19	0.22	0.12	0.24	0.20

* CD value at 5% level

of rapeseed irrespective of years (Table 2). Populations of 70 and 100 plants/m^2 did not show significant difference in harvest index. It showed that 40 plants/m^2 gave higher harvest index, which had positive relation with higher seed yield. Shrief *et al.* (1990) reported higher seed yield of rapeseed (30 plants/m^2), along with higher harvest index.

The different plant densities had significant influence on oil and protein content of seed (Table 2). Seed oil content was negatively correlated with protein content in seed. Increasing plant density significantly increased the oil and decreased the protein content in seed. When the plant density was high, the percentage of oil increased but the oil yield/ha decreased due to reduction in the seed yield/ha. This higher percentage of oil might be an account of higher contribution of oil from the main shoot. Since the seeds obtained from the main shoot had a longer period available for development, the oil percentage remained higher when the plant density was high.

The interaction between N x S was found significant for oil and protein contents in seed, N x plant density on plant height, primary branches/plant, siliquae/m^2, seed and stover yields, harvest index, oil and protein content, S x plant density and N x S x plant density on seed yield oil and protein content. However, we discussed interaction effects on seed yield. In pooled data analysis the maximum seed yield of 1,504 1,582 and 1,364 kg/ha was obtained under the combination effect of 120 kg N/ha + 30 kg S/ha; 400,000 plants/ha + 120 kg N/ha and 400,000 plants/ha + 30 kg S/ha respectively.

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