Influence of nitrogen and sulfur on seed yield and quality of hybrid canola

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Abstract

Nitrogen and sulfur are the key nutrients required for oilseeds owing to their important role in plant metabolic processes. An experiment was conducted to study the response of these nutrients on the seed yield and quality of canola hybrid Hyola PAC 401 during winter 2004-05. Nitrogen (100, 125 and 150 kg/ha) was applied in two splits half at sowing and remaining after first irrigation. Sulfur (20, 40 and 60 kg/ha) was applied at time of sowing. Phosphorus was applied @ 30 kg P_2O_5/ha at sowing in all treatments. Application of 125 kg N/ha resulted in 6.3 per cent higher seed yield over 100 kg N/ha (1517 kg/ha). Further increase in N was inconsequential. Response of S was discernible up to 40 kg/ha where it resulted in 19.4 per cent higher seed yield than application of 20 kg S/ha (1389 kg/ha). Combined application of 125 kg N + 40 kg S/ha resulted in 28.9 per cent higher seed yield (1708 kg/ha) as compared to application of 100 kg N + 20 kg S/ha. Varied doses of N failed to significantly alter fatty acid profile; however, glucosinolates content decreased from 14.6 µmole/g defatted seed meal with 100 kg N/ha to 12.9 µmole/g defatted seed meal with 125 kg N/ha and leveled off following further increase in N. Glucosinolate content with 40 or 60 kg S/ha (12.5 µmole/g defatted seed meal) was lower than that registered with 20 kg S/ha (15.3 µmole/g defatted seed meal). Glucosinolate content increased with increasing dose of S from 20 to 60 kg/ha with application of 100 kg N/ha but it decreased when dose of N was also increased to 125 or 150 kg/ha. Thus, balanced application of N and S leads to higher seed yield and better quality of seed meal.

Key words: Oilseed rape, *Brassica napus*, canola, nitrogen, sulfur, yield, quality

Introduction

The demand of vegetable oil is increasing throughout the world at a rapid pace. The annual increase in demand for India has been estimated to be about 4-6 per cent. Different oilseed crops are grown in India to supply vegetable oils among which rapeseed-mustard (*Brassica* sp.) represents an important group of oil crops, which are grown throughout the country under varied agro-climatic conditions. Among *Brassicas*, Indian mustard (*Brassica juncea* L.) and oilseed rape (*Brassica napus* L.) are important. The fatty acid composition of edible oils influences the human serum cholesterol level. The oil of conventional rapeseed-mustard cultivars of India contains nutritionally undesirable long chain fatty acid mainly eicosenoic and erucic acids. The protein rich seed meal obtained after oil extraction is considered a valuable animal feed but contains higher amount of glucosinolates. Owing to health benefits of canola oilseed rape, its demand in the country is likely to increase in future. Nitrogen (N) and sulfur (S) play multiple roles in oilseed crops (Ahmad & Abdin, 2000a; Milleo & Doni, 2000). The assimilatory pathways of N and S are considered to be functionally convergent and the availability of one nutrient, in addition to its direct role in promoting growth and yield, regulates the activity of another (Barney & Bush, 1985). There is greater synergistic influence of N and S on growth, yields, nutrient uptake, protein and oil production in oilseed rape (Aulakh et al., 1995; McGrath & Zhao, 1996).

Indian soils are generally deficient in N. With increasing cultivation in light textured soils, use of S-free fertilizers particularly in the intensive cropping systems and canal water for irrigation, deficiency of S is becoming more widespread throughout the country. Since cultivation of canola oilseed rape has recently started in India, information on its nutritional requirements is urgently needed. Because N and S are considered the major nutrients influencing the yield and quality of oil and seed meal, this investigation was conducted to (i) find out the N and S requirements for hybrid canola oilseed rape, and (ii) to study the influence of these nutrients on fatty acid composition and glucosinolate content of seed meal.

Material and Methods

The experiment was conducted at the Punjab Agricultural University, Ludhiana (30°56'N, 75°52'E, 247 metres above mean sea level), India during winter 2004-05. Sandy loam (*Typic Ustochrepts*) soil of the experimental field was low in organic carbon (0.30 %), rich in available phosphorus (0.5 M sodium bicarbonate extractable P, 28.0 kg/ha), available potassium (ammonium acetate extractable K, 217 kg/ha) and medium in available S (DTPA extractable S, 12 ppm).

The study comprised 9 treatments of combinations of 3 doses of nitrogen (100, 125 and 150 kg/ha) and 3 doses of sulfur (20, 40 and 60 kg/ha), which were replicated thrice in randomized complete block design. Canola oilseed rape hybrid PAC 401 was sown on November 25, 2004 in 0.45 m apart rows using seed rate of 3.75 kg/ha. Plot size of 14.4 m^2 was maintained to accommodate eight rows each of 4 metre length. Net plot size was 8.1 m^2 comprising six inner rows each of 3 metre length. The crop was manually harvested on April 11, 2005. A uniform dose of 30 kg P_2O_5/ha was applied through di-ammonium phosphate (18% N and 46% P_2O_5) before sowing. The N was applied through urea (46% N) in addition to the amount available from dia-ammonium phosphate to supply half of the dose of N (as per treatments) at time of sowing. The required dose of S as per treatments was also applied at sowing through gypsum (15.5% S). After completion of thinning/gap filling and application of first irrigation the remaining amount of N was top dressed at about 35 days after sowing (DAS). Statistical analysis was done by factorial randomized complete block design.

The seed samples were collected randomly from the produce of whole plot. Nuclear Magnetic Resonance Spectroscope (Newport Analyser model MK 111A) employing non-destructive method of oil estimation was used to determine oil content in the whole seed. The fatty acid composition of oil and glucosinolate contents in seed were estimated using standard procedures.

Results

Application of 125 kg N/ha resulted in 6.3 per cent higher seed yield than 100 kg N/ha (Table 1). Likewise, significant response to S application was discerned up to 40 kg/ha, which contributed 19.4 per cent more seed yield over 20 kg S/ha. Similar trend was noticed for stover yield (Table 1). With 100 or 125 kg N/ha, application of 40 kg S/ha resulted in significantly higher seed yield over 20 kg S/ha (Table 2). The highest seed yield was obtained with 125 kg N + 60 kg S/ha (1728 kg/ha) which was at par with 125 kg N + 40 kg S/ha (1708 kg/ha), 150 kg N + 40-60 kg S/ha (1625-1720 kg/ha) and 100 kg N + 40 kg S/ha (1646 kg/ha) but conspicuously higher than other combinations of N and S. Thus application of 125 kg N with 40-60 kg S/ha resulted in 28.9-30.4 per cent higher seed yield than 100 kg N + 20 kg S/ha (1325 kg/ha). Effect of N and S on oil content was non-conspicuous (Table 1).

Application of N and S failed to significantly alter the fatty acid composition of oil (Fig 1). The palmitic and oleic acid marginally increased up to 150 kg N/ha, whereas, such trend for linoleic and linolenic acid was observed up to 125 kg/ha. However stearic, eicosenoic and erucic acid content showed decreasing trend with increasing N application. Similar trend was discerned for S application except eicosenoic acid, which was highest with 40 kg S/ha.

Table 1. Influence of nitrogen and sulfur application on yield attributes, seed yield, stover yield and oil content of oilseed rape

Doses of nutrients	Plant height (cm)	Length of main shoot (cm)	Primary branches per plant	Number of siliquae per plant	Seed yield (kg/ha)	Stover yield (kg/ha)	Oil content (%)
			Nitrogen (kg/ha)				
100	130	62.0	4.4	157	1517	4944	41.4
125	130	62.3	5.0	179	1613	5232	41.2
150	133	64.3	4.9	170	1595	5388	40.9
LSD (p=0.05)	NS	NS	0.4	18	NS	NS	NS
			Sulfur (kg/ha)				
20	133	61.3	4.6	163	1389	4839	41.6
40	130	64.3	4.8	170	1660	5309	41.0
60	130	63.0	4.9	173	1676	5416	41.0
LSD (p=0.05)	NS	NS	NS	NS	185	377	NS

Table 2. Interactive effect of graded doses of nitrogen and sulfur on seed and stover yield of oilseed rape

Doses of nitrogen (kg/ha)	Doses of sulfur (kg/ha)					
	20	40	60	20	40	60
	Seed yield (kg/ha)			Stover yield (kg/ha)		
100	1325	1646	1580	4806	5144	4881
125	1403	1708	1728	4811	5247	5638
150	1440	1625	1720	4900	5535	5728
LSD (p=0.05)	302			NS		

Increase in N from 100 to 125 kg/ha significantly reduced the glucosinolate content in seed meal, which leveled off with further increase in N (Table 3). Similarly increase in S from 20 to 40 kg/ha caused significant reduction in glucosinolates. With lower dose of N, glucosinolate content increased with increasing S application, whereas it decreased when both N and S were increased.

Table 3. Interactive effect of graded doses of nitrogen and sulfur on glucosinolates content (µmole/g defatted seed meal)

Doses of nitrogen (kg/ha)	Doses of sulfur (kg/ha)			Mean
	20	40	60	
100	12.63	15.0	16.26	14.63
125	16.20	11.68	10.68	12.85
150	16.94	10.90	10.55	12.80
Mean	15.26	12.53	12.50	

LSD (p=0.05) N: 1.53, S: 1.88, N X S: 3.26

Discussion

Nitrogen occupies prominent position among essential nutrients required for plant growth, development and economic yield. Nitrogen plays crucial role in determining photosynthetic capacity of plants (Kumar et al., 2003), nutrient uptake and yield of oilseed rape (Aulakh et al., 1999; Momoh etal., 2004). Sulfur indirectly influences photosynthetic efficiency by improving N utilization efficiency (Ahmad & Abrol, 2000a; Ahmad et al., 2001). Both N and S affect enzyme activity in their assimilatory pathways (Barney & Bush, 1985; Bell et al., 1995; Ahmad et al., 1999) and interact in such a way that inadequacy of one reduces the uptake and assimilation of other (Zhao et al., 1999). In the present study, improvement in yield accrued from increase in number of primary branches and siliquae per plant and main shoot length due to application of N and S. Influence of S was more pronounced than N.

Favorable influence of N and S on crop yield and oil quality has been reported through many studies (McGrath & Zhao, 1996; Ahmad et al., 2000b; Fismes et al., 2000). Fismes et al. (2000) found increase in glucosinolates with S application. Zhao et al. (1997) observed that S supply decreased glucosinolates in rapeseed. The findings of this investigation are in agreement with Momoh et al. (2004) for N application.

Conclusion

Application of 125 kg N + 40 kg S/ha significantly increased seed yield, reduced erucic acid in oil and glucosinolates in seed meal.

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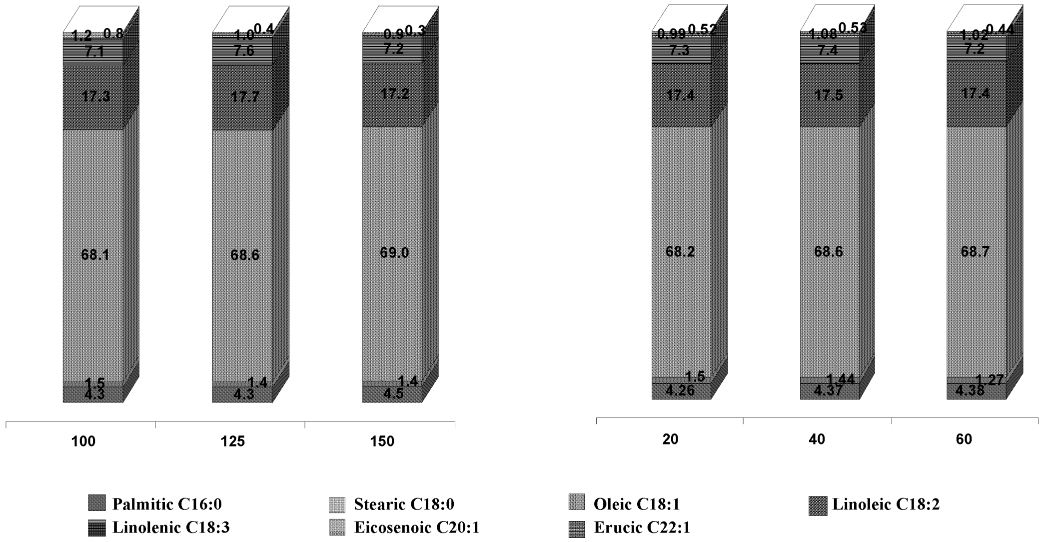

Fig. 1. Influence of nitrogen and sulfur application on different fatty acids (%) of oilseed rape