Pak. j. life soc. sci. (2003), 1(1): 09-12

Pakistan Journal of Life and Social Sciences

Interactive Effects of Nitrogen and Sulphur on the Growth, Seed Yield and Oil Quality of Canola

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Abstract

Investigations were carried out to see the interactive effects of nitrogen and sulphur on the growth, seed yield and oil quality of canola (*Brassica napus* L.). The experimental treatments comprised four nitrogen levels i.e. 0, 60, 90 and 120 kg ha^{-1} and three sulphur levels i.e. 0, 125 and 250 kg ha^{-1}. Different growth and yield parameters of canola such as plant height at maturity, number of pod m^{-2}, number of seeds pod^{-1}, 1000-seed weight and oil contents were significantly affected by nitrogen and sulphur levels. Maximum seed yield (2704 kg ha^{-1}) was attained where the crop was fertilized @ 120 kg N ha^{-1}, whereas, maximum oil and protein content were recorded where the crop was fertilized @ 120 kg N ha^{-1} and 250 kg S ha^{-1}.

Key words: Canola, Nitrogen , Sulphur

Introduction

Pakistan has been facing a chronic shortage of edible oils. The total requirement of edible oil for 2000-01 was 1.95 million tonnes of which 0.562 million tonnes came from local production and remaining 1.388 million tonnes was imported (Anonymous, 2001). Rapeseed and mustard are the second important source after cotton seed contributing towards the national production of edible oil (Anonymous, 2001) but their oil is of low quality due to high erucic acid contents (> 60%) which decreases the taste and flavour and glucosinolates (> 100 μ mg^{-1}) which not only cause nutritional disorders and goitres but also adversely affect growth and reproduction of animals if fed at significant level in diet (Varma and Reddy, 1985). Newly introduced canola cultivars with low erucic acid and glucosinolates also known as “double zero” varieties made the canola oil more popular. Besides, it has the lowest level of saturated and highest level of mono and poly-unsaturated fatty acids which reduce cholesterol level. Keeping in view the importance of canola oil, there is a dire need to evolve certain package of technology for exploring the full potential of the crop.

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There are different factors responsible for low yield of canola. Besides many other agronomic aspects proper fertilization leads to higher yields, therefore its balance and judicious use is of prime importance.
Nitrogen is one of the most important nutrient elements affecting the yield attributes and yield of Indian mustard (Saini *et al.*, 1989). Higher rate of nitrogen application at sowing leads to more rapid leaf area development, prolongs the life of leaves, improves leaf area duration after flowering and increases overall crop assimilation thus contributing to increased seed yield (Wright *et al.*, 1988). Sulphur is the “fourth major nutrient” in crop production. It is a component of amino acids cysteine, methionine, essential amino acids for protein synthesis. Canola has higher requirements of sulphur than cereals. Grant and Bailey (1993) reported that S deficiencies frequently restrict canola yield. Oilseed crops, in general respond more to sulphur application which is expressed in yield and quality of produce (Nagar *et al.*, 1993, Patgiri and Baruah, 1993). It also increases the oil contents of crops (Tisdal *et al.*, 1950). Increase in oil concentration has also been observed with sulphur application on deficient soils. Application of sulphur on deficient soil can increase protein content (Nuttal *et al.*, 1987). Sulphur is also essential for the formation of chlorophyll and nodulation in leguminous plants. Therefore the present study was conducted to investigate the yield and oil quality response of canola to different nitrogen and sulphur levels.

Materials and Methods

The experiment was conducted at the Agronomic Research Area, University of Agriculture, Faisalabad (31.25^{o} N, 73.09^{o} E) during the year 1999-2000. The soil was a sandy clay loam in texture. Before sowing soil test showed a pH of 8.0, 0.93% organic matter, 0.042% N, 9.1 mg kg^{-1} P_2O_5 and 131 mg kg^{-1} K_2O. The experiment was laid out in a Randomized Complete Block Design (RCBD) under factorial arrangement with three replications and net plot size was 1.2 m x 5 m. The experimental treatments comprised four nitrogen levels i.e. 0, 60, 90 and 120 kg N ha^{-1} and three sulphur levels i.e. 0, 125 and 250 kg S ha^{-1}. Crop (Canola cv. Hyola 401) was sown on 14th October, 1999 using a seed rate of 5 kg ha^{-1} in 30 cm apart rows with a single row hand drill on a well prepared fine seed bed. Urea, triple superphosphate and crude sulphur used as source of nitrogen, phosphorous and sulphur, respectively. A standard dose of phosphorus (60 kg ha^{-1}), sulphur and half of nitrogen was side dressed at the sowing time and remaining half nitrogen was top dressed at flowering stage with second irrigation. All other agronomic practices were kept normal and uniform for all the treatments. Observations recorded during the course of study using the standard procedures were plant height at maturity (cm), number of pods m^{-2}, number of seeds pod^{-1}, 1000-seed weight (g), seed yield (kg ha^{-1}), seed oil percentage (Soxhlet Fat Extraction Method, A.O.A.C. 1990) and seed protein content (Jackson, 1962). Data collected were analysed statistically using Fisher's analysis of variance technique and least significant difference (LSD) test at 5% probability was applied to compare the differences among treatments' means (Steel and Torrie, 1984).

Results and Discussion

Data regarding plant height as affected by various treatments at maturity are given in Table 1. Plant height was significantly affected by different levels of nitrogen and sulphur. Maximum plant height (138.7 cm) was observed at N_2 (90 kg N) which is statistically at par with plant height achieved with N_3 (120 kg N) treatment. Minimum plant height (127.3 cm) was attained in N_0 (0 kg N) treatment. Similarly maximum plant height (138.2 cm) was observed in S_2 (250 kg S) while the minimum plant height (130.4 cm) was found in control (S_0). The interaction between nitrogen and sulphur was found to be non-significant. Bhagwan and Kumar (1996) working in India on Indian mustard also reported that increasing rate of N significantly increased the plant height, over the control and lower rates of N application.

The data pertaining to number of branches $plant^{-1}$ is presented in Table 1. It was revealed that number of branches $plant^{-1}$ was significantly affected by different treatment of nitrogen and sulphur. Maximum number of branches $plant^{-1}$ (13.10) was observed at N_3 (120 kg) followed by N_2 (90 kg) which gave 10.70 branches $plant^{-1}$ while lowest number of branches $plant^{-1}$ (6.60) was produced in case of N_0 treatment. Maximum number of branches $plant^{-1}$ (10.59) was produced by S_2 (250 kg) treatment followed by S_1 (125 kg) and S_0 (0 kg) which gave the 9.70 and 9.16 number of branches $plant^{-1}$, respectively. The interaction between nitrogen and sulphur (NxS) was found to be non-significant. However, higher number of branches $plant^{-1}$ at 120 kg N and 250 kg S can be attributed to the balanced nutrient management. Ali *et al.* (1996) working in Bangladesh on rapeseed also reported similar findings. They observed that application of N upto 120 kg ha^{-1} significantly increased branches $plant^{-1}$ over the lower rates of N application. They also reported that sulphur significantly increased the primary branches $plant^{-1}$.

Nitrogen and sulphur fertilizers gave the significant results with respect to number of siliquae m^{-2} but their interaction (NxS) was found to be non-significant (Table 1). Maximum number of siliquae m^{-2} (6116) was produced by N_3 (120 kg) treatment followed by N_2 (90 kg). Minimum number of siliquae m^{-2} (3742) was recorded in N_0 (control) treatment. Similarly, the treatment S_2 (250 kg) gave the maximum number of siliquae m^{-2} (5254) followed by S_0 (control) treatment which produced 4755 siliquae m^{-2}. Minimum number of siliquae m^{-2} (4751) were recorded in S_1 (125 kg) treatment. Maximum number of siliquae m^{-2} was attained when the crop was fertilized @ 120 kg N and 250 kg S ha^{-1}. More number of siliquae m^{-2} may be due to higher levels of N and S. Improvement in yield components in Indian mustard with N and S was also reported by Varma and Reddy (1985).

Significant differences were recorded in number of seeds $siliqua^{-1}$ among various nitrogen and sulphur rates (Table 1). N_3 (120 kg) treatment produced maximum number of seeds $siliqua^{-1}$ (21.58) than all other treatments. Similarly N_2 (90 kg) treatment was also superior in the number of seeds $siliqua^{-1}$ than lower rate of nitrogen application and control, and gave 18, 15 and 13 number of seeds $siliqua^{-1}$, respectively. Similarly, maximum number of seeds $siliqua^{-1}$ (18.36) was attained in S_2 (250 kg) treatment, followed by S_1 (125 kg) treatment which produced 17.46 seeds against the minimum of 16.28 seeds $siliqua^{-1}$ in S_0(control) treatment. The interaction between different nitrogen and sulphur levels (NxS) was found to be significant (Table 2). Maximum number of seeds $siliqua^{-1}$ (22.72) was observed in N_3S_2 (120 kg and 250 kg S) treatment combination while minimum number of seeds $siliqua^{-1}$ (12.32) was noted with N_0S_0 (control) treatment combination. The results of this study are quite in line with the early research work done by Ali *et al.* (1996) who reported maximum number of seeds $siliqua^{-1}$ (31.22) at 120 kg N ha^{-1}. However, maximum number of seeds $siliqua^{-1}$ (31.19) was observed at 30 kg S ha^{-1} against the lower rates of S application and control.

The data regarding 1000-seed weight of canola as shown in Table 1, revealed significant effect of nitrogen and sulphur fertilizers application. While the interaction (NxS) between the two fertilizers was found to be non-significant. The maximum 1000-seed weight (3.82 g) was recorded in N_3 (120 kg) treatment, followed by N_2 (90 kg) treatment i.e. 3.65 g. Minimum 1000-seed weight (3.29 g) was produced by N_0 (control) treatment. Similarly the treatment S_2 (250 kg) gave the maximum 1000-seed weight (3.62 g) while the minimum 1000-seed weight (3.49 g) was found in S_0 (control) treatment. The results are supported by Singh and Gangasaran (1987), Trivedi and Singh (1999) who reported increased levels of nitrogen and sulphur produced the highest 1000-seed weight.

Table 1: Effect of different nitrogen and sulphur levels on plant height, number of branches plant^{-1}, number of siliqua m^{-2}, 1000-seed weight, seed yield and protein content of canola.

Treatments	Plant height at maturity (cm)	No. of ranches plant^{-1}	No. of siliqua m^{-2}	1000-seed weight (g)	Seed yield (kg ha^{-1})	Protein contents (%)
Nitrogen levels						
N_0 (0 kg ha^{-1})	127.3c*	6.60d	3742d	3.29d	1563d	18.49d
N_1 (60 kg ha^{-1})	132.6b	8.67c	4568c	3.45c	1994c	20.39c
N_2 (90 kg ha^{-1})	138.7a	10.70b	5254b	3.65b	2337b	21.65b
N_3 (120 kg ha^{-1})	138.1a	13.10a	6116a	3.82a	2704a	22.55a
Sulphur levels						
S_0 (0 kg ha^{-1})	130.4c	9.16b	4755b	3.49b	2087.5^{NS}	20.54c
S_1 (125 kg ha^{-1})	133.9b	9.70b	4751b	3.54b	2138.89	20.72b
S_2 (250 kg ha^{-1})	138.2a	10.59a	5254a	3.62a	2222.22	21.04a

N.S. = Non-significant; *Any two means not sharing a letter in common differ significantly at 5% probability level.

Table 2: Effect of different nitrogen and sulphur levels on the number of seeds siliqua^{-1} of canola.

	S_0(0 kg S ha^{-1})	S_1 (125 kg S ha^{-1})	S_2 (250 kg S ha^{-1})	Mean
N_0 (0 kg ha^{-1})	12.23l*	13.78k	14.33j	13.45d
N_1 (60 kg ha^{-1})	15.17i	15.77h	16.79g	15.91c
N_2 (90 kg ha^{-1})	17.28f	18.70d	19.60d	18.53b
N_3 (120 kg ha^{-1})	20.43c	21.58b	22.72a	21.58a
Mean	16.28c	17.46b	18.36a	

*Any two means not sharing a letter in common differ significantly at 5% probability level.

Table 3:Effect of different nitrogen and sulphur levels on the oil content (%) of canola.

	S_0(0 kg S ha^{-1})	S_1 (125 kg S ha^{-1})	S_2 (250 kg S ha^{-1})	Mean
N_0 (0 kg ha^{-1})	43.00c*	43.50b	44.27a	43.59a
N_1 (60 kg ha^{-1})	41.13e	41.37de	43.47b	41.99c
N_2 (90 kg ha^{-1})	41.20e	43.33bc	41.70d	42.08c
N_3 (120 kg ha^{-1})	41.20e	43.70b	44.43a	43.11b
Mean	41.63c	42.97b	43.47a	

*Any two means not sharing a letter in common differ significantly at 5% probability level.

A perusal of Table 1 shows that the different levels of nitrogen showed significant effect on seed yield. The maximum seed yield (27.04 kg ha^{-1}) was recorded in N_3 (120 kg) treatment followed by N_2 (90 kg) treatment which gave 2337 kg ha^{-1} seed yield. The mìnimum seed yield (1563 kg ha^{-1}) was produced by N0 (control) treatment. The higher seed yield in N_3 (120 kg N) was based largely on greater number of siliquae plant $^{-1}$ and seeds siliqua^{-1}. These results are in accordance with the early research workers working on rapeseed (Ali *et al.*, 1996) who reported maximum yield at 120 kg N ha^{-1}. Sharma (1994) working on Indian mustard also reported that increasing rate of N and S fertilizer increased seed yield. The data exhibited in Table 3 revealed that maximum oil content (43.59 %) was produced by N_0 treatment , while minimum oil content (41.99 %) were found in N_1 (60 kg) treatment. Increasing rates of sulphur increased the oil contents of canola and the maximum oil content (43.47%) was recorded in S_2 treatment followed by S_1 treatment which produced 42.97% oil content against the minimum of 41.63 % in control. The interaction between different nitrogen and sulphur levels was found to be significant (Table 3). The maximum oil content (44.43%) was observed N_3S_2 (120 kg N & 125 kg S) treatment combination which is statistically at par with N_0S_2 (0 kg N & 250 kg S) treatment. The minimum oil content (41.13 %) was obtained N_1S_0 (60 kg N & 90 kg S) treatment combination. These results are in accordance with those of Verma and Reddy (1985) and Ali *et al.* (1996).

Protein contents were significantly affected by different nitrogen and sulphur levels (Table 1). The maximum protein content (22.55%) was observed in N3 (120 kg) treatment followed by N_2 (90 kg) treatment. The minimum protein (18.49%) was recorded in control, treatment. Similarly the maximum protein (21.04%) was also obtained in S_2 (250 kg) treatment followed by S_1 (125 kg) while the minimum protein (20.54) was produced by control. The interaction between nitrogen and sulphur was found to be non-significant. The protein content increased with increasing nitrogen inputs which showed inverse relation ship with oil content. Ahmad *et al.* (1999) obtained similar results with nitrogen in respect of oil and protein content of *Brassica campestris* and *Brassica juncea*.

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