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Effects Different Rates of Nitrogen and Sulphur Application on Canola Yield in North of Khuzestan

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ABSTRACT
In order to study the effects of nitrogen and sulphur on yield and oil content of canola (*Brassica napus* L. cv.RGS003), this experiment was conducted in 2007-09 at Safiabad Agricultural Research Center of Dezful, Iran. The experimental design was a complete randomized block with factorial arrangement of treatments with three replications. Factors included two levels of nitrogen: 180 and 240 kg N ha^{-1} as Urea and four levels of sulphur: control (S0), 200 kg S ha^{-1} as sulphur powder inoculated with *Thiobacillus*.sp (S1), 100 kg S ha^{-1} as ammonium sulphate (S2) and 100 kg S ha^{-1} as gypsum (S3). The results showed that nitrogen had no effect on seed and oil yield, while sulphur affected these traits significantly. Interaction of nitrogen and sulphur was not significant on seed and oil yield. The highest seed and oil yield (2182 kg ha^{-1} and 675 kg ha^{-1}, respectively) were obtained with application of 180 kg ha^{-1} N and 100 kg S ha^{-1} as ammonium sulphate .

Keywords: Canola, Nitrogen, Sulphur sources

INTRODUCTION

During the last decades the acreage of winter oilseed rape has been increased considerably in the world (Sieling and Kage, 2010). Production of edible oils through canola plantations has been only noticed in recent years. Management of balanced and efficient use of fertilizers is certainly necessary to obtain maximum yield and quality. Good and Glendinning, (1998) reported that the amount of required elements for optimum production depends on the yield potential, application method, type of applied fertilizers and nutrients availability in the soil (e.g., N, S, Zn, and B). Nitrogen and sulphur are among the most important elements in oilseed crop production especially in canola (Malhi and Leach, 2002). Canola nitrogen requirement is higher than cereals and it is considered as a high nitrogen demanding crop (Hocking *et al.*, 1997; Rathke *et al.*, 2005). High rates of nitrogen application are necessary and economically profitable when canola has a desirable growth in irrigated fields (Ahmadi and Javidfar, 1998). Many soils have difficulties to provide the required nitrogen for vigorous growth and maximum yield production of canola; therefore nitrogen fertilizers are effective in all growth stages of plant. Smith *et al*., (1988) reported that a fertilizer rate of 200 kg N ha^{-1} is the best recommendation to obtain the highest oil yield in winter canola in Australia. Porter (1993) found that the application of 135 kg N ha^{-1} increased canola yield significantly. Jackson *et al*. (2000) found that the highest canola seed yields were achieved when 180 to 220 kg N ha^{-1} of nitrogen was applied. Absorption of other nutrients is also strongly related to sufficient nitrogen supply (Nutall *et al.*, 1987). However direct effects of nitrogen fertilizers are obvious when other agronomic factors including soil texture, water, temperature and soil nutrients are also in optimum levels. One of these nutrients is sulphur which is a part of plant amino acids, proteins, vitamins and enzymes structures. Increasing sulphur application has been shown to increase oil, protein and glucosinolates of canola seeds (Haneklaus *et al.*, 1999). Sulphur applications also enhanced nitrogen use efficiency in canola (Fisme *et al.*, 2000). Booth *et al.* (1991) reported that in addition to the amount of applied sulphur, its source was also important in its interactions with nitrogen. There are many studies about the nitrogen application management in Iran, but most of these studies ignored the role of sulphur in canola yield and quality and its interactions with nitrogen. This experiment was conducted to evaluate the effects of nitrogen rates and sulphur application on canola seed and oil yields.

MATERIALS AND METHODS

A factorial experiment in randomized complete block design in three replications including two rates of nitrogen application: 180 and 240 kg N ha^{-1} from urea, and four rates of sulphur: 0 (S0), 200 kg S ha^{-1} from sulphur powder inoculated with *Thiobacillus*.sp as 2% w/w (S1), 100 kg S ha^{-1} from ammonium sulphate (S2) and 100 kg S ha^{-1} from gypsum (S3) was conducted in 2007-09 at Safiabad Agricultural Research Center of Dezful (48^o 23' E and 22^o 24' N) on a Silty Loam soil, to evaluate the effects of nitrogen and sulphur on seed and oil yields of canola (*Brassica napus* L. cv.RGS003).

A combined soil sample (depth of 0-30 cm) was used to determine the physico-chemical properties of soil according to soil and water research institute recommendations (Ehiaie and Behbahani zadeh, 1993). Based on soil analysis results 100 kg ha^{-1} of KCl (first year) and 200 kg ha^{-1} of KaCl + 100 kg ha^{-1} of triple super-phosphate (second year) were applied with sulphur powder and gypsum treatments as pre-plant applications mixed with top soil. The amount of nitrogen in ammonium sulphate treatments was considered and subtracted from the whole applied nitrogen in these treatments. Nitrogen was applied in three times: pre-plant, end of rosette stage (stem elongation stage) and before flowering stage. Each plot had an area of $12m^2$ (5×2.4m) with 4 planting rows on 60 cm ridges. Plant samples were taken from ⅓ of the above shoots before flowering to determine the nitrogen and sulphur concentrations. Seed and oil yields , and nitrogen and sulphur contents were determined after the harvest and another combined soil sample (0-30 cm of depth) was taken to determine the amount of total nitrogen and sulphur in the soil. Results were analyzed using MSTATC and mean comparisons were conducted according to Duncan's multiple range test at 5% probability level.

RESULTS AND DISCUSSION

Results of soil analysis are illustrated in Table 1. Considering the data from Table 1, the soil of experimental fields had no salinity and alkalinity problems with high $CaCO_3$ percentages, medium and high amounts of available potassium and phosphorous, respectively. The amount of micronutrients was also higher than the critical limits (critical limits for Zn, Mn, Fe and Cu are <0.75, <6, <8 and <0.5 mg kg^{-1}, respectively) and total soil nitrogen was low (880 mg kg^{-1}).

Nitrogen had no significant effect on seed and oil yields. However, sulphur had a significant effect ($p < 0.01$) on both of these traits. The highest seed yields produced with 180 kg N ha^{-1} and 100 kg ammonium sulphate ha^{-1} (2093 and 1845 kg ha^{-1}, respectively), while there was no significant difference between S2 and S1 treatments. The highest oil yields were also achieved with 180 kg N ha^{-1} and S2 (574 and 663 kg ha^{-1}, respectively), however there was also no significant difference between S2 and S1 treatments (Table 2). Based on Mirzashahi *et al.* (2003) findings, the best treatment for winter canola in Safiabad region of Dezful was 180 kg N ha^{-1}. The nitrogen requirement range for winter canola was reported between 150 to 210 kg ha^{-1} by Grant and Baily (1993). Jackson (2000) was also reported that on two irrigated and three rainfed locations with calcareous and gypsum soils, spring canola produced the highest seed yield when nitrogen applied between 180 to 220 kg ha^{-1}. N and S interaction had no effect on seed and oil yields. However, the application of sulphur from each of its sources with 180 kg N ha^{-1} increased seed and oil yields and the highest seed and oil yields were achieved by using 180 kg N ha^{-1} × S2 (2182 and 675 kg ha^{-1}, respectively). These were in accordance with Jan *et al.* (2002), Booth *et al.* (1991), Schnug and Haneklaus (1994) and Fismes *et al.* (2000) for positive interaction of nitrogen and sulphur.

As it mentioned previously, application of sulphur increased seed and oil yields, however, the source of applied sulphur was affected its effectiveness and ammonium sulphate had the highest effect than other sources of applied sulphur. Mahli *et al.*, (2007) resulted that oil concentration in seed increase with S fertilization. The effects of the source of applied sulphur were also confirmed by Donald *et al.*, (1993) and Solberg *et al.* (2007).

Sulphur sources which supply sulphur as sulphate ions, satisfy the needs of plants in short term due to their easier absorption and rapid availability, and thus has a profound impact on plant yield. Other forms of sulphur supplies should be oxidized first and then be converted to sulphate (e.g. sulphur powder). It is also possible that, the sulphur supply have a low solubility (e.g. gypsum). So the use of such supplies to provide the needs of plants during growth season may impose greater risks (Solberg *et al.*, 2007).

Results showed that nitrogen had a significant effect on plant nitrogen concentration. Increasing nitrogen increased nitrogen concentrations (Table 2). The source of sulphur supplies had also a significant effect on this trait ($P \leq 0.01$), and ammonium sulphate had the highest plant nitrogen concentration of 5.31% (Table 2).

Nitrogen and Sulphur interaction had no significant effect on this characteristic. Results also showed that only the source of sulphur supply had a significant effect on seed nitrogen concentration. Application of sulphur increased seed nitrogen concentration but there were no significant difference among various sources of applied sulphur for this trait, however, ammonium sulphate produced the highest seed nitrogen concentration of 4.23% (Table 2).

Nitrogen had no significant effect on plant nitrogen concentration, but the source of sulphur significantly affected. Ammonium sulphate and sulphur powder had the highest plant sulphur concentrations (Table 2). Results also showed that only the source of sulphur had a significant effect on seed sulphur concentrations and ammonium sulphate increased the seed sulphur concentration to 1.72 % (Table 2). Results showed that the highest amount of nitrogen and sulphur concentrations was achieved by application of 100 kg ha^{-1} ammonium sulphate which is in accordance with Jackson *et al.*(2000).

Nitrogen and different sources of sulphur had no significant effect on soil total nitrogen content. However, application of sulphur increased post-harvest soil nitrogen content compared to control (Table 3). Nitrogen had also no significant effect on soil sulphur, but the sulphur significantly affected. Application of sulphur powder inoculated with *Thiobacillus.sp* (38.48 mg kg^{-1}) resulted the highest post-harvest soil sulphur content (Table 3).

Table 1. Soil analysis results of experimental fields (2007-09)

Characteristics	Amount		
	First Year	Second Year	Mean
pH	7.25	6.77	7.01
EC_e(dS m^{-1})	0.91	0.73	0.82
O.C (%)	0.71	0.68	0.7
T.N.V (%)	46	46	46
S (mg kg^{-1})	26.9	12.5	19.7
P_{ava}(mg kg^{-1})	17.2	6.10	11.65
K_{ava}(mg kg^{-1})	209	159	184
Fe_{ava}(mg kg^{-1})	10	7.4	8.7
Zn_{ava}(mg kg^{-1})	2.86	1.6	2.23
Cu_{ava}(mg kg^{-1})	2.06	1.1	1.58
Mn_{ava}(mg kg^{-1})	6	6.4	6.2
Total N (mg kg^{-1})	900	860	880
Clay (%)	24	26	25
Sand (%)	54	52	53
Silt (%)	22	22	22
Soil Texture	Silty Loam	Silty Loam	Silty Loam

Each data is an average of 3 replications (Depth of 0-30 cm)

Table 2. Mean comparison results for the main effect of treatments (2007-09)

Treatments	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})	Plant nitrogen content (%)	Seed nitrogen content (%)	Plant sulphur content (%)	Seed sulphur content (%)
N 180	1845a	574a	4.94 b	4.18a	1.01a	1.36a
N 240	1737a	534a	5.1 a	4.14a	1.01a	1.46a
S0	1476 b	444 b	4.71 c	4.03 b	0.87 c	1.21 c
S*	1964 a	614 a	5.09 b	4.18 a	1.08 a	1.41 b
S**	2093 a	663 a	5.31 a	4.23 a	1.13 a	1.72 a
S***	1632 b	497 b	4.99 b	4.21 a	0.97 b	1.3 bc

In each column means followed by the same letter are not statistically different according to Duncan's multiple range test (*P*=0.05).

*200 kg S ha^{-1} as sulphur powder

**100 kg S ha^{-1} as ammonium sulphate

***100 kg S ha^{-1} as gypsum

Table 3. Mean comparison results for the main effect of treatments for soil post-harvest nitrogen and sulphur content (2007-09)

Treatments	Soil total nitrogen content (mg kg^{-1})	Soil sulphur content (mg kg^{-1})
N 180	904a	24.03a
N 240	902a	22.03a
S0	879a	17.71 b
S*	904a	38.48 a
S**	908a	17.89 b
S***	922a	19.85 b

In each column means followed by the same letter are not statistically different according to Duncan's multiple range test (*P*=0.05).

*200 kg S ha^{-1} as sulphur powder

**100 kg S ha^{-1} as ammonium sulphate

***100 kg ha^{-1} as gypsum

CONCLUSIONS

Considering the variability of sulphate in soil and also some problems associated with solubility evaluation of sulphur compounds such as gypsum and pyrite, in addition to low reliability of soil sulphur evaluation methods, application of 20 kg ha^{-1} of sulphur as a starter in canola production should be considered (Lichthardt and Jacobsen, 1991, Franzen, 1997 ; Jackson, 2000).

The results of present study showed that the application of 180 kg ha^{-1} nitrogen and 100 kg S ha^{-1} as ammonium sulphate (equivalent of 24 kg ha^{-1} of sulphur) is advisable for environmental conditions of this experiment.

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