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Effect of Nitrogen and Sulfur on Yield, Yield Components, Some Chemical Composition and Nutritional Quality of Canola Plant Grown in Saline Soil Condition.

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ABSTARCT

A field experiment was carried out at the Agricultural Production and Experimental Farm, in Faculty of Agriculture Fayoum, Univeristy, during two successive winter seasons 2012/2013 and 2013/2014 .In order to study the effects of different concentrations of nitrogen and/or sulfur and their interaction on seed yield quantity and quality of canola plant sowing in saline soil with salinity level (EC dSm^{-1} 9.17). In general, yield and its components (plant height, pod weight, pod numbers / plant, seed number/plant, seed yield g/m^2 , seed yield (ton fed^{-1}) and seed yield (ton fed^{-1}) increases by all N 100kg/fed or S 30kg/fed concentrations, concomitantly with an increase in the levels of carbohydrates %, oil%, proteins %, macronutrient, micronutrients, total flavonoids and antioxidant activity in yielded seeds. Moreover, the interaction between N and S treatments was more effective as it gave higher increases in nutritional values of the yielded seeds. As a conclusion, cultivation of canola plant in the presence N and/ or S improved the nutritional values of the yielded seeds under saline soil condition.
Keywords: *Canola, Nitrogen, Nutritional values, Sulfur, Yield*

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INTRODUCTION

Canola (*Brassica napus* L.) has become a plant of major agro-economic importance, has a wide range of uses (oil production, animal feeding, alternative fuel, etc.). The name 'canola' actually stands for 'Canadian oil, low acid'. Canola's low erucic acid content differentiates it from rapeseed (*Brassica napus*) and is sometimes referred to as LEAR or 'low erucic acid rapeseed. It currently hold the third position among oilseed crops after palm oil and soybean (FAO, 2011), but its oil is of low quality due to the presence of high concentration of erucic acid and glucosinolate. Erucic acid and glucosinolate are considered toxic for both human and animals' health in addition to its bitter taste (Muhammad, *et al.,* 1991and Ahmad, *et al.,* 2007). Moreover, canola is also considered to be an excellent rotation crop for cereals as it enhances suppression of soil-borne pathogens either by the release of biocidal compounds or by improvements in subsoil macro porosity caused by its deep tap rooting system (Abdallah, *et al.,* 2010). As for other large cropping systems, its intensive culture requires important amounts of nitrogen (N), sulphur (S), phosphorus (P), and potassium (K) fertilizers. Amongst these fertilizers, N plays a major role (Abdallah *et al.,* 2010 and 2012). Canola is adapted to a wide range of environmental conditions; therefore, high N availability is strongly correlated with high yield and seed quality. The main effects of increasing N status in oil seed rape have been shown to be an increase in leaf numbers and area (Leleu, *et al.,* 2000; Svecnjak and Rengel, 2006), leaf chlorophyll content (Ogunlela, *et al.,* 1989), and pod number (Leleu *et al.,* 2000). Optimizing the yield of oilseed rape involves balancing the synthesis of oil and crude protein in the seeds. Many researchers indicated that oil content of oilseed rape declined with increasing rate of N fertilizer that had positive effect on crude protein (Rathke *et al.,* 2005), but Brennan and Bolland (2008) are of the opinion that high N rate did not always affect the oil content.

Sulphur is also an essential element for plant growth because it is present in major metabolic compounds such as amino acids (methionine and cysteine), glutathione, proteins, and sulpho-lipids. Therefore, oil seed rape is particularly sensitive to S deficiency or limitation, which reduces both seed quality De Pascale *et al.,* 2008 and yield by 40% (Scherer, 2001). As S is immobile in plants, its deficiency can occur any time during the growing season and drastically reduce seed yield of canola, particularly on soil well fertilized with N (Malhi and Gill, 2002). S requirement and metabolism in plants are closely related to N nutrition (Reuveny *et al.,* 1980), and N metabolism is also strongly affected by the S status of the plant (Duke and Reisenauer, 1986). A deficiency in S supply has been shown to depress the uptake of nitrate and the activity of nitrate reductase in maize and spinach (Friedrich and Schrader, 1978; Prosser et *al.,* 2001), and to result in transient or steady-state nitrate accumulation in maize, wheat, and oil seed rape (Gilbert *et al.,* 1997). Oil and protein concentrations in seed increase with S fertilization (Malhi *et al.,* 2007). Fismes *et al.* (2000) have shown using field-grown oilseed rape that S deficiency can reduce nitrogen use efficiency (NUE: ratio of harvested N to N fertilization) and that N deficiency can also reduce sulphur use efficiency (SUE).

Salinity is one of the major environmental factors limiting plant growth and productivity. Salinity has become more and more important to the scientific and political agenda. Over 6% of the world's total land area and 20% of irrigated land are salt-affected (Bakry *et al.,* 2014). Salinity problems are particularly relevant for arid and semiarid areas like Egypt. Approximately 33% of the cultivated land and most extension agricultural land in Egypt is already salinized Ghassemi *et al.,* (1995). The reduction in yield of different crops due to salinity in most of these areas is about 60% when compared with normal soil. Salinity reduces plant growth by the presence of excessive amounts of Na+ and Cl- ions, osmotic effects and nutrients imbalance Rais et al., (2013). Salt stress adversely affects nutrients uptake, carbon, nitrogen N and S metabolism.

The aim of the present study was to investigate the effects of N and/or S availability on yield, seed quality, and nutritional value of Canola (*Brassica napus* L.) and alleviating the adverse effect of salinity stress.

MATERIALS AND METHODS

A field experiment was conducted in Experimental Farm, Faculty of Agriculture, Fayoum, University, Egypt. During the two seasons of 2013 and 2014, to study the impact of different concentration of nitrogen applied to soil during the processing of the ground before planting ammonium nitrate (33.5%N) at rates 50,100 and 150kg/fed and elemental sulfur in the rate of 30 and 60 kg/fed and their interaction on productivity and quality of canola seed in saline soil condition.

Sowing date was on the first of September. in the two seasons. The seeds were sown in hills on the rows, the distance, between rows was 60 cm and between hills was 30 cm, the plant trend to one plant in hill. Some physical and chemical properties of the soil sample used in the experirnental site were determined according to Chapman and Pratt (1978) and shown in Table (1).

Table (1): Some physical and chemical properties of the experimental soil site

pH (1:2.5)	EC dSm^{-1}	OM %	$CaCO_3$ %	Particle size distribution			Texture class
				Sand %	Silt %	Clay %	
8.28	9.17	0.19	2.07	54.93	41.25	3.027	Sandy Loam
Available nutrients (Mg/kg)				Available Micronutrients(ppm)			
N	P		K	Fe	Zn	Mn	Cu
62.12	6.01		201	6.38	2.18	5.81	2.16
Soluble cation (meq/l)				Soluble anions (meq/l)			
72.17	1.27	9.25	8.26	2.48	6.29	35.23	46.95

The experimental treatments were arranged in a factorial experiment and laid out in a complete randomized block design with three replicates. Treatments were as follows.

1: control (P and K) 2: 50 kg N/fed
3:100 kg N/fed 4: 150 kg N/fed
5: 30 kg S /fed 6: 50 kg N/fed + 30 kg S /fed
7: 100 kg N/fed + 30 kg S/fed 8: 150 kg N/fed + 30 kg S/fed
9: 60kg S/fed 10: 50 kg N/fed + 60 kg S/fed
11: 100 kg N/fed + 60 kgS/fed 12: 150 kg N/fed + 60 kg S/fed

Phosphorus fertilization was applied to soil before cultivation (during soil preparation) at the standard recommended rate of 100 kg calcium – super phosphate 15.5% P_2O_5 fed^{-1} in one dose. Potassium fertilizer in the form of potassium sulphate (48% K_2O) with 50Kg/fed. was applied in one dose after thinning. The other usual cultural practices were carried out as plants needs.

Chemical analysis of the yielded seeds:

Determination of total carbohydrates was carried out according to Herbert *et al.,* (1971). Seed oil content was determined using soxhlet apparatus and petroleum ether (40-60 ^{o}C) according to AOAC, (1990). Total protein concentration of the supernatant was determined according to the method described by Badford, 1976. Total N was determined by using micro-Kjeldahl method as described in AOAC (1970). Macro and microelement contents were determined according to Chapmen and Pratt (1978). Phosphors was determined using a Spekol spectrocolorimeter (VEB Carl Zeiss; Jena, Germany, while, estimation of K+ contents were done using a flame photometer. Fe, Mn, Zn contents were estimated using atomic absorption spectrophotometer. Total flavonoids were determined using the method reported by Chang *et al.* (2002). The antioxidant activity (DPPH radical scavenging) was determined using the method of Liyana-Pathiranan and Shahidi (2005).

Statistical analysis:

The data were statistically analyzed on complete randomized design system according to Snedecor and Cochran (1980). Combined analysis of the two growing seasons was carried out. Means were compared by using least significant difference (LSD) at 5% levels of probability.

RESULTS AND DISCUSSION

Changes in yield and yield components:

Table 2 show the effect of different concentration of N, S and their interaction on the yield and its components of canola plants grown in saline condition. Table 2 revealed that all N treatments caused significant increases in yield and its components, of canola seeds when compared to control plant. Yield and its components, increased with increasing level of N from 100 to 150 kg Feddan^{-1} but an increase in N level to 50 kg fed^{-1} did not significantly enhance seed yield. The seed yield increased with an increase in S level from 0 to 30 kg fed^{-1} but a further increase in S level to 60 kg fed-^{1} did not significantly increased seed yield of canola. Significantly higher seed yield was produced by the plots fertilized with N and S as compared to control. There were significant differences in seed yield due to N × S interaction (Table 2). The efficiency of N in enhancing seed yield was increased when it was applied in combination with S. Canola and brassica species in general require S for their growth (Zhao *et al.,* 1993). Seed is the ultimate output of a crop which determines the efficiency of profitability of crop production enterprise. In our study, the increase in seed yield with the increase in N and S levels could be the consequences of the increase in yield components such as plant height, number of pods plant^{-1} and seed pod^{-1}. The positive impact of N on the seed yield of canola has been frequently reported Hao *et al.,* (2004). Brennan and Bolland (2008) reported that grain yield responses to applied S only occurred when N was applied and tended to increase as more N was applied. Likewise, Bishnoi *et al.,* (2007) reported that the highest seed yield was obtained with 30 kg S ha−1 along with 228 kg N ha−1. Results pertaining to the impact of S levels on seed yield of canola, are in agreement with Subhani *et al.,* (2003) who achieved maximum seed yield from 40 to 50 kg S ha^{-1}. Likewise, Ahmad *et al.,* (1999) stated that S fertilization increased seed yield of Brassica species by 30 to 46% as compared with zero - S control. The increase in the seed yield could be a reflection of the effect of S on growth and development; it might be due to marked increase in the number of branches per plant which gave a chance to the plant to carry more flowers, pods and hence more seeds. Similarly, Malhi *et al.,* (2007) indicated that seed yield increased sharply with first 10 kg S ha^{-1} increment, and moderately with second increment.

Table (2): Effect of application of different concentrations of N, S and N × S interaction on yield and yield components of canola plant grown under saline soil condition. Each value represents the mean ± standard error (n =3).

Treatments	Plant height (cm)	Pod weight (g\plant)	Pod No / plant	Grain No/plant	Grain yield g/m^2	Grain Yield (ton fed^{-1})	Seed Yield (ton fed^{-1})
1	81.00	6.41	18.03	156.3	88.7	0.35	0.38
2	85.67	6.73	18.93	162.3	133.6	0.53	0.41
3	92.33	7.85	21.52	187.0	137.9	0.55	0.47
4	94.67	8.43	24.56	190.3	149.1	0.60	0.49
5	98.33	8.25	23.30	228.7	166.4	0.67	0.54
6	104.00	9.55	25.13	241.3	189.9	0.76	0.60
7	117.33	11.14	30.67	546.0	237.6	0.95	0.98
8	114.67	10.84	28.89	451.0	216.8	0.87	0.92
9	102.00	9.15	24.56	232.7	181.3	0.73	0.60
10	107.67	9.70	25.97	249.0	193.1	0.77	0.71
11	113.00	10.30	28.43	410.0	205.9	0.82	0.89
12	110.00	9.91	26.24	389.7	196.4	0.79	0.74
LSD 5%	9.7	1.66	3.19	16.7	9.5	0.14	0.09

***1**: control (P and K) ***2**: 50 kg N/fed
***3**:100 kg N/fed ***4**: 150 kg N/fed
***5**: 30 kg S /fed ***6**: 50 kg N/fed + 30 kg S /fed
***7**: 100 kg N/fed + 30 kg S/fed ***8**: 150 kg N/fed + 30 kg S/fed
***9**: 60kg S/fed ***10**: 50 kg N/fed + 60 kg S/fed
***11**: 100 kg N/fed + (ES) 60 kg/fed *** 12**: 150 kg N/fed + 60 kg S/fed

Nutritive Value of the Yielded Seeds:
Changes in oil %

Subhani *et al.,* (2003) found that the number of pods plant^{-1} and seed pod^{-1} increased with increasing level of S up to 40 kg ha^{-1}. They obtained heavier seeds from 30 to 50 kg S ha^{-1}. Mailer (1989) noted an increase in 1000 seed weight of canola with application of S. In this study, yield components also improved with N which is also supported by many researchers. For instance, Khan *et al.,* (2002) and Uddin *et al.,* (1992) reported that number of branches plant^{-1} increased with increasing levels of N up to 120 and 150 kg N ha^{-1}, respectively. Like- wise, Fismes *et al.,* (2000) reported that N increases vegetative growth and S improves N use efficiency and the present increase in branches plant^{-1} could be the consequence of improved N use efficiency. Similarly, Qayyum *et al.,* (1999) found that number of seeds pod^{-1} increased with increasing level of N up to 120 kg ha^{-1}. Rais *et al.,* (2013) stated that, combined application of N and S was more effective in reducing the negative effects of salt stress than their individual application.

Table (3): Effect of application of different concentrations of N, S and N × S interaction on Nutritive Value of the Yielded Seeds of canola plant grown under saline soil condition. Each value represents the mean ± standard error (n =3).

Treatment	Protein%	Oil %	Carbohydrate %	Phenol (mg/g)	Flavonoids (mg/g)	Antioxidant activity (%)
1	7.06	29.6	13.25	13.50	0.32	23.30
2	11.52	32.0	14.79	14.00	0.39	25.93
3	14.00	33.9	15.52	14.39	0.4	32.60
4	15.67	33.1	17.86	15.35	0.4	30.78
5	17.65	39.0	17.95	16.25	0.42	30.50
6	18.38	39.3	19.89	17.20	0.44	29.17
7	28.21	44.5	23.72	20.58	0.59	35.40
8	27.15	43.9	21.55	19.85	0.54	29.58
9	17.04	38.6	16.66	15.35	0.37	27.67
10	19.23	40.9	19.36	17.60	0.43	25.96
11	22.77	42.0	20.67	18.39	0.47	32.93
12	22.00	41.5	20.66	18.03	0.45	27.50
LSD 5%	5.52	3.4	1.10	0.15	0.015	1.14

***1**: control (P and K) ***2**: 50 kg N/fed
***3**:100 kg N/fed ***4**: 150 kg N/fed
***5**: 30 kg S /fed ***6**: 50 kg N/fed + 30 kg S /fed
***7**: 100 kg N/fed + 30 kg S/fed ***8**: 150 kg N/fed + 30 kg S/fed
***9**: 60kg S/fed ***10**: 50 kg N/fed + 60 kg S/fed
***11**: 100 kg N/fed + (ES) 60 kg/fed * **12**: 150 kg N/fed + 60 kg S/fed

Data in Table 3 showed that, Oil percentage increased with increasing in N level from 50 to 100 kg fed^{-1} but a further increase in N up to 150 kg fed^{-1} level did not significantly increase oil percentage of canola plant as compared with those of other N treatment. Data also show significant increases in oil content of canola plant treated with different concentrations of S fertilization. Application of 30 kg fed^{-1} S was the most effective treatment as compared with the untreated control plant. However, further increase in S level did not significantly enhance oil yield. Significantly higher oil percentage was produced by the plots fertilized with N and S as compared to control plots and plants treated with S and N only. The plants that received 100 kg N fed^{-1} in combination with 30 kg S fed^{-1} produced higher oil content as compared to the rest of N and S combinations (Table 3). The results are in line with Brennan and Bolland (2008) who reported that oil concentration in seed of canola tended to decrease as more N was applied and increased as S was applied. Similarly Kumar *et al.* (2007) reported that the percent oil content decreased with the increase in rates of nitrogen and was highest (39.04%) with application of 57 kg N ha^{-1}. The decrease in oil yield with N application is supported by the findings of several researchers. Fismes *et al.* (2000) and Ahmed (2014) reported that increasing N rate decreased oil concentration in seed of canola but the overall oil yields increased because of the higher seed yield. Biswas *et al.* (1995) noted that oil concentration in canola seed was increased by S and decreased by high N application but combined application of these nutrients have a positive impact on oil concentration of canola. Ahmad *et al.* (1999) got maximum oil yield from the combined application of 40 kg S and 100 kg N ha^{-1}.

Changes in Protein %

Data regarding protein content of canola as affected by N and S fertilization are shown in Table 3. The effects of N and S on protein content of canola were significant. Mean values for N rates revealed that seed protein contents enhanced progressively with increase in N rates and the highest protein content of 15.67% was found at the maximum level of 150 kg N fed^{-1}. Similarly, seed protein content also had a positive response to increasing S levels. Higher protein contents of 17.65% and 17.04% were recorded for plants that received 30 to 60 kg S/fed, respectively. The interaction between S and N also indicated that protein content were higher at the highest levels of S and N. Protein content enhanced with increasing levels of both S and N . Higher value of the protein content was noted in the plants supplied with 100 kg N fed^{-1} in combination with 30 kg S fed^{-1} (28.21%) as compared to control plots (7.06%). The increase in seed protein content of canola with the application of N and S could be due to the fact that N is an integral part of protein and the protein of rapeseed contains relatively large quantities of the S containing amino acids like methionine and cystine (Gardner *et al.,* 1985). Increases the content of the S-rich protein ferredoxin, which is involved in nitrate reduction Srivastava, (1980). Application of N or S to salt-stressed plants increased salt tolerance, more conspicuously with combined application of N and S Rais et al., (2013). The individual role of N in the alleviation of salt stress by increasing N assimilation and osmolyte formation has been reported Khan, N., (2003). However, S may also regulate the formation of osmolytes by its influence on nitrate reductase activity and N assimilation as the importance of S in maintaining the tertiary structure of proteins is well documented Marschner, H., (1995). Combined application of N and S helped in maintaining the appropriate structure and activity of protein molecules by avoiding inhibition of the formation of intermolecular disulfide bridges **Szalai**, *et al.,* 2009.

Changes in Carbohydrate %

Data in Table (3) pointed out that application of nitrogen and sulfur fertilization and their combinations significantly increased carbohydrate percentage in seeds of oilseed as compared to the control. Combination of nitrogen and sulfur had marked influence on carbohydrate percentage. Application of N and S, as 100 kg N/fed + S 30 kg/fed recorded the higher carbohydrate percent and was significantly superior than control. Abd EL-Kader, Mona (2013) demonstrated that this stimulatory effect of N and S might be attributed to their effects on enzymatic activity and translocation of the metabolites to canola seed. The substantial increase in carbohydrate contents may be due to the activation of photosynthetic machinery, as a result of the stimulatory effects of the used fertilizers on photosynthetic process and carbohydrate. Von Uexkull, (1986) found that Sulfur availability may influence photosynthetic rate since ferredoxin and acetyl-CoA contain S and play a significant role in the reduction of CO2 and production of organic compounds. Also, sulfur is necessary for enzymatic reactions, chlorophyll formation, synthesis of certain amino acids and vitamins, hence, it helps to have a good vegetative growth leading to have a high yield (Marschner, 1995).

The combined application of N and S improved N assimilation more than their individual application suggesting that these two nutrients worked co-ordinately in enhancing N assimilation resulting in protection of chlorophyll degradation and photosynthetic efficiency and increase carbohydrate of plants. Anjum *et al.,* 2008 have shown that sufficient-S supply improved the photosynthetic efficiency of *Brassica campestris* because S maintained higher cell redox state responsible for reducing environment in the cell.

Total phenol, flavonoid and Antioxidant activity:

Table 3 shows that all N treatments cussed significant increases in total phenolic content, flavonoids, and antioxidant activity of the yielded seeds. Treatment of 100 kg N/fed + 30 kg S /fed was the most pronounced and effective treatment. The increases in phenol, flavonoid and antioxidant activity due to 100 kg N/fed + 30 kg S /fed were 52 %, 84 % and 52% respectively relative to corresponding controls. These results indicate that 100 kg N/fed + 30 S kg/fed approximately similar enhancement effect on phenolic content, flavonoids, and antioxidant activity under saline soil conditions. For some brassica species, the antioxidants profile has been described. It has been reported that the main phenolic constituents of broccoli are flavonols (quercetin and kaempferol derivates) and phenolic acids (hydroxycinnamic acids derivates) (Vallejo *et al.,* 2003 a,b). Phenolic compounds also contribute to the health properties of these vegetables (Hertog *et al.,* 1993; Garcia-Closas *et al*., 1999). These molecules are able to inhibit LDL cholesterol oxidation, to chelate redox-active metal ions and to attenuate other processes involving reactive oxygen species, as they are highly effective free radical scavengers (Rice-Evans *et al.,* 1997). The importance of the flavonoids was known to possess significant antimicrobial activities and was utilized as natural plant protectants (Weidenbomer *et al*., 1992). It could be suggested that flavonoids content may be an alternative to conventional fungicides in the control of storage grains against some fungi. Data in Table 3 showed that N addition to soil caused significant increases the antioxidant activity (as DPPH- radical scavenging capacity) of canola grain. Also, treatment of canola plant with S with different concentrations (30 and 60kg/fed) caused increases in the antioxidant activity as compared with control plants. The increase in the scavenging activity can be considered an advantage of treatment used. This could be attributed to the increases in total phenols and total flavonoids (Zilic, *et al*., 2011). Yu, *et al.,* (2002) suggesting that significant levels of antioxidant activities and phenolic components have been detected in some brassica species and indicating that brassica species may serve as an excellent dietary source of natural antioxidants for disease prevention and health promotion.

Changes in macronutrient and micronutrient contents:

Table (4): Effect of application of different concentrations of N, S and N × S interaction on macronutrient (N, P, K) and micronutrient (Fe, Zn, Mn) contents of Yielded Seeds of canola plant grown under saline soil condition. Each value represents the mean ± standard error (n =3).

Treatments	Macronutrient (%)			Micronutrient (ppm)		
	N	P	K	Fe	Zn	Mn
1	1.13	0.10	0.44	232.3	38.60	22.43
2	1.84	0.12	0.51	311.5	43.50	23.70
3	2.24	0.14	0.53	337.3	48.07	28.30
4	2.51	0.14	0.54	352.9	51.50	33.50
5	2.82	0.13	0.55	290.7	42.97	24.30
6	2.94	0.16	0.57	326.2	46.77	26.53
7	4.51	0.20	0.79	393.6	53.87	39.30
8	4.34	0.19	0.72	382.4	51.97	35.97
9	2.73	0.15	0.55	283.5	42.40	25.37
10	3.08	0.17	0.58	314.8	47.40	27.53
11	3.64	0.19	0.64	352.9	50.90	32.30
12	3.52	0.17	0.61	367.1	52.00	35.43
LSD 5 %	**0.09**	**0.025**	**0.079**	**1.76**	**1.08**	**0.89**

***1**: control (P and K) | ***2**: 50 kg N/fed
***3**:100 kg N/fed | ***4**: 150 kg N/fed
***5**: 30 kg S /fed | ***6**: 50 kg N/fed + 30 kg S /fed
***7**: 100 kg N/fed + 30 kg S/fed | ***8**: 150 kg N/fed + 30 kg S/fed
***9**: 60kg S/fed | ***10**: 50 kg N/fed + 60 kg S/fed
***11**: 100 kg N/fed + (ES) 60 kg/fed | *** 12**: 150 kg N/fed + 60 kg S/fed

Regarding the effect of N and / or S application on nitrogen, phosphorus and potassium contents of canola seeds. Data presented in Table 4 show that different concentrations of N and S stimulated nitrogen, phosphorus and potassium contents of canola seed compared with the control. The results revealed also that, 100 kg N/ fed + 30 kg S / fed were more effective in increasing seed contents of nitrogen, phosphorus and potassium compared with control plants.

Regarding to micronutrient contents, Table 4 presented the effect of N and / or S application on with different concentrations on micronutrient contents (Fe++, Mn++, Zn++) of the yielded canola seeds. Data clearly show that, addition of N and S to the soil significantly increased all the studied micronutrient of the yielded seeds. Data also showed that, 100 kg N/fed + 30 kg S/fed increased micronutrient contents of the yielded seeds in all the studied micronutrient.

The increase in yield and yield components and higher content of K could be attributed to the combined application of sulfur and micronutrients helped in better absorption and translocation. Similar results were obtained by Babhulkar *et al.,* (2000). These increases also in micronutrient constituents of seed may be due to the effect of N and S on stimulating biological activities, i.e. enzyme activity, chlorophyll synthesis, rate of translocation of photosynthetic products and increase in nutrient uptake through roots. Such improvement could be explained by the role of these elements in increasing adsorbing surface of the root and the improvement transportation of the nutrients from the soil to plant organs via the roots. Similar results were obtained by and Shaban *et al*., (2010).

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