J. Basic. Appl. Sci. Res., 2(5)5196-5202, 2012
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ISSN 2090-4304
Journal of Basic and Applied Scientific Research
www.textroad.com

Growth and Oil Production of Canola as Affected by Different Sulphur Sources.

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ABSTRACT

A field experiment was carried out in the Research and Production Station, National Research Centre, El- Nobaria Site, Beheara Governorate- Delta Egypt. The experiment was conducted to evaluate the effect of different sources and rates of sulphur on canola growth and oil production.

The obtained results showed:

- Treatments can be arranged in descending order as follows: ammonium sulphate > ammonium thiosulphate > elemental sulphur.
- Elemental sulphur gave the lowest values of the growth, seeds and oil yield along with mineral and chemical content of canola seeds.
- Ammonium sulphate addition in plant media enhanced all parameters of canola growth, seeds and oil yield as well as chemical and minerals content of canola seeds especially with 300 Kg/fed rate.

Keywords: Canola, Sulphur, oil production, Minerals and Chemical contents.

INTRODUCTION

Sulphur (S) is an essential nutrient for all crops production. It is essential for protein synthesis and the formation of chlorophyll. Sulphur is required in the development of fertile canola flowers. Symptoms of sulphur deficiency vary between different crops. In canola, deficiency symptoms may begin as early as the one leaf stage (Hall, 1999). Elemental S° fertilizer should be surface applied period cultivation so it can be oxidized to plant available SO4. The rate of S oxidation depende on many environmental factors (Hala Kandil *et al*., 2011).

Sulphur (S) is often the second most limiting nutrient after nitrogen for successful canola production. Sulfur is required to attain high yield and good seed quality. Canola sulfur deficiencies result in pale yellow plants with poor growth. Canola crop require one pound of sulfur for each expected 100 pounds per acre of seed yield. Heavy precipitation over winter can move sulphur-sulphate (SO_4-S) deep into the soil profile away from canola roots. Sulphur should be applied according to appropriate soil tests. To have SO_4-S from zero to 5 ppm 20 to 40 pounds S should be applied per acre; and four 6 to 10 ppm SO_4-S, 10 to 20 pounds S should be applied per acre. It should be mentioned that some recommendations for sulfur application are limited to no more than 25 pounds S per acre since it is highly prone to leaching in the soil. However, others recommend application of higher rates, particularly with field history of higher yield potential and hence to apply one pound S per acre for every 100 pounds of expected seed yield Jack Brown *et al.,* (2008).

Sulphur 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 (Janzen and Bettany, 1984; Duke and Reisenauer, 1986).

Sulphur deficiency symptoms vary between crops. In canola, deficiency symptoms may begin as early as the one leaf stage, with the newest leaves turning yellowish green with dark vein coloration. Leaves may take on a cupped appearance, later reddening from the leaf margins. Flowers are small and pale, and they produce small underdeveloped purple pods. Under mild S deficiency, there may be good vegetative growth, but flowers and pods will be undeveloped. For cereals and forage grasses, yellowing of newly emerging leaves is a strong indicator of S deficiency. Depending on the degree of deficiency, the leaves may be a shade of light green to entirely yellow. Yellowing of the new growth occurs because S is immobile in the plant. Thus, newly emerging leaves cannot scavenge S from older leave Hall, (1999).

Fertilizers that supplies (S) in the sulphate form are immediately available to crops. Elemental sulphur fertilizers must be surface applied where they can be oxidized to plant available (SO_4-S). Depending on soil type and environmental conditions, this conversion can take from less than a year to more than two years. Ammonium sulphate fertilizers are so rapidly available; it can be applied to crops

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in different ways. Elemental sulphur must be oxidized by soil microbes to (SO_4-S) before it is available to crops Hall, (1999).

In Egypt, oil crops occupies only about 1.83 % of the total cropped area (Abd El-Hady*,* 2004). Canola is an important oilseed with worldwide importance; it is currently ranked third, after soybean and palm oils, and fifth in the world trade in agricultural crops, after rice, wheat, maize and cotton.

Canola *(Brassica napus L.)* is one of the most important oilseed crops in the world. It is widely cultivated throughout the world for the production of vegetable oil for human consumption and animal feed.

Canola oil is generally regarded as one of the healthiest edible oils available to consumers, used for cooking and other uses of edible oils in many parts of the world. It is the lowest in saturated fatty acids (6%) compared to 9 % for flax seed oil, 12 % for sunflower oil, 13 % for corn oil, 15 % for olive oil, and soybean oil, 19 % for peanut oil and 51% for palm oil. The composition of canola oil is similar to that of peanut and olive oil, with large amounts of oleic acid, which is desirable in frying oils (Gillis, 1988). Mc Donald and Bruce (1994) found that, the fatty acid composition of canola oil is consistent with nutrition recommendations aiming to reduce the amount of saturated fat in the diet. Canola is characterized by a low level of saturated fatty acids. It contains a relatively high level of oleic acid (6%) and an intermediate of which linolenic acid makes up approximately one-third. Diets containing canola oil have been found equally as effective in reducing plasma total cholesterol as those containing corn, sunflower, soybean oil or sunflower oils.

Canola (*Brassica napus* L.) is an important source of vegetable oil for humans and canola cake is a nutritious feed for animals (Lekhanath Paudel *et al.,* 2008). Canola is now second only to soybean as the most important source of vegetable oil and during the past 20 years the use of canola oil has surpassed peanut, sunflower and cotton seed (Raymer, 2002). Worldwide production of, canola was 47.6 million tons in 2006/2007 and United States shared 1% of this global production. Canola is extensively produced in Canada, Europe, China and Australia and to a limited extent in the United States (ERS 2008).

MATERIALS AND METHODS

Soil analysis:-

Particle size distribution and soil texture along with soil moisture content of the representative soil samples collected from Research and Production Station, National Research Centre, El-Nobaria Site were determined according to Blackmore *et al.,* (1972). Contents of organic matter and $CaCO_3$ as well as EC and pH along with soluble cations and anions were evaluated according to Black *et al*., (1982). Total N and available P, K, Fe, Mn, Zn and Cu were determined according to Jackson (1973).

Total sulphur was determined in sulphate form by potassium chromate according to Cottanei *et al.,* (1982). Data of soil analysis were recorded in Table (1).

Table (1): Some physical and chemical properties of the El-Nobaria soil.

Soil property	Particle size distribution (%)				Soil moisture constant (%)			
Physical	Sand	Silt	Clay	Texture	Saturation	FC	WP	AW
	68.7	24.5	6.8	S L	32.0	19.2	6.1	13.1
Chemical	pH[a]		EC[b] dS/m		$CaCO_3$ %		OM [c] %	
	7.8		0.18		3.07		0.16	
	Soluble cations (meq/L)				Soluble anions (meq/L)			
	Ca^{++}	Mg^{++}	K^{+}	Na^{+}	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	
	3.00	2.00	0.32	2.09	0.00	1.41	0.70	
	Total	Available			Available micronutrients			
	N	P	K	S	Fe	Mn	Zn	Cu
	mg/100 g soil				mg/kg			
	15.0	9.4	16.0	6.2	7.8	3.3	1.86	4.0

Plant material and experimental analysis design:

Field experiment has been conducted at Research and Production Station, National Research Centre, El-Nobaria Site, Behera Governorate- Delta Egypt under drip irrigation system to evaluate the effect of different sources and concentrations of sulphur on canola productivity. The experiment contains 12 plots. Each plot area was 15 m^2 (5 X 3 m) containing 3 rows. Each row was planted with 10 plants. Farmyard manures at a rate of 20 m^3/fed and super phosphate (15.5 % P_2O_5) at 200 kg /fed were added during soil preparation. Treatment with three source of sulphur namely elemental sulphur-ammonium thiosulphate – ammonium sulphate were used. Four levels of the aforementioned S sources (50, 100, 200, 300 Kg/fed) was used. Seeds of canola *(Brassica napus* L. *var. pactol)* were sown at 29 September, 2011. Ammonium nitrate as a source of nitrogen fertilization was added in a rate of 150

Kg/fed including the ammonium encombined in ammonium sulphate and thiosulphate used. Potassium sulphate (50 kg /fed, 50 % K_2O) were added after plants were thinned. Fertilizing and other agriculture practices were run as recommended practice, whenever needed. After 120 days (end of the vegetative stage) growth parameters such as plant height, number of branches and leaves, leaves area, root length as well as fresh and dry weights were recorded according to FAO (1980). Plants were harvested and the parameters of seeds and oil yield, pods no./plant, seeds no. per pod, weight of seed yield, seeds yield per Fadden, oil yield (kg/fed) were recorded according to A.O.A.C. (1995). Seeds chemical content such as total protein, oil % and total carbohydrates were determined according to Gabal *et al.,* (1984) also total phenols aqueous acetone (70%) was determined by Kaluza *et al*., (1980). Finally the seed mineral content (N, P, K, S, Mn, Fe, Cu and Zn) were determined according to Cottanei *et al*., (1982). Statistical analysis of the obtained data were run according to Snedcor and Cochran (1982).

RESULTS AND DISCUSSIONS

Vegetative characteristics:

The effect of sulphur source and rates on plant height, no. of branches and leaves/ plant, root length, fresh and dry weight are presented in Table (2). The presented data show that all growth parameters were increased under different sulphur source and rates compared with control. Ammonium sulphate significantly increased all growth parameters compared with the other sources at the same levels. The highest values of fresh and dry weight were obtained when ammonium sulphate was used followed by ammonium thiosulphate and sulphur. Results also reveale that, increasing levels of sulphur increased all canola growth parameters. Sulphur addition at 300 Kg/fed from different sources gave the highest values. These results are in harmony with these obtained by (Hall, 1999) who found that suppling sulphur in the form of sulphate are readily available to canola crop but elemental sulphur have to be oxidized by soil microbes before it is absorbed by crop. Also, Hala Kandil *et al.* (2011) stated that the application of sulphur improved the growth parameter of sorghum plants.

Table (2): Effect of sulphur sources and levels on the growth of canola plants.

Sulphur Treatments		Plant hight (cm)	No. /plant		Root length (cm)	weight (g/plant)			
						Fresh		Dry	
Sources	(kg/fed)		branch	leaves		Shoots	Roots	Shoots	Roots
Control		**140**	**9**	**40**	**11**	**119**	**58.3**	**34.5**	**16.9**
Elemental Sulphur	50	106	10	42	13	135	59.1	39.3	18.8
	100	126	11	47	15	182	61.2	52.7	19.1
	200	130	13	50	18	229	63.6	66.4	19.7
	300	138	15	56	19	268	65.9	77.5	21.3
Mean		**125**	**12.25**	**48.75**	**16.25**	**203.50**	**62.45**	**58.98**	**19.73**
Ammonium thiosulphate	50	112	10	44	14	160	61.5	46.3	19.8
	100	131	12	49	19	216	63.8	62.6	20.6
	200	137	14	54	23	270	65.6	78.1	21.4
	300	144	16	57	27	306	67.4	88.5	21.9
Mean		**131**	**13.00**	**51.00**	**20.75**	**238.00**	**64.58**	**68.73**	**20.93**
Ammonium sulphate	50	124	11	45	15	171	65.2	49.6	20.3
	100	137	13	52	23	235	67.7	68.1	21.8
	200	148	16	56	26	291	70.1	84.3	22.6
	300	151	18	59	30	328	73.5	95.1	23.7
Mean		**140**	**14.5**	**53.00**	**23.50**	**256.25**	**69.13**	**74.28**	**22.10**
LSD at 5%		3.75	0.62	0.58	0.37	1.03	0.33	0.49	0.28
LSD of interaction at 5%		5.34	0.95	0.89	0.75	1.62	0.86	0.89	0.50

Yield parameters:

Data in Table (3) indicated that all sulphur sources increased pods number per plant, seeds number per pod, weight of 100 seeds (g), seeds yield per plant (g), seeds yield per Fadden (kg) and oil yield per Fadden (kg). Increasing the levels of sulphur addation (from 50 to 300 Kg/fed) increased all yield parameters of canola. Sulphur in the ammonium form at 300 Kg/fed gave the highest seed yield figures while elemental sulphur gave the lowest ones. These data are agreement with those obtained by

Malhi *et al.,* (2007) who reported positive effect for seed yield and other parameters to sulphur fertilizers in *Brassica*.

Table (3): Effect of sulphur sources and levels on yield of canola plants.

Sulphur Treatments		Number		Weight of 100 seeds (g)	Seeds yield (g plant^{-1})	Seeds yield (Kg fed^{-1})	Oil yield (Kg fed^{-1})
Sources	(kg/fed)	Pod plant^{-1}	Seeds pod^{-1}				
Control		**73**	**63.3**	**2.06**	**95.1**	**761**	**254.17**
Elemental Sulphur	50	76	68.3	2.24	106.3	830	289.75
	100	82	72.0	2.38	114.5	924	322.84
	200	89	76.3	2.49	129.4	985	345.83
	300	97	80.0	2.67	138.2	1004	353.50
Mean		**86.00**	**74.15**	**2.45**	**122.10**	**935.75**	**327.92**
Ammonium thiosulphate	50	80	70.0	2.43	116.1	888	310.35
	100	87	73.3	2.74	128.7	967	340.67
	200	93	79.0	3.03	146.5	1052	372.19
	300	107	88.3	3.31	162.7	1101	389.97
Mean		**91.75**	**77.65**	**2.88**	**138.50**	**1002.00**	**353.30**
Ammonium sulphate	50	90	74.0	2.68	128.5	897	313.86
	100	98	78.3	2.97	137.9	996	353.78
	200	106	86.3	3.54	158.8	1095	391.02
	300	118	98.6	4.09	175.8	1143	409.65
Mean		**103.00**	**84.30**	**3.32**	**150.25**	**1032.75**	**367.08**
LSD at 5%		1.06	0.76	0.06	2.78	-	-
LSD of interaction at 5%		1.98	1.03	0.12	4.59	-	-

Results in Table (3) show the effect of sulphur levels on the number of pods per plant, seeds per pod, weight of 100 seeds, seed yield per plant, seed yield per Fadden and oil yield per Fadden. It indicate that applying 300 Kg from the tested S sources per Fadden increased the seed yield by 31.93%, 44.68 % and 50.19 % compared to control. These data are in harmony with those obtained by Ahmed *et al.,* (1998) who found that sulphur fertilization increased seed yield of canola plants *(B. juncea cv. Pusa jai Kisan)* by 30% and *(B. rapa cv. Pus Gold)* by 46% compared with zero sulphur (control).

As well as the oil yield increased by 39.8%, 53.43% and 61.17% respectively. These results agrees with those obtained by Malhi and Gill, (2002) who found that sulphur application to canola increased oil concentration in seeds.

Oil yield:

Data in Fig. (1) and Table (3) show that all sulphur sources enhanced oil yield (Kg/fed) of canola seeds compared with control. Increasing sulphur rates increased oil seed yield. Sulphur at 300 Kg/fed gave the highest oil seed yield was reaction to the applied sources. It is evident that sulphur at 300 Kg/fed significantly increased canola oil seed yield compared to control by 5.42%, 6.04% and 7.31% respectively for elemental sulphur, ammonium thiosulphate and ammonium sulphate. These data are agrees with those obtained by Malhi and Gill, (2002) who found that sulphur addation in plant media increased oil concentration in canola seeds.

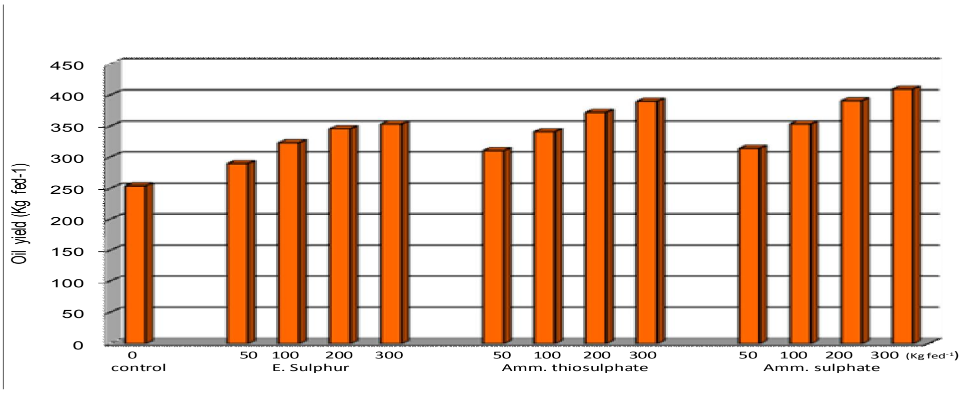

Fig. (1): Effect of sulphur sources and levels on oil seed yield (kg fed^{-1}) of canola.

Table (4): Effect of sulphur sources and levels on chemical contents of canola seeds.

Sulphur Treatments		oil	Protein	Total carbohydrate	Total phenols
Source	**(kg/fed)**	**(%)**			
Control		**33.40**	**4.75**	**9.73**	**1.02**
Elemental Sulphur	50	34.91	4.94	10.46	1.05
	100	34.94	5.13	10.57	1.10
	200	35.11	6.00	10.69	1.16
	300	35.21	6.31	10.76	1.23
Mean		**35.04**	**5.59**	**10.62**	**1.14**
Ammonium thiosulphate	50	34.95	5.50	10.51	1.14
	100	35.23	6.31	10.63	1.21
	200	35.38	6.63	10.79	1.28
	300	35.42	6.88	10.90	1.33
Mean		**35.25**	**6.33**	**10.71**	**1.24**
Ammonium sulphate	50	34.99	6.06	10.78	1.20
	100	35.52	6.31	10.89	1.29
	200	35.71	6.81	11.02	1.31
	300	35.84	6.94	11.16	1.41
Mean		**35.52**	**6.53**	**10.96**	**1.30**
LSD at 5%		0.03	-	0.02	0.005
LSD of interaction at 5%		0.05	-	0.03	0.009

Chemical contents:

Data presented in Table (4) show the chemical contents of oil, protein, total carbohydrates and total phenol in canola seeds as affected by sulphur sources and levels. The highest values of chemical contents are noticed with ammonium sulphate at 300 kg/fed. Oil percentage in seed increased with different sulphur sources resulting 5.42%, 6.04 and 7.31% in case of elemental sulphur, ammonium thiosulphate and ammonium sulphate respectively. Protein percentage in canola seeds increased with varied sulphur sources seeding 32.28%, 44.84% and 46.10% respectively compared with control. Moreover total carbohydrate in canola seeds increased with different sulphur sources addition to 10.58%, 12.02% and 14.69% respectively compared with control. Also, total phenols increased with different sulphur sources to 20.58%, 30.39% and 38.23% respectively. These results are agrees with those obtained by **Jack Brown *et al.*, (2008)** who showed that sulphur is required to attain high yield and good seed quality.

Nutrition status:

Data in Table (5) showed that all sulphur sources and levels significantly increased the content of macronutrients N, P and K and micronutrients Fe, Mn, Zn and Cu in canola seeds as compared with control. The highest values of nutrients status were obtained by using ammonium sulphate at 300 kg/fed.

Total sulphur concentration in seed generally, increased with the increasing sulphur rate with all sulphur forms. These results are harmony with those obtained by **Jackson, (2000) and Malhi *et al.* (2007)** who stated that sulphur increased nutrients in canola seeds.

Table (5): Effect of sulphur sources and levels on mineral composition of canola seeds.

Sulphur Treatments		Macronutrients (%)				Micronutrients (ppm)			
Source	(kg/fed)	N	P	K	S	Fe	Mn	Zn	Cu
Control		**0.76**	**0.23**	**1.16**	**0.16**	**233**	**24.1**	**26.0**	**13.4**
Elemental Sulphur	50	0.79	0.31	1.20	0.31	237	25.3	28.1	13.9
	100	0.82	0.38	1.23	0.54	240	27.1	30.2	14.3
	200	0.96	0.43	1.28	0.68	243	29.4	32.1	14.8
	300	1.01	0.48	1.31	0.83	246	30.2	34.0	15.5
Mean		**0.90**	**0.40**	**1.26**	**0.59**	**241.5**	**28.0**	**31.1**	**14.6**
Ammonium thiosulphate	50	0.88	0.36	1.22	0.48	239	26.3	29.7	14.1
	100	1.01	0.42	1.27	0.75	245	28.2	31.9	14.8
	200	1.06	0.49	1.32	0.96	249	30.0	34.0	15.7
	300	1.10	0.52	1.37	1.11	253	32.3	36.4	16.9
Mean		**1.01**	**0.45**	**1.30**	**0.38**	**246.5**	**29.2**	**33.0**	**15.4**
Ammonium sulphate	50	0.97	0.40	1.26	0.65	240	27.1	30.3	14.5
	100	1.01	0.49	1.34	0.89	248	29.8	33.0	16.3
	200	1.09	0.53	1.39	1.16	254	33.2	36.2	18.1
	300	1.11	0.56	1.43	1.38	259	36.1	39.1	19.6
Mean		**1.05**	**0.50**	**1.36**	**1.02**	**250.3**	**31.6**	**34.7**	**17.1**
LSD at 5%		0.004	0.003	0.006	0.001	0.41	0.14	0.11	0.09
LSD of interaction at 5%		0.008	0.007	0.009	0.003	0.93	0.27	0.21	0.17

Conclusion

All sulphur sources and rates gave promotive effect on canola growth and oil production compared with control. Increasing sulphur levels in plant media from 50 up to 300 kg/fed increased canola growth and oil seed yield as well as seed quality. Ammonium sulphate form gave the superior results of canola growth, seed quantity and quality and oil production. Elemental sulphur showed the lowest ones.

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