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Effect of sulfur foliar fertilization on reproductive growth and development of canola

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Abstract

Plant nutrients availability at appropriate time and amount is inevitable to harvest optimum yield. A field experiment was conducted, to evaluate the effects of sulphur foliar fertilization on reproductive growth and development of canola. The experiment was laid out in randomized complete block design, having three replications with a net plot size of 3m × 5m. Data on various growth and yield parameters of canola were recorded. The results revealed that sulphur foliar spray at the rate of 2% as aqueous solution of ammonium sulphate (AS), significantly improved number of pods plant^{-1}, productive pods plant^{-1}, grains pod^{-1}, pod length (cm), 1000 grains weight (g) and grains oil content (%). Highest pods plant^{-1} (96), pro. Pods plant^{-1} (69), grains pod^{-1} (25.3), and seed oil content (36.5%) ware recorded in 2% AS foliar application, however, it was statistically at par with 0.6% AS foliar application, followed by 0.4%AS application, while minimum pods plant^{-1} (87.6), pro. Pods plant^{-1} (50.7), grains pod^{-1} (18), and seed oil contents (32.9%) ware recorded in control (water spray only). From above results it is concluded that 2% A.S foliar application is best for higher yield of canola.

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Introduction

Canola (*Brassica rapa*) is an oilseed crop that is related to broccoli (*Brassica oleracea*var. *Italica*) and turnip (*Brassica campestris*var. *Rapifera*). Among *Brassica spp*., canola is one of the largest sources of edible oil after soybean and palm oil in the world (Rehman *et al*., 2013). It is grown for the production of vegetable oil for human consumption, animal feed and biodiesel etc. European Union, Canada, the United States, Australia, China and India are the leading producers of canola. Canada is the world's largest producer, while Pakistan has world's third largest importer of edible oil. In Pakistan, "Canola" is attaining the status of leading oilseed crop, both as a source of edible oil for human and a protein supplement for animals. It is cultivated throughout the country, either alone as main crop or intercrop with the other winter crops. Area under canola cultivation was 90283.40 thousand hectares with total production 136 thousand tons oilseed and 52 thousand tons oil that are much lesser than the other oil producing countries (MANFAL, 2012).

Sulfur (S) is the fourth major plant nutrient after nitrogen (N), phosphorus (P) and potassium (K). Sulphur is an essential element for plant growth because it is present in major metabolic compounds such as amino acids (methionine and cysteine), glutathione, sulpho-lipids and proteins. 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). When a soil is deficient in S, then the full potential of a crop variety cannot be realized, regardless of top husbandry practices. Several authors are of the opinion that oilseeds not only respond to applied S, but their requirement for S is also the highest among other crops, thereby attributing a role for the nutrient in oil biosynthesis (Ahmad *et al*., 2007). The effect of increasing canola production on the incidence of S deficiency relates directly to the high S content of canola relative to other commonly grown annual crops. Plants differ extensively for its S supplementation. Canola have higher need for S application compared to other crops i.e. wheat and maize. In general, the oilseed crops, such as canola have a much higher requirement for S per unit of production than others small grain for maximum seed yield (Karamanos *et al*., 2007).

Plant nutrients availability at appropriate amount is unavoidable for obtaining higher yields (Habtegebrial and Singh, 2006). Foliar application of nutrients, especially the expensive major and minor nutrients can be applied to crop plants in the form of a spray where the nutrients readily reach the actual site of activity (Kołota and Osińska, 2000). Foliar fertilizer application may results in better nutrients absorption by the plants and thus can be used for increasing fertilizer use efficiency.

Materials and methods

A field experiment was conducted to study the effect of sulfur foliar fertilization on reproductive growth and development of canola at Amir Muhammad khan campus, Mardan, during rabi session 2014-15.The experiment was laid out in a randomized complete block design (RCBD) having three replications.

Source of sulphur

Ammonium sulphate foliar application at the rate of 0.4%, 0.6% and 02% were used as source of Sulphuralong with one control (only water spray) at the pods initiation stage. Ammonium sulphate was used as sulphate source whereas urea was used to counter the effect of ammonium ion as per requirement. Total area of each plot was 3m x 5m.The field was first ploughed three times and then planking were done to prepare a fine seedbed for the good germination. The test crop, "canola" were sown in 30 cm apart in lines. After germination, thinning was done to maintain optimum plants population. The DAP and half of urea were applied at sowing times and half of urea with second irrigation. The agronomic practices were carried as required.

Ammonium sulphate foliar spray

Ammonium sulphate foliar application were applied as

T1= 0.4 % Ammonium Sulphate,

T2= 0.6 % Ammonium Sulphate
T3= 2 % Ammonium Sulphate along with one Control, only water spray (T4)
The following parameters were studied.

Numbers of total pods plant^{-1}

The data of the total number of pods (productive and non-productive) plant^{-1} were collected by randomly selected ten plants in each plot and counted its pods and then averaged.

Number of grains pod^{-1}

The number of grains pod^{-1} were recorded by counting total grains in each pod of ten randomly selected plants and then averaged.

Number of productive pods plant^{-1}

Productive pods mean those pods which have filled grains. Number of productive pods were counted by physical examination of pods in ten randomly selected plants in each plot and then averaged.

Pod length (cm)

Data of pod length was taken by measuring the length (in cm) of pods of ten randomly selected plants in each plots through ruler and then averaged.

1000 grains weight (g)

1000 grain weight data was taken by taken a thousand grains sample from each plot and then weighted, through a sensitive electronic balance.

Seed oil contents (%)

Oil content ware find by using standard procedure for the extraction of oil from the solid powdered material (Rooskvisky's method) (Sattar *et al.*, 2011)

Statistical analysis

The data was analyzed statistically according to Randomized Complete Block design. Least significant differences (LSD) test was employed upon obtaining significant F-value (Steel *et al.*, 1997). The analysis was done through statistics software named "STATISTIX 8.1.

Results and discussion

Pods plant^{-1}

Data regarding to the number of pods plant^{-1} shown in Table 2. Statistical analysis of the data revealed that ammonium sulphate foliar application was significantly affected treated plots as compere to control (Table 1).

Table 1. Mean square data of pod plant^{-1}, Productive pod plant^{-1}, pod length (cm), grain pod, 1000 grains weight (g) and oil content (%) as affected by Sulphur foliar spray of different levels.

SOV	DF	Total pods plant^{-1}	Productive pod plant^{-1}	Pods length (cm)	Number of Grains pod^{-1}	1000 grains weight (g)	SeedsOil content (%)
Replication	2	1.02	4.00	0.00	1.75	0.01	0.84
Treatments	3	38.08*	199.2*	0.57*	29.63*	0.026 *	7.36 *
Control vs Rest	1	90.25**	469.4*	1.38*	72.25*	0.071**	13.73*
Error	6	1.85	13.22	0.01	2.64	0.00	1.38
Total	11						

The ammonium sulphate foliar application significantly increasedpods plant^{-1}, highest number of pods plant^{-1} (96) were recorded with application of 2% AS, followed by 0.4% AS, while minimum number of pods plant^{-1} (88) were recorded in control plots. The results are similar withthe finding of Rahman *et al.* (2013), Katiyar*at al.* (2014) and Abd Allah *at al.* (2015), they reported that sulfur application increase number of pods plant^{-1}.These results are also in accordance with the findings of the early workers, Singh and Gangasaran (1987) they also reported higher number of pods plant^{-1} when sulphur wasapplied as compared to the treatment where no sulphur was applied. Growth attributes are the primary requirement forthe development of the yield components: number ofpods plant^{-1}, higher number of pods is the first sign for higher production. Yield components are positively correlated with seed yield

(Abdin *et al.*, 2003; Farahbakhsh *et al.*, 2006; Jamal, 2006). These findings clearly indicate that crop supplied with balanced doses of sulphur during growth and development produced the optimum number of pods plant^{-1}, because of the availability of more photo assimilates.

Productive pods plant^{-1}

Data regarding to the number of productive pods plant^{-1} shown in Table 2. Statistical analysis of the data revealed that ammonium sulphate foliar application were significantly affected treated plots as compere to control (Table 1), higher productive pods plant^{-1} (55) were recorded for 2 % AS followed by 0.4 % A S, while minimum productive pods plant^{-1} (46) were recorded for control (water spray only). The increase in productive pod might be due to sulfur application, because it is mainly responsible for promoting pods growth and the ratio of the reproductive tissues (inflorescences and pods) in total dry matter (Ngezimana and Agenbag, 2013). Sulphur is a vital element in forming protein, enzyme, vitamins and chlorophyll in rapeseed-mustard like in other plants. Out of the total plant Sulphur, about 90% is present in these amino acids (Tandon and Messick, 2002). Sulphur is also a constituent of plant hormones like thiamine and biotin, both of which are involved in carbohydrate metabolism. Many plant species, particularly Brassicaceae crops, incorporate Sulphur into a wide range of secondary compounds such as the sulfation of flavonol, desulfoglucosinolate, choline, and gallic acid glucoside (Leustek and Saito, 1999). Several studies show that glucosinate levels in Brassicaceae vegetables will change in response to Sulphur treatments (Aires *et al.*, 2006). Chhonkar and Shroti (2011) reported an increase in growth characters of mustard.

Table 2. Effect of Sulphur foliar application levels on total pods plant^{-1}, total productive pods plant^{-1} and pod length (cm) of canola.

Treatments	Total pods plant^{-1}	Productive pods plant^{-1}	Pod length (cm)
0% A.S (control)	87.6 c	50.7 c	3.6 c
0.40% A.S	91.0 b	59.0 b	4.2 b
0.60% A.S	94.0 ab	66.2 ab	4.5 a
02% A.S	96.0 a	69.0 a	4.6 a
LSD	2.72	7.27	0.17

Pod length (cm)

Data regarding to the pod length (cm) of canola shown in Table 2. Statistical analysis of the data showed that ammonium sulphate foliar application significantly affected treated plots as compare to control (Table 1). Pod length of canola increased with application of ammonium sulphate, higher pod length (4.6 cm) were recorded for 2 % A S foliar application but it was statistically similar with application of 0.6% AS, followed by 0.4% AS while shortest pods (3.6 cm) ware observed in control(water spray only). Plant well supplied with sulphur will have relatively larger photosynthesizing area, consequently accumulating higher quantities of photosynthates which will be translocated to sink site i .e. pods and seeds. With higher quantities of photosynthates being accumulated in the siliqua and seeds, the size of siliqua, number of seeds per siliqua and test weight of seeds had increased.

Grains pod^{-1}

Data regarding to the grains pod^{-1} of canola shown in Table 3. Statistical analysis of the data showed that ammonium sulphate foliar application was significantly affected treated plots as compare to control (Table 1). Significant differences was recorded in number of seeds pod^{-1} among various sulphur levels (Table 3). Maximum number of seeds pod^{-1} (29) were produced where 2% AS was applied which are par with 0.6% AS, followed by 0.4% A.S, while minimum number of seeds pod^{-1} was recorded in control treatment (water spray only). These results are quite in line with the early research work done by Ali *et al*. (1996) who reported maximum number of seeds pod^{-1} (31.19) at application of Sulphur as compared to control. The result are also similar to finding of khandil and Gad (2012) and khandil and Gad (2014) and Abd Allah *et al*. (2015), they report that application of Sulphur increase grains pod^{-1}.

1000 grains weight (g)

Data regarding 1000 grain weight is shown in Table 3. Statistical analysis of the data showed that ammonium sulphate foliar application was significantly affected control vs rest (Table 1). Highest 1000-seeds weight (3.4 g) was recorded for 2% AS and 0.6% AS followed by 0.4% A.S whereas minimum 1000-seedsweight (3.30 g) was recorded in control (water spray only). Generally, 1000-seed weight increased with application of increasing fertilizer levels. The results are supported by Singh and Gangasaran (1987), Trividi and Singh (1999) who reported that increased levels of sulphur produced the highest 1000-seed weight. Sulphur increased supply of photosynthates to pods would also provide an opportunity for seeds to grow to their full potential, with an obvious increase in 1000-seed weight (Malhi *et al*., 2005) as observed in our study. Shekhawat *et al*., (1996) have been reported that increasing levels of Sulphur increased thousand grain weights.

Table 3. Effect of Sulphur foliar application levels on grain pod^{-1}, 1000 grains weight (g) and seeds oil content (%) of canola.

Treatments	Number of grains pod^{-1}	1000 Grains weight (g)	Seeds oil Content (%)
0% A.S (control)	18.0 c	3.2 c	32.9 C
0.40% A.S	22.0 b	3.3 b	34.1 b
0.60% A.S	23.7 ab	3.4 a	35.6 ab
02% A.S	25.3 a	3.4 a	36.5 a
LSD	3.25	0.08	2.35

Seed oil content (%)

Data regarding oil content is shown is in Table 3. Statistical analysis showed significant effect of ammonium sulphate foliar application on oil content of canola (Table 1). The maximum oil content (36.5%) was produced in treatment receiving 2% AS, which was at par with 0.6% AS, followed by 0.4% AS producing34.1 %.

The minimum oil content (32.9%) were produced in control (water spray only). The increased in oil content might be due to the reason that sulphur is an important component of many fatty acids and is required for the synthesis of other metabolites including coenzyme A,vitamin B, Biotin, Lipoic acid and sulpholipids. This results in the increase in the seed oil contents at higher sulphur levels. These results are quite in line with those of Majumdar and Pingoliya (2000) who also reported the increase in oil content (39.02%) with increasing the S level in *Brassica juncea*. These data are also agrees with those obtained by Malhi and Gill, (2002) who found that sulphur addation in plant media increased oil concentration in canola seeds.

Conclusion

On the basis of this study, it is concluded that the application of sulphur at the rate of 2% as foliar spray of ammonium sulphate enhanced the yield of canola crop and thus recommended for the agro-ecological condition of Mardan.

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