Impact of sulfur foliar fertilization on some growth characteristics, yield and quality of two flax cultivars.

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Abstract

This study was conducted at Grdarasha Research Field / College of Agriculture / University of Salahaddin / Erbil with global positional system (GPS) reading of 360 0N, 440 01E (03411359 , 03997002 UTM) during November 2015 to June 2016 , to study the role of five concentrations of Sulfur foliar feeding (0. 100.200.300 and 400) mg per liter on some growth characteristic, yield and yield component of two flax cultivars(Poland and local) using (RCBD) design with 3 replications. The results referred that the sulfur foliar feeding affected significantly at level of significant 5 % on the studied characters such as height of flax branches number , technical length , fruit length, capsules produced by one plant, seeds per one capsule, total yield of seeds, oil% in additional to protein %.The highest seed yield 1.66*M*g ha^{-1}**)**was recorded from treatment combination (300 mg L^{-1}sulfur – Poland cultivar), while the highest oil and protein content (26.67% and 27.02 %) respectively were recorded from treatment combinations (400mg L^{-1} sulfur-local cultivar).On the other hand the lowest values for most of the studied characters were recorded from control –local treatment combination.

Keywords: Flax cultivars, sulfur, yield and quality.

الخلاصة

اجريت هذه الدراسة في حقل كرده ره شه كلية الزراعة / جامعة صلاح الدين / اربيل/ العراق خلال موسم النمو الشتوي 2015 -2016 لتحديد تأثير الرش الورقى بخمس مستويات من كبريتات البوتاسيوم (200،100،0،300و 400 ملغم/لتر) في بعض صفات النمو ، الحاصل والنوعية لصنفين من الكتان (بولندي و محلى) . طبقت تجربة عاملية فى تصميم القطاعات الكاملة العشوائية و بثلاثة مكررات .تم تسجيل الفروق ا لمعنوية على مستوى 5% بين مستويات الكبريت لصفات النمو(ارتفاع النبات وعدد الافرع الثمرية و الارتفاع التكنيكى و الارتفاع الثمرى وعدد العلب الثمرية / نبات و عدد البذور / علبة وحاصل البذور والنسبة المئوية الزيت و النسبة المئوية للبروتين) . اعلى زيادة لحاصل البذور تم تسجيله كانت (1.66ميكاكرام / هكتار) للمعاملة التداخلية 300ملغم /لتر للصنف البولندى) بينما سجلت اعلى زيادة معنوية لنسبة الزيت و البروتين (26.67 % و 27.02 %) للمعاملة التداخلية (400 ملغم /لتر المحلى) ومن جهة اخرى كانت اقل القيم و لمعظم الصفات المدروسة ضمن المعاملة العاملية (بدون، ا ضافة * الصنف المحلى) .

Introduction

Flax is an economical plant grown for producing fibers and seeds as mentioned by Bakry *et al, (*2015 b) It has different chemical and industrial uses. This plant can be used for feeding animals and poultry in additional to uses for industrial purpose such as making various types of compact wood and boards.This crop has other medical and industry applications. (Robbelen *et al*, 1989). The important task in agricultural production is not only for obtaining high yields, but also to provide the highest quality of raw material. Production may be raised during the cultivation of high yielding varieties and appropriate agricultural practices,(Patile *et al* ,2018) In the case of oil plants, it is crucial to provide them with sufficient amount of Sulfur as S fertilizer is especially important, because oil crops require more Sulfur than cereal grains (Jamal *et al,2010).*Among the nutrients, sulfur has great effect on quality and quantity of linseed, which stimulates setting of fruits and formation of seeds as reported by Pateil *et al* , (2014). Sulfur plays significant role in formation of chlorophyll and encourages vegetative growth and it is necessary for the synthesis of some amino acids and oils (Pateil *et al* ,2014), the significant difference of yield and oil% at level of significant 5% were recorded between the studied flax cultivars (Bakry *et al* , 2012) . Sulfur is one of the essential nutrient for crop growth, yield and development in additional to increase in plant tolerance to different stresses (Bakry et al,2015a).

This element (S) is necessary for assimilation of nitrogen , some co- enzymes and protein synthesis (Sune*et et al,* (2006). Sulfur regards as a master element for production of oil seeds as mentioned by Bakry *et al,* (2015b). The fertilization with sulfur caused increase in both protein % and oil % as compared with control treatment. The Highest value of sulfur uptake was recorded from fertilization with 30 kg sulfur per hectare this caused increase in phosphorus and nitrogen uptake by plants and then increases in the quantity of protein and fat in seeds (Wondołowska-Grabowska,2014). The aim of this work was to investigate the effect of sulfur foliar application, on yield, yield components and quality of two flax cultivars (Poland and Local)*(Linumu sitatissimum* L.).

Materials and methods

This investigation was conducted at the Grdarasha Field / Agriculture College / Salahaddin University , Erbil the global positional system (GPS) of the studied area were 360 0N, 440 01 E (03411359 ,03997002 UTM), during 17th of November , 2015 to 25th of June ,2016, to test the role of foliar feeding of five concentrations of sulfur (0, 100,200 and 300and 400) mg L^{-1} using K_2SO_4 which contain (18.39 % S) on growth characteristics, yield and quality of two flax varieties (Thorshansity 72 (Polandcultivar)and local cultivar) using (RCBD) randomized complete block design with 3 replications . Table (1) shows some physic-chemical properties of the studied soil . The seeds were sown on the 17th November 2015, using 58 Kg ha^{-1} of flax varieties by drilling method keeping 0.2 meter distance between the rows. The constant level of nitrogen (15 Kg N $donumm^{-1}$) using urea 46% N and 200 kilogram P_2O_5 per hectare using triple superphosphate (46% P_2O_5) which was applied before seeding.
The area of each experimental unit was (1 * 1.5)m^2. The experiment was done under rain-feed condition; weed control was done 3 times using hand method. The spraying treatments were done at 50% of flowering on 4th of April 2016.

Table (1) Shows Some physic-chemical properties of the studied soil.*

pH	EC dSm^{-1}	HCO_3^-	Ca^{+2}	Mg^{2+}	Na^+	SO_4^{2-}	HCO_3^-	Cl^-	CO_3^{2-}	K	P
		mmol^{-1}								Available *Mg* kg^{-1}soil	
7.55	0.70	2.40	4.50	2.10	0.50	1.15	4.80	2.01	0.00	119	2.99
Sand	Silt	Clay	Texture name			Moisture at field capacity		Moisture at Wilting point			
%			Clay loam			%					
32.9	33.0	34.1				25.50		15.78			

***Cited from (Yssin *et al* , 2018)**

Random representative samples of ten plants were used at full maturity stage from each experimental unit to estimate the following characteristics:

1. Length of Stem (cm).
2. Length of Technical stem (cm).
3. Length of Fruiting zone (cm).
4. Diameter of Stem (mm).
5. Fruiting branches number per one flax plant.
6. Capsules produced per one plant.
7. Seeds Produced by one capsule.
8. Iindex of flax seed.

Plants were harvested from the whole plot to determine:

- .Biological yield (kg ha^{-1}).

The seeds were separated and weighted to record:

- Seed production (kg ha^{-1}).

- Percentage of harvest Index.

The oil was determined by Soxhlet extraction apparatus using hexane according to the methods described by (Association of Official Analytical Chemists. 1980). The total yield of oil was determined by multiplying seed yield kgha^{-1} by seed oil percentage . The Total Nitrogen was determined using Kjeldahl method then protein percentage was determined as follow:

Protein% = N% × constant value

Constant value =6.25

Total yield of Oil (ton (mega gram per hectare): The oil yield was calculated by using the following formula:

Oil yield (*M*g ha^{-1}) = Oil % ×Seed yield (*M*g ha^{-1}).

Statistical analysis were done using SPSS program version 20 for comparing between means using Duncan's multiple range test at probability ($p \leq 0.95$) (Cochran and Cox, 1957) .

Results and discussion

Table (2) shows significance superiority of the Poland cultivar on local cultivar in all growth characters and yield component the highest values of them were (84.50 cm,58.80cm,25.70cm,2.42mm,30.12,8.88 and 12.22) for length of technical stem , length of fruiting zone ,stem diameter no. capsules plant^{-1},number of seeds capsule^{-1} and seed index respectively (Sarkess and Mahmood ,2018), The results agree with Bakry *et al,(*2012).

Table 2.Effect of flax cultivars on some growth characteristics and yield components

cultivars	Stem hieght (cm)	Technical stem height (cm)	Length of Fruiting zone l (cm)	Stem diameter (mm)	Fruiting branches Plant^{-1}	Capsules Produced by one Plant	Capsule^{-1}	Seed index
Poland	84.50a	58.80a	25.70a	2.42a	6.16a	30.12a	8.88a	12.22a
Local	73.81b	53.95b	19.86b	2.19b	5.92a	27.47b	7.04b	10.91b

Table (3) Shows that the application of different levels of sulfur significantly increased the plant height, the highest value of it was (83.65)cm which was recorded for 400mg L^{-1},while the highest values of fruiting zone length(cm), stem diameter (mm),No. of fruiting branchesplant^{-1}, No. of capsulesplant^{-1}, No. of seeds capsule^{-1} and Seed index were (26.58cm,2.64mm,6.75,33.87,9.02 and 12.50) respectively which were recorded for 300 mg /L .This results are in agreement with Minz *et al*, (2017),this might be attributed to direct and indirect role of sulfur in the photosynthetic process of plant (Patil *et al*, 2014). The positive impact effect of Sulfur on plant growth could be due to the role of sulfur in cell division which which causes expanding of leaf and light interception then increase in plant vegetative growth (Bakry *et al*, 2015 ,b) . This results was in agreement with (Patil *et al* , 2014). , he found that lowest plant height with control treatment (0 kg Sulfur ha^{-1}), So, these results were in confirmatory with his results. From another research (Khourang*etal*,2012) found that the highest concentration of sulfur(S) (0.02%) had the great impact on length of technical stem, capsules number per plant, number of seeds per plant .This might be due to better growth of plant because of sulfur availability which caused increase in number of capsules per plant ((Patil *et al*, 2014). This might be because of better growth of plant due to more availability of sulfur. Increase in leaf chlorophyll % of flax plant treated with sulfur may be due to the impact of sulfur on synthesis of chlorophyll ,which might delay the leaf senescence (Bakry *et al*, 2015 b,).

Table 3.Impact of (S) foliar feeding on some plant growth characteristics and yield.

Sulfur mgL-1	Plant height (cm)	Technical stem length (cm)	Fruiting zone length (cm)	Stem diameter (mm)	No. of fruiting branches Plant^{-1}	No. of capsules Plant^{-1}	No. of seeds Capsule^{-1}	Seed index
0	73.12d	54.29a	18.83c	1.87c	5.30b	24.38d	6.89c	10.62b
100	76.47cd	56.49a	20.06bc	2.30b	5.83ab	26.33cd	7.72bc	11.31ab
200	79.40bc	55.99a	23.41abc	2.39ab	6.40a	31.02ab	8.07ab	11.91ab
300	83.14ab	56.55a	26.58a	2.64a	6.75a	33.87a	9.02a	12.50a
400	83.65a	58.64a	25.02ab	2.32b	5.92ab	28.37bc	8.09ab	11.48ab

Table (4) Explains the significant differences between levels of Sulfur foliar application and the two varieties of flax for the growth characters and yield components ,the highest value of stem length (91.77cm) was recorded for the treatment combination (Poland *400mg L^{-1}) , on the other hand (Poland *300mg L^{-1}) achieved highest value for fruiting zone length ,stem diameter ,no fruiting branches ,number of capsules per plant ,number of seeds per capsule and seed index respectively they recorded (31.60cm , 2.91mm, 7.20 ,35.40 ,9.87 and 13.51) respectively ,this variation is due to cultivars response difference to different levels of sulfur fertilization. The mentioned results were in agreement with those recorded by (Bakry *et al* , 2012) they indicated that there were significant differences in straw yield and its components among flax genotypes. These results indicated that the difference between Sakha-2 and Amon varieties may be due to the difference of these varieties in origin, growth habit, environmental condition and genetic properties environmental conditions (Bakry *et al*, 2015 b)

Table 4.Effect of interaction treatment on some growth characteristics and yield componentof flax

	S mg L^{-1}	Length of (cm)			Stem diameter (mm)	Number per plant		Seeds per one Capsule	Seed index
		Stem	Technical stem	Fruiting zone		fruiting branches	capsules		
Poland	0	75.20cd	55.12a	20.08c	1.75d	5.10c	24.63d	7.75b-e	10.92bc
	100	81.33bc	59.27a	22.07bc	2.54ab	5.76abc	27.65cd	8.67abc	11.55ab
	200	85.43ab	60.63a	24.8abc	2.59ab	6.63ab	33.40ab	9.04ab	12.59ab
	300	88.77a	57.17a	31.60a	2.91a	7.20a	35.40a	9.87a	13.51a
	400	91.77a	61.82a	29.95ab	2.30bc	6.09abc	29.50bdc	9.06ab	12.55ab
Local	0	71.04d	53.46a	17.58c	1.99cd	5.50bc	24.14d	6.02e	10.32c
	100	71.60d	53.54a	18.06c	2.05cd	5.90abc	25.00d	6.78de	11.08bc
	200	73.36d	51.35a	22.02bc	2.20bc	6.17abc	28.63bcd	7.11cde	11.23bc
	300	77.50cd	55.93a	21.57bc	2.37bc	6.30abc	32.33abc	8.16abcd	11.49ab
	400	75.53cd	55.45a	20.08c	2.35bc	5.75abc	27.23cd	7.12cde	10.41bc

As shown from table (5) Poland cultivar gave the highest rate for seed yield (1.42*Mg ha*$^{-1}$) for Poland cultivars while the lowest value(1.26*M*g ha^{-1}) was recorded for local varieties , this results was in agreement with (Barky *et al* , 2015 ,a) , they indicated to significant effect of cultivars on yield..In the same table oil percentage (24.10 %)was recorded for the same cultivar comparing with the lowest value for Local cultivar (22.16%) ,Similar results were obtained by (Sarkess and Mahmood, 2018). The highest and lowest value for protein were obtained for local cultivar and Poland cultivar (23.86, 21.95 %) respectively.

Table 5 .Impact of flax cultivars on yield, oil % and protein % .

Cultivars	yield (*Mega gram* ha^{-1})* (		HI	Oil (%)	Oil yield (*M*g ha^{-1})	Protein %	Protein yield (*M*g ha^{-1})
	Biological	Seed					
Poland	6.77a	1.42a	0.21a	24.10a	35.5.3a	21.95b	31.73a
Local	6.55a	1.26b	0.19a	22.16b	36.74a	23.86a	30.25a

*** *Mg* ha^{-1} = Mega gram (ton) ha^{-1}.**

Data in Table (6) shows that (seed yield ,HI and oil %), (oil yield , protein and protein yield) were affected clearly by sulfur foliar fertilization, or increase in concentration of sulfur from 100-300mg L^{-1} and 100 - 400mg L^{-1} caused significance increase in the mentioned characters respectively .The same indicates that the levels of applied S affected significantly on the studied characteristics seed yield , harvest index , oil% , oil yield , protein % and protein yield the highest (1.58 ,0.24 and 59.36*M*g ha^{-1}) values was recorded for sulfur foliar application at 300mg L^{-1} for seed yield ,HI and oil% while the application of 400 mg L^{-1} causes increases significantly in oil yield ,protein % protein yield at the values of (469.35,26.76 and 393.59*M*g ha^{-1}) respectively . This might be because of better growth of plant due to availability of sulfur leading to increase in number of capsules plant^{-1} as seed yield is directly related to the growth and yield attributes. ((Patil *et al* ,2014). Increase in yield attributes with increase in the levels of sulfur was also reported by (Patil *et al* ,2018). Thus the fertilization with sulfur might enhanced the seed formation in linseed plant resulting in to increased seed yield plant^{-1} and ultimately ha-^{1} (Sune *et al,* 2006) and (Patel *et al* ,2018). Sulfur fertilization had significant effect on seed oil percentage of flax plant(Bakry *et al,*2015b),The role of sulfur in increasing yield could be due to the role of S in protein and ferridoxin formation in chloroplast then improving the rate of photosynthesis (Bakry *et al* ,2015,b). The increase in oil content might be due to higher oil synthesis due to increased dose of sulfur, however increased oil yield might be due to increased oil content and seed yield. Similar results were also reporte(Sune*et al.* 2006) and (Choudhary *et al* , 2016)mentioned that adding of 30 kg S per hectare also caused obtaining the highest yield contributing parameters like number of capsules plant^{-1} (27.97) , seed yield (7.50 *M*g ha^{-1}and straw yield (25.86 *M*g ha^{-1}) which was significantly superior over 10 and 20 kg sulfur ha^{-1} . Higher straw production might be due to increased growth and yield parameters resulting into more dry matter accumulation plant $^{-1}$. Similar results were also reported by (Sune *et al.,* 2006). and (Patil *et al* ,(2018) , This might be because of better growth of plant due to availability of S culpture leading to increased number of capsules plant as seed yield is directly related to the growth and yield attributes. Increase in yield attributes with each increase in the levels of sulfur (Patil *et al,* 2014). The increase in oil content might be due to higher oil synthesis due to increased dose of sulphur(Minzet al, 2017). Khourang *et al,(*2012) refers that treating the plant with K 2 SO_4 had a significance effect on oil% , this may be due to the role of sulfur in oil formation. There are a number of researchers which indicated to the

increase of oil and fatty acids in oily plants such as flax; Similar results were also reported (Sune *et al.* 2006 and Choudhary*et al,* 2016). Similar results were also reported by (Patil*et al* ,2018) and (Asisan *et al,* 2017). Increase in yield attributes with increase in the levels of sulphur was also reported by Sune *et al.*, (2006)and Patil*et al*(2018).Higher straw production might be due to increased growth and yield parameters resulting into more dry matter accumulation plant $^{-1}$. Similar results were also reported by (Sune*et al.*2006) and(Patil *et al,* 2018).Many in ventilators reported significant differences among flax varieties (Bakry *et al ,2012)*

Table6.Effect of (S) foliar application on yield and quality of flax cultivars.

Sulfur Mg L^{-1}	Biological yield (*M*g ha^{-1})*	Seed yield (*M*g ha^{-1})	HI	Percentage of oil .	Amount of produced oil (*M*g ha^{-1})	Percentage of Protein	Protein yield (*M*g ha^{-1})
0	6.80a	0.92c	0.14b	27.40c	18.33d	20.18d	18.49c
100	6.29a	1.31b	0.21a	42.11b	31.52c	21.58c	28.21b
200	6.77a	1.43ab	0.21a	49.40ab	38.67b	22.39c	31.85b
300	6.77a	1.58a	0.24a	59.36a	45.20ab	23.62b	37.03a
400	6.71a	1.47ab	0.22a	52.74ab	46.94a	26.76a	39.31a

Table (7)Shows that the interaction treatments affected significantly on seed yield and HI the highest value of them (1.66 *Mg* ha $^{-1}$and 0.26) was recorded from the treatment combination (Poland and 300mg L^{-1} S), while the lowest values (0.88 and0.14) was recorded for control*local) , The same table shows that the interaction treatments affected significantly on oil yield, protein % and protein yield the highest value of them (509.39*M*g ha^{-1},26.49 and 434.54*M*g ha^{-1}) respectively were recorded from the treatment combination (Poland and 400mg L^{-1}),this was in agreement with (Bakry *et al* , 2012) they stated that Flax cultivars are differing in yield , oil content and oil yield.

Table7. Effect of interaction treatment on yield and qualityof flax cultivars.

Cultivars	Sulfur Mg L^{-1}	Biological yield (*M*gha^{-1}) *	Seed yield (*M*g ha^{-1})	HI	Oil (%)	Oil yield (*M*g ha^{-1})	Protein %	Protein yield (*M*g ha^{-1})
Poland	0	6.98a	0.95d	0.14c	21.41e	152.81e	19.17d	18.27d
	100	6.59a	1.35abc	0.21ab	23.01de	252.49d	20.69cd	27.95c
	200	7.04a	1.52abc	0.22ab	24.55bcd	372.28c	21.35cd	32.52ab
	300	6.46a	1.66a	0.26a	25.08abc	482.37ab	22.06cd	36.45ab
	400	6.78a	1.64ab	0.24ab	26.47ab	509.39a	26.49a	43.45a
Local	0	6.62a	0.88d	0.14c	16.01g	213.72de	21.19cd	18.71d
	100	5.98a	1.27c	0.21ab	18.58f	377.88c	22.48bc	28.46c
	200	6.49a	1.34abc	0.21ab	23.91cd	401.11bc	23.42bc	31.18ab
	300	7.05a	1.50abc	0.21ab	25.64abc	449.33abc	25.19ab	37.62ab
	400	6.63a	1.31bc	0.20b	26.67a	394.65bc	27.02a	35.27bc

Conclusion

The results of this study indicated that the foliar feeding of sulfur has the great effect on growth , yield , yield components in additional to its impact of oil %,protein % , protein yield and oil yield of flax cultivars. The best concentration of sulfur in this study was 300 mgL^{-1} sulfur .

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