

Potassium and Zinc in Relation to Improve Flax Varieties Yield and Yield Components as Grown under Sandy Soil Conditions

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Abstract

Two field experiments were carried out at the experimental station of National Research Centre, Al-Nubaria District, El-Behira Governorate, Egypt during winter seasons of 2011/2012 and 2012/2013 to study the effect of potassium soil application at the rates (0, 50, 75 and 100 kg/fed.) with or without chelated zinc foliar application 5% at the rate of (0.03 kg/fed.) on the yield and quality of two flax varieties (Sakha-2 and Amon) in newly reclaimed sandy soil. The obtained results could be summarized as follow: Sakha-2 variety significantly surpassed Amon in plant height, technical length, number of branches/plant, seed yield/plant, straw yield/plant, 1000 seed weight, seed yield/fed., straw yield/fed., fiber %, fiber yield/fed. and oil yield/fed. Amon variety surpassed Sakha-2 in fruiting zone length, number of capsules/plant and oil % in both seasons. Potassium soil application at the rate of (100 kg/fed.) with chelated zinc foliar application 5% at the rate of (0.03 kg/fed.) gave the highest value for all studied characters.

Keywords

Flax, Potassium Fertilizer, Zinc Fertilizer

1. Introduction

Egypt vitally needs sustained agricultural development to cope with the social and economic obligations that are the normal consequences of the contributed high rates of population growth. This urgent need requires continu-

ously scientifically based implementation of both vertical and horizontal schemes for more effective agricultural practices.

Flax is a source of two products; flax seed for oil and fiber for linen products. In Egypt, it is an old economic crop grown as a dual purpose crop for seeds and fibers which are used for the manufacture of linen. Production could be increased through the cultivation of high yielding cultivars and appropriate agronomic practices, among which fertilization is the most important.

Generally, the plants response to K fertilizers might be due to the soils with high fixing capacity [1]; the soil texture is sandy intensive cropping system, the introduction of high yielding varieties, the increment in nitrogen doses are applied in crop management [2] and [3]. In this connection, [4] concluded planting Giza-8 as flax seed variety for production seed and oil yields however, sowing vaiking variety as fiber flax variety for fiber yield production when they fertilized by KNO_3 foliar application under sandy soil conditions.

Concerning micronutrients *i.e.* Fe, Mn and Zn, [5] cleared that the availability of micronutrients is much affected by pH, $CaCO_3$ content, organic matter and soil texture [6].

[7] studied the effect of micronutrients on flax yield and quality. [8] concluded that Zn foliar application was important to correct the nutrient balance in flax plant (Sakha-2) undesirable soil conditions.

Many in ventilators reported significant differences among flax varieties [4] [9]-[11].

The objective of this investigation was to study the effect of potassium soil application and zinc foliar application of two flax varieties on yield and quality traits under sandy soil conditions.

2. Materials and Methods

A field experiment was carried out at the experimental Station of National Research Centre, Al-Nubria District El-Behira Governorate—Egypt, during the two successive winter seasons of 2011/2012 and 2012/2013. The soil of both experiment sites (0 - 30 cm) were newly reclaimed sandy soils where mechanical and chemical analysis is reported in **Table 1**.

The aim of this work was to investigate the effect of zinc foliar application and potassium sulfate soil application on yield and its components of flax (*Linum usitatissimum* L.) varieties (Sakha-2 and Amon) grown under newly reclaimed sandy soil. The experimental design was split plot design with four replicates, which flax varieties occupy the main plots and potassium sulfate treatments at rates of (0, 50, 75 and 100 kg/fed.) with or with

Table 1. Mechanical and chemical analyses of the experimental site.

Properties	Year	2011/2012	2012/2013
Mechanical analysis			
Sand (%)		91.20	92.33
Silt (%)		03.70	02.95
Clay (%)		05.10	04.78
Soil texture		Sandy	Sandy
Chemical analysis			
pH (1:8.5 water)		07.40	07.50
E.C. (mmhos/cm)		00.30	00.50
$CaCO_3$ (%)		01.40	01.65
Organic matter %		00.30	00.24
Available P ppm	} mg/100 g soil	00.22	00.24
Exchangeable K ppm		10.18	12.00
		92.00	90.00
		18.04	18.00
		12.36	15.02
	} mg/Kg soil	04.92	03.99
		03.95	03.15
		00.13	00.04
		00.10	00.08

out chelated zinc foliar application (5%) at the rate of 1.5 g/l (0.03 kg/fed.) were allocated at random in sub-plots. Seeds of flax varieties (Sakha-2 and Amon) were sown on the 17th November in both season in rows 3.5 meters long, the distance between rows was 20 cm apart, Plot area was 10.5 m² (3.0 m in width and 3.5 m in length). The recommended agricultural practices of growing linseed were applied and the seeding rate was 2000 seeds/m². Pre-sowing, 150 kg/fed. of calcium super phosphate (15.5% P₂O₅) was applied to the soil. Nitrogen was applied after emergence in the form of ammonium nitrate 33.5% at rate of 75 kg/fed. was applied at five equal doses before the 1st, 2nd, 3rd, 4th and 5th irrigation. Irrigation was carried out using the new sprinkler irrigation system where water was added every 5 days.

Flax plants were foliar sprayed with chelated zinc 5% at rate of 1.5 g/l (0.03 kg/fed.) In both seasons, foliar application of zinc was carried out twice; the plants were sprayed after 45 and 60 days from sowing. Flax plants were pulled when signs of full maturity were appeared, then left on ground to suitable complete drying. Capsules were removed carefully. At harvest the following characters were recorded on random samples of 10 guarded plants in each plot to estimate the following characters:

1. Fiber yield and its related characters:

- Plant height (cm)
- Straw yield/plant (g)
- Biological yield/ (ton/fed.)
- Fiber yield (kg/fed.) = straw yield (kg/fed.) after retting multiplied by fiber
- Technical stem length (cm)
- Fiber yield/plant (g)
- Fiber (g)

2. Seed yield and its related characters:

- Number of fruiting branches/plant
- Number of capsules/plant
- Fruiting zone length (cm)
- Seed yield/plant
- 1000 seed weight (g)
- Seed yield (kg/fed.)
- Seed oil %: was determined by sox let apparatus using petroleum ether (4°C - 60°C b.p) according to the Official Method [12].
- Oil yield (kg/fed.) was calculated by seed yield (kg/fed.) *Seed oil

Data were statistically analyzed separately for each season. The combined analysis was conducted for the data of the two seasons according [13], the least significant differences (LSD) was used to compare between means.

3. Results and Discussion

A) Effect of flax varieties on growth characters

As can be seen from **Table 2** that yield and yield components of the studied varieties differed significantly in all characters under this trials.

Sakha-2 variety surpassed Amon variety in seed yield (587.9 kg/fed.) and oil yield (220.38 kg/fed.). The superiority of this variety may be due to the highest values of numbers of branches/plant (2.56) and seed yield/plant (0.34).

Similar results were previously obtained by [4] [10] [14] [15] and who reported that the flax cultivars differed in seed yield productivity.

Sakha-2 variety significantly exceeded Amon variety in straw yield (3.19 ton/fed.) and fiber yield (424.48 kg/fed.). These results may be attributing to the highest value of plant height (87.85 cm), technical length (75.00 cm) and fiber % (13.23). These results are in agreement with those obtained by [4] [9]-[11] and, they showed that there were large differences in straw yield and its components among flax genotypes. These results indicated that the variability among Sakha-2 and Amon varieties which may be expected due to the difference of these varieties in origin, growth habit, the high diversity in genetic constituent and the environmental conditions of investigated cultivars under sandy soils.

B) Effects of potassium (K) and zinc (Zn) on morphological characters

The results given in **Table 3** indicate clearly that morphological characters, yield and yield components of flax at harvest were significantly affected levels of potassium and zinc.

The same table shows that the mean values of studied characters of plants tend to increase with increasing (K levels from 0, 50, 75, 100 kg/fed.) and Zn treatments from (Zn, K₁ + Zn, K₂ + Zn, K₃ + Zn). The highest values

Table 2. Effect of flax varieties on seed straw, oil fiber yields and there components (combined 2011/2012 and 2012/2013 seasons).

Varieties	Sakha-2	Amon	LSD _{0.05}
Plant height (cm)	87.85	66.21	2.15
Technical length (cm)	75.0	50.30	5.33
Fruiting zone length (cm)	12.85	15.91	0.47
Number of capsules/plant	11.41	11.62	0.11
Number of branches/plant	0.54	2.42	0.03
Seed yield/plant (g)	0.34	0.27	0.01
Straw yield/plant (g)	1.47	1.11	0.13
1000 seed weight (g)	7.75	5.89	0.51
Seed yield (kg/fed.)	587.9	468.91	31.45
Straw yield (ton/fed.)	3.19	2.10	0.45
Fiber (%)	13.23	10.77	1.12
Fiber yield (kg/fed.)	424.48	228.71	71.55
Oil (%)	37.36	37.81	0.17
Oil yield (kg/fed.)	220.38	177.72	6.87

Table 3. Effect of potassium fertilization with or without zinc foliar application on seed, straw, oil and fiber yield and there components (combined 2011/2012 and 2012/2013 seasons).

Treatments	Control	Potassium (kg/fed.)			Zinc (Zn)	Potassium with zinc			LSD _{0.05}
		K ₁ (50)	K ₂ (75)	K ₃ (100)	(1.5 g/l)	K ₁ + Zn	K ₂ + Zn	K ₃ + Zn	
Plant height (cm)	69.94	75.22	76.31	78.89	73.33	79.75	80.58	82.23	2.05
Technical length (cm)	56.93	60.35	61.75	64.19	59.92	64.97	65.68	67.45	1.18
Fruiting zone length (cm)	13.01	14.88	14.56	14.70	13.42	14.78	14.91	14.79	1.04
Number of capsules/plant	8.41	10.08	11.21	11.93	9.58	13.34	13.75	13.84	1.28
Number of branches/plant	2.06	2.34	2.35	2.61	2.35	2.53	2.66	2.97	0.51
Seed yield/plant (g)	0.17	0.24	0.30	0.34	0.24	0.36	0.38	0.40	0.21
Straw yield/plant (g)	0.80	1.06	1.24	1.50	1.15	1.34	1.56	1.66	0.25
1000 seed weight (g)	6.19	6.85	6.92	6.96	6.76	6.97	7.00	7.08	0.16
Seed yield (kg/fed.)	453.15	520.58	529.73	539.29	494.19	552.24	564.96	573.12	31.03
Straw yield (ton/fed.)	2.20	2.47	2.69	2.78	2.31	2.84	2.91	2.95	0.19
Fiber (%)	9.60	11.34	12.49	12.64	11.17	12.87	12.91	12.99	0.15
Fiber yield (kg/fed.)	217.87	290.47	343.51	358.05	262.44	371.5	380.84	388.12	12.22
Oil (%)	34.07	36.75	38.01	38.72	36.53	38.72	38.87	39.03	1.05
Oil yield (kg/fed.)	153.74	181.01	201.23	208.95	180.26	213.93	219.63	223.64	5.31

of plant height technical length, fruiting zone length were obtained with K at the rate 100 kg/fed. with Zn at the rate (5%). This may be referred to the rate of Zn in biosynthesis of the natural auxin, indole acetic acid [16] and account promotion of stem elongation [17] indicated the positive effect of micronutrients on growth and flax plant. In addition, the role of K information of carbohydrate, proteins, photosynthesis translocation regulation, enzyme action [18].

C) Effect of potassium and zinc yield and yield components

It is visible from **Table 3** that number of capsules/plant, number of branches/plant, seed yield/plant, straw yield/plant, 1000-seed weight, seed yield/fed., straw yield/fed., fiber %, fiber yield/fed. oil % and oil yield/fed. were significantly increased by potassium and Zn treatments.

The number of branches/plant was reached the highest increase due to the treatment of highest potassium application and Zn foliar application ($K_3 + Zn$). In this connection, it is worthily to note that trace elements were reported to control the hormonal balanced of the plant [19] in addition, [4] indicated that all potassium sources were significantly affected in all plant studied characteristics except technical length .

Table 3 illustrate that the increase on seed flax yield/plant and fed. were significantly and this results may be due to the treatment ($K_3 + Zn$) in both seasons which [20] reported that plants can't take up their micronutrients requirements under undesirable soil conditions. Such as high pH, low organic matter content (**Table 1**). These increases of flax yield/plant and fed. may be attributed to the effect of micronutrients, on dry matter or due to the great efficiency of enzyme activities which affected plant pigments and at the rate of photosynthesis. The same results with cotton plants reported by [21]-[24] presented that application of zinc increased seed/yield and oil yield as well as total unsaturated fatty acids (Oleic and Linoleic) content in cotton. On the other hand, [18] indicated that these effects for the treatment, $K_3 + Zn$ may be due to the role K in plant such as synthesis of nucleic acid, chlorophyll, oxidative, photospherylation and translocation of solutions [18].

Data presented in **Table 3** exhibit that seed oil% was significantly increased by addition the highest rate of potassium with zinc foliar application ($K_3 + Zn$). The same finding has occurred by [8] [25] with Zn, where [10] and [4] with (K).

The high level of K application with Zn foliar application ($K_3 + Zn$) significantly increased seed yield/fed. by 20.93%, straw yield/fed. by 25.42% and oil % by 12.71% over the control. In this connection, [8] suggested that Zn foliar application can improve seed yield of flax seed. Also, [4] cleared the importance of K increasing the flax production.

Data presented in **Table 3** pointed out that treatment of K especially high dose with Zn gave a positive effect of all the studied characteristics of flax plant. These results may be due to the improving of physiological performance in tested plants due to more nutrients uptake by plants from soil. Such results are in harmony with those obtained by [17] [26].

D) Effect of potassium and zinc on fiber yield

According to the above mentioned results in **Table 3** cleared that fiber yield and fiber % were affected significantly with all treatments especially by application at the highest rate with Zn foliar application in both seasons may be due to the role of Zn on fundamental metabolic reaction and acceleration protein synthesis [25] and the role of K in formation of carbohydrates, protein, photosynthesis translocation regulation and translocation of solutions [18].

E) Interaction effect

Results in **Table 4** showed that there was significant affect of interaction between the flax varieties, potassium and zinc fertilization on yield and yield components.

$K_3 + Zn$ treatment recorded superiority among all the treatments with flax varieties. The greatest straw yield (1.9 ton/fed.) and fiber yield (492.83 kg/fed.) were obtained when sowing Sakha-2 var. and treated the plants by ($K_3 + Zn$) fertilizer. This was due to the obtained highest values of plant height (94.51), fruiting zone length (14.85 cm), straw yield/plant (1.91 g) and fiber % (13.91). While the best results of oil % (37.10) was achieved by Amon variety was due to highest values of fruiting zone length (17.06 cm) and number of capsules/plant (14.10).

4. Conclusion

Eventually, it could be concluded that the studied growth and yield characters response significantly to the investigated factors. Shaka-2 variety showed its superiority to the most characters under study, whereas Amon

Table 4. The effect of interaction between the flax varieties and potassium and zinc fertilization on seed, straw, oil and fiber yields and there components (combined 2011/2012 and 2012/2013 seasons).

Varieties	Treatments	Plant height cm	Technical length cm	Fruiting zone length cm	Number of capsules/plant	Number of branches/plant	Seed yield/plant (g)	Straw yield/plant (g)	1000 seed weight (g)	Seed yield kg/fed.	Straw yield kg/fed.	Fiber %	Fiber yield kg/fed.	Oil %	Oil yield kg/fed.
Sakha-2	Control	80.15	69.50	10.05	8.50	2.11	0.20	0.86	6.81	515.60	2.665	11.14	296.88	33.03	170.30
	K ₁ (50 kg/fed.)	85.13	72.44	12.69	10.61	2.35	0.29	1.15	7.86	575.25	2.997	13.34	397.13	36.19	208.18
	K ₂ (75 kg/fed.)	86.50	73.61	12.89	11.27	2.33	0.34	1.42	7.88	580.33	3.265	13.75	448.94	37.82	219.48
	K ₃ (100 kg/fed.)	89.92	76.81	13.11	11.63	2.57	0.36	1.78	7.93	595.27	3.339	13.79	460.45	38.97	231.98
	Zn (1.5 g/l)	83.11	72.17	10.94	9.15	2.35	0.27	1.27	7.75	545.82	2.782	12.19	339.13	36.05	196.77
	K ₁ + Zn	91.16	77.63	13.53	12.96	2.67	0.35	1.55	7.96	621.13	3.433	13.85	475.47	38.91	241.68
	K ₂ + Zn	92.30	78.20	14.10	13.56	2.87	0.40	1.79	7.98	633.19	3.497	13.87	485.03	38.95	246.63
	K ₃ + Zn	94.31	79.66	14.85	13.58	3.05	0.44	1.91	8.10	636.63	3.543	13.91	492.83	38.96	248.03
	LSD _{0.05}	3.33	2.53	1.13	0.51	0.13	0.11	0.18	0.15	13.21	0.25	0.33	16.34	0.13	3.11
Amon	Control	59.72	44.36	15.36	8.31	2.00	0.13	0.74	5.57	390.70	1.725	8.05	138.86	35.11	153.17
	K ₁ (50 kg/fed.)	65.31	48.25	17.06	9.54	2.33	0.19	0.96	5.83	465.91	1.970	9.33	183.80	37.31	173.83
	K ₂ (75 kg/fed.)	66.12	49.89	16.23	11.15	2.36	0.25	0.06	5.95	479.12	2.120	11.23	238.08	38.19	182.98
	K ₃ (100 kg/fed.)	67.85	51.56	16.29	12.22	2.65	0.31	1.22	5.98	483.31	2.225	11.49	255.65	38.47	185.93
	Zn (1.5 g/l)	63.55	47.66	15.89	10.01	2.35	0.21	0.02	5.76	442.55	1.830	10.15	185.75	37.00	163.74
	K ₁ + Zn	65.33	52.30	16.03	13.71	2.38	0.33	1.12	5.98	483.35	2.250	11.89	267.53	38.52	186.19
	K ₂ + Zn	68.86	53.15	15.71	13.93	2.45	0.35	1.33	6.02	496.72	2.315	11.95	276.64	38.78	192.63
	K ₃ + Zn	69.95	55.23	14.72	14.10	2.88	0.36	1.41	6.05	509.61	2.350	12.06	283.41	39.10	199.26
	LSD _{0.05}	3.33	2.53	1.13	0.51	0.13	0.11	0.18	0.15	13.21	0.25	0.33	16.34	0.13	3.11

variety surpassed the other in a few cases. The combination between the highest rate of potassium and Zn foliar application gave in most cases the best results for the studied characters. It seemed evident that the fertilization with the highest rate of potassium sulphate (100 kg/fed.) with Zn foliar application at rate of (5%) gave the best result with all the varieties.

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