Effect of Seeding Rates and Potassium Levels on Growth, Yields and Its Components of Flax under Salinity Soil Conditions

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ABSTRACT

In order to mitigate the salinity effects on flax grown on saline soil, two field experiments were carried out at Horticultural Sakha Agriculture Research Station(El-Hamrawy Farm), Kafr El-Shiekh Governorate, Egypt, during 2014/2015 and 2015/2016 seasons to study the effect of different seeding rates(50, 60 and 70 kg flax seed fed^{-1}) and potassium fertilizer levels(0, 12, 24 and 36 kg K_2O fed^{-1}) on growth, yield and its components of flax cultivar Sakha3 under saline soil conditions. The experiments were carried out in a split-plot design with four replications. The main-plots were assigned to seeding rates. The sub-plots were randomly allocated to potassium fertilizer levels.

The obtained results showed that sowing flax with 50 kg flax seed fed^{-1} recorded the highest values of chlorophyll a in the first season, total chlorophyll and stem diameter in both seasons, whereas, sowing flax with 70 kg flax seed fed^{-1} recorded the highest values of technical length, straw yield/fed, number of capsules/plant, seed yield/fed, fiber length, fiber yield/plant and fiber yield/fed in the two growing seasons. However, sowing flax with 60 kg flax seed fed^{-1} recorded the highest values of seed index in both seasons.

All growth characters and photosynthetic pigments, straw, seed and fiber yields and its components of flax were gradually increased as a result of increasing potassium fertilizer levels from 0 to 12, 24 and 36 kg K_2O fed^{-1} in both seasons.

It could be recommended sowing flax with the highest seeding rate(70 kg flax seed fed^{-1}) and fertilizing with 36 kg K_2O fed^{-1} is the best practice in order to maximize flax growth, yields and its components under saline soil conditions in Kafr El-Shiekh Governorate, Egypt.

Key Words: Flax, Seeding rates, Potassium levels, Salinity conditions, Growth, Yields.

INTRODUCTION

Flax (*Linum usitatissimum* L.) is one of the oil seed plants, and demand for its valuable oil and fatty acids is increasing all over the world. The seed contains 40-45% oil and 23-34 % protein. Besides it`s valuable, seed meal with high percent of protein 42-46 percent, is also used in the animal diet. Besides, fiber produced from flax is used in manufacturing high-grade paper, upholstery tow, insulating materials, rugs, yarn, linen, and other textiles. Hence, flax is a dual purpose crop that is grown for fiber and oil production. The gap between the production and local requirements increased because it is difficult to increase flax area due to great competition from other major winter crops. The gap could be minimized partly by cultivating flax on moderate saline soils and try to increase yield per unit area. To increase crop yields suitable agricultural practices that aim to maximize yield per unit area should be applied i.e. high yielding cultivars with suitable plant density or seeding rate and using optimum potassium fertilizer level are needed.

Salinity is one of the major abiotic stresses in arid and semi-arid regions that reduces the yield of major crops by more than 50% due to low rainfall in these areas besides lack of soil leaching(Corwin et al., 1996). Salinity also limits soil fertility in irrigated regions of the world. Moreover, salinity affects 7% of the world's land area for around 930 million ha(Ghasemi et al., 2002). Although all soils contain some amount of soluble salts of multifarious nature, when soil and environmental conditions allow the concentrations in soil profiles to a high level, soil salinity becomes a severe threat to land degradation and crop productivity**(**Munnus**,** 2002**)**. Salinity is one of the most serious factors limiting crops production, especially the sensitive ones **(**Zadeh and Naeni, 2007**)**. Often salinity occurs in patches within fields causing irregular plant density and growth, with consequent reduction of the harvesting efficiency(Ritzk and Normand**,** 1966; Spalding, 1983**)**. Consequently, plant density is a critical practice for determining the productivity of flax. Adjusting planting density is an important tool to optimize crop growth and maximize seed and fiber yields and quality parameters of flax. Plant density influences modulating crop environment and help to improve disease avoidance, thus adjusting plant density is an important tool to optimize crop growth and the time required for canopy closure and to achieve maximum biomass and seed yield. In this concern, Abd El-Mohsen et al.(2013**)** pointed out that maximum seed, straw and fiber yields/ha were produced when seeding rate was 180 kg/ha. Abd

Eldaiem(2015) reported that using flax plant density of 2500 plants/m^2 significantly recorded the highest values of total plant height, technical length, stem diameter, number of fruiting branches, number of capsules/plant, number of seeds/capsule, straw yield/plant, seed yield/plant, biological yield/fed, straw yield/fed, seed yield/fed and long fiber yield/fed. Delesa and Choferie(2015) indicated that significant effects of seeding rates were observed on all yield components reflecting the importance of seeding rate for flax growth, yield and yield components. Emam and Dewdar**(**2015**)** showed that increasing seeding rate significantly increased straw and seed yields in most cases. The favorable straw yield and its components (plant height, technical length, stem diameter and straw yield/plant) were observed when flax plants were applied with seeding rate of 2250 seed/m^2.

High salinity/sodicity levels lead to potassium deficiency due to antagonistic effect of Na on potassium absorption or disturbance of the Na^+/K^+ ratio (Chhabra, 1983 and Muhammed. 1986).

Potassium(K) participates in many important functions in plants *i.e.* photosynthesis, translocation of photosynthates, protein synthesis, control of ionic balance, regulation of plant stomata and water use (Marschner, 1995 **;** Dong et al., 2004 and Reddya *et al*., 2004), enzyme activation and osmoregulation (Mengel, 2007). Also, potassium enhances the ability of plants to resist stress such as diseases, pests, cold, salinity and drought. Potassium performs these roles in all crops and flax, therefore it is an important plant nutrient to sustain high productivity and quality, in equilibrium with other essential plant nutrients, so it is important to ensure adequate potassium levels for flax crop. In this concern, Fataneh et al.(2012**)** showed that yield components of flax were significantly increased by increasing potassium fertilizer levels. Application of potassium to barley led to significant increase in relative water content(RWC) Noroozi and Sepanlou, (2013**)**. Potassium application could play an important role in alleviation of injury of salinity on wheat irrigated with saline water depending on the level of salinity(El-Lethy et al., 2013). Abd El-Dayem and Amal El-Borhamy(2015**)** stated that fertilizing flax plants with 24.0 K_2O/fed significantly increased straw yield and its components, seed yield and its components and fiber yield and its components. Abd Eldaiem et al. (2015) showed that application of 15 kg K_2O/fed gave the highest values of total length, technical length, straw yield/plant and seed oil percent, while application of potassium at the rate of 30 K_2O/fed recorded the highest values of stem diameter, seed weight/plant, seed yield/fed, straw yield/fed and fiber yield/fed. Bakry et al.(2015**)** found that increasing potassium soil application up to the rate of 100 kg K_2O/fed gave the highest values of all growth characteristics, seed yield/plant, straw yield/plant, 1000 seed weight, seed yield/fed, straw yield/fed, fiber %, fiber yield/fed, oil % and oil yield/fed.

Therefore, this study aimed to investigate the effect of different seeding rates and potassium fertilizer levels on growth, yields and its components of flax under saline soil conditions in Kafr El-Shiekh Governorate, Egypt.

MATERIALS AND METHODS

Two field experiments were carried out at Horticultural Sakha Agriculture Research Station (El-Hamrawy Farm), Kafr El-Shiekh Governorate, Egypt, during 2014/2015 and 2015/2016 growing seasons to study the effect of different seeding rates and potassium fertilizer levels on growth, yields and its components of flax cultivar Sakha3 under saline soil conditions. Sakha 3 cultivar was obtained from Fibers Research Section, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt.

The experiments were carried out in a split-plot design with four replications. The main-plots were assigned to three seeding rates(50, 60 and 70 kg flax seed fed^{-1}). The sub-plots were randomly allocated to potassium fertilizer levels *i.e.* control(without potassium fertilizer), 12, 24 and 36 kg K_2O fed^{-1}. Mineral potassium fertilizer in the form of potassium sulphate(48.0% K_2O) at the formerly mentioned levels was applied in two equal doses, the first dose was applied at sowing and the second dose before first irrigation.

Each experimental unit area was 1 × 3 m occupying an area of 3.0 m^2 *i.e.* 1/1400 feddan. The preceding summer crop was Kenaf(*Hibicus cannabinus* L.) in both seasons. Soil samples were taken at random from the experimental field area at a depth of 0 - 30 cm from soil surface before the growing seasons to determine the chemical soil properties as shown in Table 1.

Table1: Some chemical properties of the site during 2014/2015 and 2015/2016 seasons.

Chemical analyses		2014/2015	2015/2016
pH		8.08	8.28
E.C. dSm^{-1}		6.20	8.00
Cations (meq./100 g soil)	K^+	0.22	0.64
	Na^+	17.2	63.00
	Ca^{++}	29	16.55
	Mg^{++}	19	24.81
Anions (meq./100 g soil)	$HCO3^-$	0.7	4.50
	CL^-	20	46.66
	$SO4^{--}$	21.73	53.85

Flax seeds were sown on the first week of November in the two growing seasons using broadcasting method at the aforementioned seeding rates. The mineral phosphorus fertilizer in the form of calcium superphosphate(15.5% P_2O_5) at the recommended rate(15kg P_2O) was added before sowing and during seed bed preparation(after ploughing and before division).The mineral nitrogen fertilizer in the form of ammonium nitrate(33.5 % N), at the recommended rate(45kg N / fed.) was applied into two equal doses, before the first and the second irrigation, respectively. The common agricultural practices for growing flax according to the recommendations of Ministry of Agriculture were followed, except the factors under study.

Studied characters:

1-Growth characters and photosynthetic pigments:

At the flowering stage, samples of ten plants from each sub-plot were taken to determine dry matter accumulation, photosynthetic pigments (chlorophyll a, chlorophyll b and total chlorophyll), which was determined using the spectrophotometric method according to the following formulas (Moran, 1982):

Chlorophyll a = 12.64 A664-2.99 A647 (mg L^{-1}).

Chlorophyll b = -5.6 A664 + 23.26 A647(mg L^{-1}).

Total chlorophyll =7.04A664+20.27 A64(mg L^{-1}).

Relative water content percentage (RWC %) according to Ritchie and Nguyen(1990) was measured. All leaves of one plant were taken from each sub-plot and weighed (fresh weigh "FW"). The leaves were then placed in distilled water for 5 h at 25° C and then their saturated weights(SW) were recorded, leves were then dried in an oven at 70° C for 24 h to calculate dry weight(DW). RWC were calculated by the following formula:

RWC % = (FW- DW / SW- DW)*100

Proline content in flax leaves was determined according to the method of Bates et al. (1973**)**.

II. Yield and its components:

At harvest, ten guarded plants of flax were pulled out manually from each sub- plot to be used in recording the flax yield components. Straw yield/fed, seed yield/fed and long fiber yield/fed were recorded from the whole sub-plot area

A- Straw yield and its components:

1- Technical length(cm). The length of main stem in cm from cotyledonary node to the lowest branching zone.
2- Stem diameter(mm). It was measured at the middle of technical length.
3- Straw yield/plant(g). As the total weight in grams of the air dried straw per plant after removing the capsules.
4- Straw yield/fed(ton). It was calculated from the whole area of each sub plot.

B- Seed yield and its components

1- Number of capsules/plant.
2- Seed index.
3- Seed yield/feddan (kg).

B- Fiber yield and its components:

1- Fiber length(cm). as an average of ten fiber ribbons from every treatment.
2- Fiber yield plant(g).
3- Fiber yield/feddan (ton).

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split– plot design as published by Gomez and Gomez (1984) using MSTAT statistical package. Duncan's Multiple Range Test was used to test the differences between treatment means at 5 % level of probability as described by Duncan (1955).

RESULTS AND DISCUSSION

1. Effect of seeding rates:

The results showed that studied seeding rates *i.e.* 50, 60 and 70 kg flax seed fed^{-1} exhibited significant effect on chlorophyll a in the first season, total chlorophyll, technical length, stem diameter, straw yield/fed, number of capsules/plant, seed index, seed yield/fed, fiber length, fiber yield/plant and fiber yield/fed of flax in both seasons, as shown in Tables 2 through 6. In contrast, chlorophyll a in the second season, chlorophyll b, relative water content (RWC %), dry matter accumulation and proline content in both seasons were not significantly affected by studied seeding rates. It can be observed that sowing flax with the lowest seeding rate (50 kg flax seed fed^{-1}) significantly recorded the highest values of chlorophyll a in the first season, total chlorophyll and stem diameter in both seasons. However, sowing flax with the highest seeding rate (70 kg flax seed fed^{-1}) significantly recorded the highest values of technical length, straw yield/fed, number of capsules/plant, seed yield/fed, fiber length, fiber yield/plant and fiber yield/fed of flax in the two growing seasons. On the other hand, sowing flax with intermediate seeding rate (60 kg flax seed fed^{-1}) significantly recorded the highest values of seed index in the first and second seasons. There were insignificant differences in chlorophyll a, stem diameter, fiber length (in the first season), total chlorophyll, technical length (in the second season) and number of capsules/plant (in both seasons) due to sowing flax with intermediate (60 kg flax seed fed^{-1}) or high seeding rate (70 kg flax seed fed^{-1}). These results may be due to the ability of individual plants, at low plant densities resulting from lowest seeding rate of adjust to low populations by increasing the vegetative growth and more accumulation of dry matter due to enhanced chlorophyll content, leading to increase branches and capsules per plant and other yield attributes. Conversely, the individual plants at high plant densities, resulting from highest seeding rate, may be exposed to considerable intra competition, which lead to reduction in vegetative growth, fewer branches capsules and seeds per plant. However, higher densities gave higher yields of straw, seed and fiber per plant and per unit area, and that could be due to higher number of plants per unit area. These results are in agreement with those reported by Kineber(2003), Burton(2007), Abd El-Mohsen et al., (2013), Abd Eldaiem(2015), Delesa and Choferie (2015) and Emam and Dewdar(2015).

2. Effect of potassium fertilizer levels:

Potassium fertilizer levels showed significant effect on chlorophyll b (in the first season), relative water content (in the second season) and chlorophyll a, total chlorophyll, dry matter accumulation, proline content, technical length, stem diameter, straw yield/fed, number of capsules/plant, seed index, seed yield/fed, fiber length, fiber yield/plant and fiber yield/fed in both growing seasons as shown from results in Tables 2, 3, 4, 5 and 6. From the obtained results it could be noticed that all growth characters and photosynthetic pigments, straw, seed and fiber yields and its components of flax were gradually increased as a result of increasing potassium fertilizer levels from 0 to 12, 24 and 36 kg K_2O fed^{-1} in both seasons. Generally, maximum means of all studied characters resulted from fertilizing flax plants with 36 kg K_2O fed^{-1} in both seasons. Fertilizing flax plants with 24 kg K_2O fed^{-1} ranked second followed by fertilizing with 12 kg K_2O fed^{-1} for all studied characters in both seasons. On the contrary, the lowest values of all studied characters were obtained from plots which did not receive potassium fertilizer(control treatment). The increase in all studied characters as a result of increasing potassium fertilizer levels, can be ascribed to the potential benefits of potassium for flax which include important functions in plants *i.e.* photosynthesis, translocation of photosynthates, protein synthesis, control of ionic balance, regulation of plant stomata and water use (Marschner, 1995), enzyme activation and osmoregulation(Mengel, 2007). Also, potassium enhances the ability of plants to resist stresses such as diseases, pests, cold, salinity and drought. These results are in agreement with those reported by many workers including Fataneh et al.(2012), Abd El-Dayem and Amal El-Borhamy(2015), Abd Eldaiem et al.(2015) and Bakry et al.(2015).

3. Effect of interaction:

The interaction between seeding rates and potassium fertilizer levels showed significant effect on technical length, straw yield/fed, number of capsules/plant, seed index, fiber length and fiber yield/fed in both seasons as well as seed yield/fed in the second season as presented in Tables 2, 3, 4, 5 and 6.

The interaction between seeding rates and potassium fertilizer levels showed significant effect on technical length, straw yield/fed, number of capsules/plant, seed index, fiber length and fiber yield/fed in both seasons as well as seed yield/fed in the second season as presented in Tables 2, 3, 4, 5 and 6.

length and fiber yield/fed in both seasons and seed yield/fed in the second season were obtained from sowing flax with the highest seeding rate(70 kg flax seed fed^{-1}) and fertilizing with 36 kg K_2O fed^{-1}. The second best interaction treatments between both studied factors was sowing flax with 60 kg flax seed fed^{-1} and fertilizing with 36 kg K_2O fed^{-1} concerning technical length, number of capsules/plant, seed index and fiber length or sowing flax with 70 kg flax seed fed^{-1} and fertilizing with 24 kg K_2O fed^{-1} concerning straw yield, seed yield and fiber yield/fed.

Table 2: Means of chlorophyll a, chlorophyll b and total chlorophyll (mg L^{-1}) in flax leaves as affected by seeding rates and potassium fertilizer levels as well as their interaction during 2014/2015 and 2015/2016 seasons.

Treatments (Characters / Seasons)	Chl. a (mg L^{-1})		Chl. b (mg L^{-1})		Total Chl. (mg L^{-1})	
	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
A- Seeding rates:						
S_1- 50 kg fed^{-1}	12.40a	11.42	5.36	3.98	17.76a	15.40a
S_2- 60 kg fed^{-1}	12.02b	11.09	5.28	3.73	17.29b	14.82b
S_3- 70kg fed^{-1}	11.68b	10.93	4.98	3.66	16.65c	14.59b
F. test	*	NS	NS	NS	*	*
B- Potassium levels:						
K_1- Control	10.73b	10.12d	4.80b	3.61	15.53c	13.74d
K_2- 12 kg K_2O fed^{-1}	11.34b	10.66c	5.06ab	3.75	16.81b	14.41c
K_3- 24 kg K_2O fed^{-1}	12.73a	11.61b	5.47a	3.79	18.22a	15.39b
K_4- 36 kg K_2O fed^{-1}	13.33a	12.19a	5.49a	4.01	18.39a	16.20a
F. test	*	*	*	NS	*	*
Interaction: A×B (F. test)	NS	NS	NS	NS	NS	NS

, and NS indicate P<0.05, P<0.01 and not significant, respectively. Means within the same column for each factor designated by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 3: Means of relative water content(RWC %), dry matter accumulation(g plant^{-1}) and proline content (mg g^{-1} fresh weight) in flax leaves as affected by seeding rates and potassium fertilizer levels as well as their interaction during 2014/2015 and 2015/2016 seasons.

Treatments / Characters	RWC (%)		Dry matter accumulation (g plant^{-1})		Proline content (mg g^{-1} fresh weight)	
Seasons	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
A- Seeding rates:						
S_1- 50 kg fed^{-1}	65.103	60.938	0.9871	0.6263	0.592	0.648
S_2- 60 kg fed^{-1}	66.959	60.707	1.0667	0.746	0.655	0.700
S_3- 70kg fed^{-1}	64.909	61.839	0.7582	0.5792	0.592	0.699
F. test	NS	NS	NS	NS	NS	NS
B- Potassium levels:						
K_1- Control	65.736	58.434b	0.817c	0.545d	0.561c	0.634b
K_2- 12 kg K_2O fed^{-1}	64.382	60.523b	0.882c	0.620c	0.598bc	0.674b
K_3- 24 kg K_2O fed^{-1}	65.234	61.011b	0.988b	0.670b	0.628ab	0.68ab
K_4- 36 kg K_2O fed^{-1}	67.277	64.677a	1.060a	0.764a	0.664a	0.731a
F. test	NS	*	*	*	*	*
Interaction: A×B (F. test)	NS	NS	NS	NS	NS	NS

* and NS indicate P<0.05 and not significant, respectively. Means within the same column for each factor designated by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 4: Means of technical length, stem diameter and straw yield/fed of flax as affected by seeding rates and potassium fertilizer levels as well as their interaction during 2014/2015 and 2015/2016 seasons.

Treatments / Characters	Technical length (cm)		Stem diameter (mm)		Straw yield (t/fed)	
Seasons	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
A- Seeding rates:						
S_1- 50 kg fed^{-1}	60.66b	56.61b	1.60a	1.51a	1.747b	1.547c
S_2- 60 kg fed^{-1}	62.57ab	60.88a	1.29b	1.35ab	1.820b	1.637b
S_3- 70kg fed^{-1}	64.16a	63.61a	1.20b	1.22b	2.319a	1.971a
F. test	*	*	*	*	*	*
B- Potassium levels:						
K_1- Control	57.07c	55.77c	1.26b	1.24c	1.799c	1.522d
K_2- 12 kg K_2O fed^{-1}	60.33bc	58.24bc	1.33ab	1.32bc	1.905b	1.635c
K_3- 24 kg K_2O fed^{-1}	63.79b	61.88ab	1.37ab	1.41ab	2.030a	1.796b
K_4- 36 kg K_2O fed^{-1}	68.67a	65.47a	1.47a	1.47a	2.114a	1.920a
F. test	*	*	*	*	*	*
Interaction: A×B (F. test)	*	*	NS	NS	*	*

* and NS indicate P<0.05 and not significant, respectively. Means within the same column for each factor designated by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 5: Means of number of capsules/plant, seed index and seed yield/fed of flax as affected by seeding rates and potassium fertilizer levels as well as their interaction during 2014/2015 and 2015/2016 seasons.

Treatments / Characters	Number of capsules/plant		Seed index		Seed yield (kg/fed)	
Seasons	2014/2015	2015/2016	2014/2015	2015/2016	2014/2015	2015/2016
A- Seeding rates:						
S_1- 50 kg fed^{-1}	5.72b	3.42b	3.87b	3.42b	274.88c	191.69b
S_2- 60 kg fed^{-1}	6.63a	5.03a	4.47a	3.87a	324.02b	199.83b
S_3- 70kg fed^{-1}	6.45a	4.85a	4.09b	3.31b	341.28a	236.52a
F. test	*	*	*	*	*	*
B- Potassium levels:						
K_1- Control	4.34c	2.94c	3.05c	2.88c	199.59c	177.97c
K_2- 12 kg K_2O fed^{-1}	4.95c	3.65c	3.48b	3.02c	317.37b	193.00c
K_3- 24 kg K_2O fed^{-1}	7.53a	5.02b	5.08a	3.59b	387.94a	214.22b
K_4- 36 kg K_2O fed^{-1}	7.62a	6.11a	4.97a	4.34a	384.67a	252.19a
F. test	*	*	*	*	*	*
Interaction: A×B (F. test)	*	*	*	*	NS	*

* and NS indicate P<0.05 and not significant, respectively. Means within the same column for each factor designated by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 6: Means of fiber length, fiber yield/plant and fiber yield/fed of flax as affected by seeding rates and potassium fertilizer levels as well as their interaction during 2014/2015 and 2015/2016 seasons.

Treatments (Characters / Seasons)	Fiber length (cm) 2014/2015	Fiber length (cm) 2015/2016	Fiber yield/plant (g) 2014/2015	Fiber yield/plant (g) 2015/2016	Fiber yield/fed (ton) 2014/2015	Fiber yield/fed (ton) 2015/2016
A- Seeding rates:						
S_1- 50 kg fed^{-1}	59.58b	54.01c	0.880b	0.625c	0.237b	0.209b
S_2- 60 kg fed^{-1}	61.66a	59.30b	0.888b	0.721b	0.257b	0.152b
S_3- 70kg fed^{-1}	63.15a	64.64a	1.200a	0.912a	0.314a	0.227a
F. test	*	*	*	*	*	*
B- Potassium levels:						
K_1- Control	56.20c	54.68b	0.867b	0.642c	0.243b	0.132b
K_2- 12 kg K_2O fed^{-1}	59.19c	59.30a	0.933b	0.725bc	0.276ab	0.139b
K_3- 24 kg K_2O fed^{-1}	62.80b	61.18a	0.975ab	0.805ab	0.278ab	0.142b
K_4- 36 kg K_2O fed^{-1}	67.16a	62.35a	1.075a	0.875a	0.285a	0.237a
F. test	*	*	*	*	*	*
Interaction: A×B (F. test)	*	*	NS	NS	*	*

* and NS indicate P<0.05 and not significant, respectively. Means within the same column for each factor designated by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test

Table 7: Means of technical length and straw yield/fed of flax as affected by the interaction between seeding rates and potassium fertilizer levels during 2014/2015 and 2015/2016 seasons..

Treatments	Characters / Seasons	Technical length (cm) 2014/2015	Technical length (cm) 2015/2016	Straw yield (t/fed) 2014/2015	Straw yield (t/fed) 2015/2016
S_1- 50 kg fed^{-1}	K_1- Control	57.10d	55.35c	1.661e	1.432f
	K_2- 12 kg K_2O fed^{-1}	62.22cd	58.20bc	1.703de	1.499ef
	K_3- 24 kg K_2O fed^{-1}	57.70d	54.47c	1.742de	1.564de
	K_4- 36 kg K_2O fed^{-1}	65.62abc	58.40bc	1.880cd	1.693c
S_2- 60 kg fed^{-1}	K_1- Control	58.22d	55.23c	1.754de	1.508ef
	K_2- 12 kg K_2O fed^{-1}	58.27d	56.45c	1.759de	1.574de
	K_3- 24 kg K_2O fed^{-1}	64.55bc	63.34bc	1.831cde	1.659cd
	K_4- 36 kg K_2O fed^{-1}	69.25ab	68.20a	1.937c	1.808b
S_3- 70kg fed^{-1}	K_1- Control	55.90d	56.72c	1.981c	1.626cd
	K_2- 12 kg K_2O fed^{-1}	60.47cd	60.07bc	2.253b	1.832b
	K_3- 24 kg K_2O fed^{-1}	69.13ab	67.85a	2.517a	2.125a
	K_4- 36 kg K_2O fed^{-1}	71.15a	69.80a	2.326a	2.260a
F. test		*	*	*	*

* and NS indicate P<0.05 and not significant, respectively. Means within the same column for each factor designated by the same letter are not significantly different at 5% level according to Duncan's Multiple Range

Table 8: Means of number of capsules/plant, seed index and seed yield/fed of flax as affected by the interaction between seeding rates and potassium fertilizer levels during 2014/2015 and 2015/2016 seasons

Treatments	Characters / Seasons	Number of capsules/plant 2014/2015	Number of capsules/plant 2015/2016	Seed index 2014/2015	Seed index 2015/2016	Seed yield (kg/fed) 2015/2016
S_1- 50 kg fed^{-1}	K_1- Control	4.37e	2.87c	3.20efg	2.95def	171.15f
	K_2- 12 kg K_2O fed^{-1}	4.92de	3.23c	3.60d	2.97def	186.15def
	K_3- 24 kg K_2O fed^{-1}	6.63c	3.80c	4.35c	3.75bc	195.96def
	K_4- 36 kg K_2O fed^{-1}	6.97e	3.77c	4.35c	4.00ab	213.53cd
S_2- 60 kg fed^{-1}	K_1- Control	4.22e	3.02c	3.07fg	3.17cdef	175.51ef
	K_2- 12 kg K_2O fed^{-1}	5.60d	3.85c	3.52de	3.80bc	184.63def
	K_3- 24 kg K_2O fed^{-1}	8.25a	5.87ab	4.97b	3.67bcd	197.55def
	K_4- 36 kg K_2O fed^{-1}	8.45a	7.20a	5.60a	4.50a	241.64bc
S_3- 70kg fed^{-1}	K_1- Control	4.65e	2.93c	2.87g	2.53f	187.26def
	K_2- 12 kg K_2O fed^{-1}	5.77d	3.87c	3.33g	2.83ef	208.22de
	K_3- 24 kg K_2O fed^{-1}	7.60ab	5.40b	5.20b	3.35dcde	249.15b
	K_4- 36 kg K_2O fed^{-1}	7.85a	7.37a	5.70a	4.53a	301.43a
F. test		*	*	*	*	*

* and NS indicate P<0.05 and not significant, respectively. Means within the same column for each factor designated by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test

Table 9: Means of fiber length and fiber yield/fed of flax as affected by the interaction between seeding rates and potassium fertilizer levels during 2014/2015 and 2015/2016 seasons

Treatments	Characters / Seasons	Fiber length (cm)		Fiber yield/fed. (ton)	
		2014/2015	2015/2016	2014/2015	2015/2016
S_1- 50 kg fed^{-1}	K_1- Control	56.07d	54.02d	0.224c	0.074c
	K_2- 12 kg K_2O fed^{-1}	56.05d	56.42cd	0.234c	0.106bc
	K_3- 24 kg K_2O fed^{-1}	61.07bcd	52.85d	0.236bc	0.144bc
	K_4- 36 kg K_2O fed^{-1}	64.63ab	52.91d	0.253bc	0.187bc
S_2- 60 kg fed^{-1}	K_1- Control	57.45cd	54.24d	0.236bc	0.126bc
	K_2- 12 kg K_2O fed^{-1}	57.15d	54.92d	0.288abc	0.138bc
	K_3- 24 kg K_2O fed^{-1}	63.60bc	61.52bc	0.246bc	0.158bc
	K_4- 36 kg K_2O fed^{-1}	67.66a	67.27ab	0.259bc	0.160bc
S_3- 70kg fed^{-1}	K_1- Control	57.64cd	55.80cd	0.267bc	0.133bc
	K_2- 12 kg K_2O fed^{-1}	58.07bcd	66.55ab	0.306ab	0.159bc
	K_3- 24 kg K_2O fed^{-1}	59.39bcd	67.17ab	0.339a	0.206b
	K_4- 36 kg K_2O fed^{-1}	68.25a	68.31a	0.442a	0.311a
F. test		*	*	*	*

* and NS indicate P<0.05 and not significant, respectively. Means within the same column for each factor designated by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

CONCLUSION

It could be concluded that sowing flax with the highest seeding rate(70 kg flax seed fed^{-1}) and fertilizing with 36 kg K_2O fed^{-1} is the best practice in order to maximize growth, yields and its components of flax under saline soil conditions in Kafr El-Shiekh Governorate, Egypt.

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الملخص العربى

تأثير معدلات التقاوى ومستويات السماد البوتاسى على نمو ومحصول الكتان ومكوناته تحت ظروف الأراضى الملحية

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أجريت تجربتان حقليتان بمحطة البساتين للبحوث الزراعية بسخا(مزرعة الحمراوى)، محافظة كفر الشيخ، مصر، خلال موسمى ٢٠١٥/٢٠١٤ و٢٠١٦/٢٠١٥ لدراسة تأثير معدلات التقاوى(٥٠، ٦٠ و ٧٠ كجم من تقاوى الكتان للفدان) ومستويات السماد البوتاسي(٠، ١٢، ٢٤ و٣٦ كجم K_2O للفدان) على النمو، والمحصول ومكوناته للكتان صنف سخا ٣ تحت ظروف الأراضى الملحية. أجريت التجارب في تصميم القطع المنشقة مرة واحدة في أربعة مكررات. حيث تم تخصيص القطع الرئيسية لمعدلات التقاوى، بينما تم تخصيص القطع الشقية لمستويات السماد البوتاسي.

أظهرت النتائج المتحصل عليها أن زراعة الكتان بمعدل تقاوى ٥٠ كجم للفدان سجلت أعلى القيم لصفات كلوروفيل أ في الموسم الأول، الكلوروفيل الكلي وقطر الساق في كلا الموسمين. في حين، أدت زراعة الكتان بمعدل تقاوى ٧٠ كجم للفدان للحصول على أعلى القيم لصفات الطول الفعال، محصول القش للفدان، عدد الكبسولات للنبات، محصول البذور للفدان، طول الألياف ومحصول الألياف للنبات ومحصول الألياف للفدان في كلا الموسمين. بينما أدت زراعة الكتان بمعدل تقاوى ٦٠ كجم للفدان للحصول على أعلى القيم لدليل البذور في كلا الموسمين.

أدت زيادة مستويات السماد البوتاسي من صفر إلى ١٢، ٢٤ و٣٦ كجم K_2O للفدان إلى زيادة معنوية في صفات النمو والكلوروفيل ومحصول القش والبذور والألياف ومكوناتهم في كلا الموسمين.

توصى نتائج هذه الدراسة بزراعة الكتان بمعدل تقاوى ٧٠ كجم للفدان مع التسميد البوتاسى بـ ٣٦ كجم K_2O للفدان للحصول على أقصى قدر من النمو، والمحصول ومكوناته تحت ظروف الأراضى الملحية بمحافظة كفر الشيخ، مصر.