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EFFECT OF POTASSIUM FERTILIZER ON YIELD AND ITS COMPONENTS OF FLAX (*LINUM USITATISSIMUM* L.)

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SUMMARY

A field experiment commenced during the winter of 2020–2021 at the Al-Hamdhyia Research Station, College of Agriculture, University of Anbar, Anbar, Iraq. The research evaluated the growth, yield, and quality traits of four flax (*Linum usitatissimum* L.) cultivars (Sakha-1, Sakha-4, Sakha-6, and Local) under the influence of three levels of potassium fertilizer (0, 25, and 50 kg ha^{-1}). The experiment, in a randomized complete block design (RCBD), had a factorial arrangement and three replications. The results showed the flax cultivar Sakha-1 was significantly superior in the fruiting branches per plant, capsules per plant, seeds per capsule, seed yield (1.297 t ha^{-1}), and seed oil percentage. However, cultivar Sakha-4 excelled in plant height, straw yield, fiber length, and fiber yield (1.869 t ha^{-1}). Moreover, the increased level of potassium fertilizer (50 kg ha^{-1}) led to a significant increase in its plant height, fruiting branches per plant, seeds per capsule (8.01 seed $capsule^{-1}$), and oil percentage. Meanwhile, the potassium fertilizer increase at 25 kg ha^{-1} was substantially superior in the capsules per plant and seed yield (1.261 t ha^{-1}) for the Sakha-4 cultivar.

Keywords: Flax (*L. usitatissimum* L.), potassium levels, growth and morphological traits, seed yield, seed oil percentage, fiber yield

Key findings: The flax (*L. usitatissimum* L.) cultivars significantly differed for morphological traits. Flax genotypes showed varied values for various agronomic and quality traits with different levels of potassium. For improving the flax seed oil and lint, cultivars Sakha-1 and Sakha-4 could benefit as a breeding source for further improvement.

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INTRODUCTION

Flax (*Linum usitatissimum* L.), also known as linseed, is a flowering plant that belongs to the family Linaceae. It is a cultivated crop for food and fiber in various regions of temperate climates. Textiles made from flax in English are linens, traditionally used for bedsheets, underclothes, and table linen. The said plant species has reached domestication just once from the wild species *Linum bienne,* called pale flax (Allaby *et al*., 2005).

Flax is a dual-purpose industrial crop, grown to obtain oil and fiber. In the flax seeds, the oil percentage ranges from 35% to 47%, while it also contains protein (20%–25%) (Rabetafika *et al*., 2011). Its seeds are widely functional for oil extraction as it contains unsaturated fatty acids, including linoleic acid (belonging to the omega-3 group), linolenic acid (belonging to the omega-6 group), and oleic acid (belonging to the omega-9 group) (Berti *et al*., 2009).

Additionally, its oil is beneficial in the treatment of stroke, cardiovascular disease, atherosclerosis, and kidney inflammation (Clark *et al*., 2001). For fiber production, growing flax genotypes help obtain fibers from stems, used in extensive areas of industry, including linen textiles' manufacture, distinct for high durability after mixing them with cotton, wool, and silk. In Iraq, the flax cultivated area was about 336 hectares, with an average productivity of 0.452 t ha^{-1} (FAO, 2020).

Several factors determine flax performance, viz., genotypes (Alukedi *et al*., 2021) and fertilizer inputs like potash (Abood and Salh, 2018). Despite the importance of this crop in the industry, its cultivation in Iraq faces various problems, limiting its cultivation expansion. These issues include the lack of cultivars with high productivity and limited specialized factories for oil extraction from seeds and fiber from its stems. Therefore, the policymakers must focus to solve those constraints in the cultivation of flax crop in Iraq.

Potassium is one of the main nutrients necessary for plant growth and productivity, as potassium activates more than 60 enzymes catalyzing several important biochemical and physiological processes in plants. Likewise, it acts as an osmotic regulator, needed by plants to produce the energy molecule (ATP), crucial for plant metabolism and photosynthesis, which is vital in transmitting sugars from sources to sinks (Ho *et al*., 2020). Therefore, the presented study pursued evaluating the growth, seed yield, and oil quality traits of some flax cultivars under the influence of diverse potassium levels.

MATERIALS AND METHODS

A field experiment evaluated the growth, yield, and quality traits of four flax (*Linum usitatissimum* L.) cultivars (Sakha-1, Sakha-4, Sakha-6, and Local) under the influence of three levels of potassium fertilizer (0, 25, and 50 kg ha^{-1}). The research ensued during the winter of 2020–2021 at the Al-Hamdhyia Research Station, College of Agriculture, University of Anbar, Anbar, Iraq. The experiment comprised a randomized complete block design (RCBD) with factorial arrangements and three replications.

The collection of random soil samples from the experimental field before flax planting sought to study the soil chemical and physical properties (Table 1). Before sowing, the soil preparation and management proceeded as required. The experiment soil division consisted of 36 experimental units; the area of each experimental unit was 5 m^2 (2 m × 2.5 m), containing 6 rows, 30 cm apart. Phosphorous fertilizer added was a triple superphosphate (45% P_2O_5) at an average of 50 kg P ha^{-1}, as a single dose at planting. Potassium fertilizer addition was according to the three different treatments (0, 25, and 50 kg ha^{-1}) as a potassium sulfate (48% K_2O) one dose at planting. The nitrogen fertilizer supplied was urea (46% N) at an average of 80 kg N ha^{-1} with two doses, at planting and after 30 days (Al-Rawi and Noman, 2020). The sowing of flax seeds occurred on November 20, 2020. The harvest at maturity was at 11, 15, 22, and 26 June 2022 for Sakha-6, Sakha-4, Sakha-1, and Local, respectively.

Table 1. Physical and chemical properties of soil.

Character		Unit	Value
pH		-----	7.81
EC		dc m^{-1}	3.61
Bulk density		g cm^{-3}	1.62
Ca^{+2}		Meq L^{-1}	18.00
Mg^{+2}			8.20
Na^{+}			11.31
CO_3^{-2}			0.00
$HCO3^{-2}$			0.91
Cl^{-}			31.50
SO_4^{-2}			2.51
Available N		mg kg^{-1} soil	105
Available P			8.25
Available K			220.00
Soil separates	Clay	mg kg^{-1} soil	300
	Silt		160
	Sand		540
Soil texture			Sandy clay

Traits measurement

In each experimental unit and replication, at the harvest stage, the random selection of 10 flax plants ensued. The recorded data were on the following traits. Measuring the plant height (cm) of the main stem began from the soil surface to the top of the plant. The number of fruiting branches and capsules per plant incurred counting and averaging. Calculating the number of seeds per capsule proceeded by dividing the number of seeds per 10 capsules by 10 capsules. For 1000-seed weight, randomly taking seeds from the harvested plants for each experimental unit received weighing with an electric balance. The straw yield (t ha^{-1}) calculation used a sample size of one m^2. The seed yield (t ha^{-1}) computation for a sample size of one m^2 of each harvested experimental unit, with the seeds isolated from the straw, weighed, and converted from g m^{-2} to t ha^{-1}.

$$\text{Oil percentage (\%)} = \frac{\text{Oil extracted weight from the seeds sample}}{\text{Sample weight}} \times 100$$

Statistical analysis

The data analysis used the Genstat program, with the least significant difference ($LSD_{0.05}$) test also used to compare and separate the treatment means (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Plant height

The results revealed the flax cultivar Sakha-4 was significantly superior in the plant height and showed 99.41 cm, with a nonsignificant difference from Sakha-6 and Local cultivars (98.28 and 96.06 cm, respectively), compared with Sakha-1, scoring the lowest value (93.58 cm) (Table 2). The differences in the flax cultivars for the plant height might be due to their variation of genetic bases and the extent of their response to the prevailing environmental conditions. These results were consistent with Abdel-Kader and Mousa (2019), Emam (2020), Abdulhamed *et al*. (2021), and Sahito *et al*. (2022), who reported the flax cultivars considerably differed for plant height.

Regarding potassium fertilizer levels, the results further indicated the notable enhancement of plant height with an increasing level of potassium fertilizers. The potassium fertilizer at the rate of 50 kg ha^{-1} achieved the tallest plant height (100.31 cm), with a nonsignificant difference from the potassium fertilizer at 25 kg ha^{-1} (99.65 cm), but significantly differing from the control treatment (90.71 cm). The reason for the superiority of the high level of potassium could refer to the role of antioxidant enzymes, such as POD, CAT, and SOD (AL-Behadili and Abed,

Table 2. Effect of potassium fertilizer levels on the plant height of flax cultivars.

Potassium levels ($kg\ ha^{-1}$)	Flax cultivars				Means (cm)
	Sakha-1	Sakha-4	Sakha-6	Local	
0	90.02	93.98	90.81	88.06	90.71
25	94.50	98.23	104.90	101.01	99.65
50	96.06	106.03	100.04	99.13	100.31
$LSD_{0.05}$	4.88				2.44
Means (cm)	93.58	99.41	98.28	96.06	
$LSD_{0.05}$	3.84				

Table 3. Effect of potassium fertilizer levels on fruiting branches per plant of flax cultivars.

Potassium levels ($kg\ ha^{-1}$)	Flax cultivars				Means (#)
	Sakha-1	Sakha-4	Sakha-6	Local	
0	12.12	10.69	10.21	9.21	10.55
25	15.73	13.98	12.81	11.80	13.55
50	15.86	14.97	12.15	11.64	13.64
$LSD_{0.05}$	3.92				1.96
Means (#)	14.57	13.18	11.71	10.88	
$LSD_{0.05}$	2.35				

2019; Alfalahi *et al*., 2022). They are responsible in enhancing resistance and photosynthesis apparatus (Sadanandan *et al.*,2002; Shaaban and Abou El-Nour, 2012) involved in the plant's phenotype and genotype (Jessup *et al*., 2020), and increasing cell division (Manian *et al*., 2021) and cell elongation or extension via gibberellin stimulation by potassium (Kanapin *et al*., 2022). In addition, it also regulates the growth and meristematic tissues (IPI, 2000, Zhang *et al*., 2020). These results were analogous to the findings of El-Borhamy and Khedr (2016), as they reported that adding potassium fertilizer led to a significant increase in the flax's plant height. The interaction between cultivars and potassium fertilizer levels also substantially affected plant height (Table 2). The flax cultivar Sakha-4 under potassium fertilizer 50 $kg\ ha^{-1}$ recorded 106.03 cm, while the Local cultivar under zero potassium fertilizer recorded 88.06 cm.

Fruiting branches per plant

The results from Table 3 details the number of fruiting branches per plant, and cultivar Sakha-1 gave the topmost value (14.57) and Sakha-4 (13.18), compared with the Local cultivar (10.88) and Sakha-6 (11.71). The explanation of divergent in the number of branches is because of genetic variation of the VG in the genome of flax cultivars, making the varieties diverse in responding to the fertilizers (Shuvar *et al*., 2021). Emam (2019), Omer (2020), and Drej and Noaman (2021) further reported significant difference among the flax cultivars for number of fruiting branches per plant.

According to the research, utilizing potassium fertilizer (50 $kg\ ha^{-1}$) revealed considerable superiority and showed the ultimate mean for fruiting branches per plant (13.64). However, it had nonsignificant difference with potassium fertilizer at 25 $kg\ ha^{-1}$ (13.55), compared with the control treatment, recording the lowest value (10.55). The reason for an increase in fruiting branches per plant may be due to the role of potassium in enhancing the plant's ability to maximum benefits from other nutrients, especially nitrogen and growth regulations to fruiting branches per plant. The interaction between the two studied factors markedly influenced this trait (Table 3). The Sakha-1 under potassium at 50 $kg\ ha^{-1}$ gave the highest value (15.86 branches), while the Local flax cultivar without potassium gave the lowest value (9.21 branches). Bakry *et al*. (2015) found the same result of potassium fertilizer effect in the number of fruiting branches in all flax genotypes under their study.

Capsules per plant

The findings showed significant differences in the number of capsules per plant. The Sakha-1 gave a supreme value for capsules per plant about 38.42 and 23.70% superiority, compared with the local cultivar, which gave 31.04 capsules per plant (Table 4). The results agree with Dawood *et al*. (2019), Mohammed *et al*. (2020), and Katore *et al*. (2021), as they mentioned flax cultivars differed significantly for the number of capsules per plant.

The supplied potassium fertilizer (25 kg ha^{-1}) showed the maximum value of capsules per plant (36.71), compared with the control treatment (30.64). The interaction between the flax cultivars and potassium levels remarkably affected capsules per plant. Cultivar Sakha-1 under potassium fertilizer 50 kg ha^{-1} had the utmost capsules per plant (41.89), and the cultivar Sakha-4 under control showed the lowest value (26.25 capsules $plant^{-1}$). These results agreed with the findings of El-Borhamy and Khedr (2016).

Seeds per capsule

The Sakha-1 gave significant superiority and the highest value of seeds per capsule (8.31), but were nonsignificant with two cultivars Sakha-4 and Sakha-6, which gave 7.69 and 7.41, respectively, compared with the Local cultivar with the lowest value (6.81 seeds $capsule^{-1}$) (Table 5). The reason for the seeds per capsule differences among flax cultivars is on their genetic variation and response to environmental conditions. These results align with findings of El-Gedwy *et al*. (2020), Mohammed *et al*. (2020), and Karpov *et al*. (2021).

The potassium fertilizer at 50 kg ha^{-1} led to attain the highest number of seeds per capsule (8.01 seeds $capsule^{-1}$); however, it has a nonsignificant difference with the second level of potassium fertilizer (25 kg ha^{-1}) (7.96 seeds $capsule^{-1}$) versus the control treatment (6.69 seeds $capsule^{-1}$) (Table 5). The reason for an increase may be due to the role of potassium in raising the efficiency of photosynthesis and then increasing the production of ATP, as positively reflected in the metabolic products from the sources to the reproductive organs (Abu-Dhahi and Al-Younis,

Table 4. Effect of potassium fertilizer levels on capsules per plant of flax cultivars.

Potassium levels (kg ha^{-1})	Flax cultivars				Means (#)
	Sakha-1	Sakha-4	Sakha-6	Local	
0	33.16	30.31	30.81	28.81	30.64
25	40.22	38.51	37.01	31.11	36.71
50	41.89	26.25	34.31	33.21	36.41
$LSD_{0.05}$	4.06				2.03
Means (#)	8.42	35.02	34.04	31.04	
$LSD_{0.05}$	2.35				

Table 5. Effect of potassium fertilizer levels on seeds per capsule of flax cultivars.

Potassium levels (kg ha^{-1})	Flax cultivars				Mean (#)
	Sakha-1	Sakha-4	Sakha-6	Local	
0	7.43	7.05	6.18	6.12	6.69
25	8.82	7.95	7.96	7.13	7.96
50	8.70	8.07	8.10	7.20	8.01
$LSD_{0.05}$	1.94				0.97
Means (#)	8.31	7.69	7.41	6.81	
$LSD_{0.05}$	1.12				

1988). The interaction between flax cultivars and potassium fertilizer levels had a significant effect on seeds per capsule (Table 5). Cultivar Sakha-1 fertilized at the rate of 25 kg ha^{-1} of potassium had the maximum value (8.82 seeds $capsule^{-1}$), while the local cultivar under the control of fertilizer gave the lowest value (6.12 seeds $capsule^{-1}$). These results were consistent with the findings of Abd-Eldaim and El-Borhamy (2015).

1000-seed weight

The results indicated noteworthy variations among the flax cultivars for 1000-seed weight (Table 6). The local flax cultivar achieved the highest value (7.31 g) and a nonsignificant difference with Sakha-6 (6.81 g), as compared to the cultivars Sakha-1 (6.31 g) and Sakha-4 (6.33 g). The basis of a decrease in the seed size and 1000-seed weight of cultivar Sakha-1 may be due to their superiority in more capsules per plant and seeds per capsule (Tables 4 and 5). Past studies also enunciated significant differences among the flax cultivars for 1000-seed weight (Abdel-Kader and Mousa, 2019; Kushwaha *et al*., 2019; Sahito *et al*., 2022).

Regarding potassium fertilizer levels, the control treatment was significantly superior and provided the highest mean for 1000-seed weight (7.46 g) versus the treatments with potassium fertilizer (50 and 25 kg ha^{-1}), which gave the lowest value (6.22 and 6.49 g, respectively) (Table 6). The cause of seed weight increase in the control treatment may refer to a decrease in the number of capsules per plant and number of seeds per capsule (Tables 4 and 5). Eventually, it caused the seeds to obtain the largest number of metabolic products, increasing their size and weight. The interaction between studied factors had a significant effect on this trait. The flax local cultivar non-fertilized with potassium had the maximum 1000-seed weight (8.01 g), whereas the cultivar Sakha-4 fertilized with 50 kg ha^{-1} of potassium emerged with the minimum mean (5.93 g). These results were also consistent with the findings of El-Borhamy and Khedr (2016), who reported similar mean values for flax cultivars and potassium levels.

Table 6. Effect of potassium fertilizer levels on the 1000-seed weight of flax cultivars.

Potassium levels (kg ha^{-1})	Flax cultivars				Means (g)
	Sakha-1	Sakha-4	Sakha-6	Local	
0	6.71	7.01	7.92	8.01	7.46
25	6.11	6.06	6.21	7.59	6.49
50	6.13	5.93	6.32	6.23	6.22
$LSD_{0.05}$	1.41				0.71
Means (g)	6.31	6.33	6.81	7.31	
$LSD_{0.05}$	0.81				

Table 7. Effect of potassium fertilizer levels on the straw yield of flax cultivars.

Potassium levels (kg ha^{-1})	Flax cultivars				Means (t ha^{-1})
	Sakha-1	Sakha-4	Sakha-6	Local	
0	8.082	8.446	8.107	7.902	8.134
25	8.511	8.947	9.639	9.234	9.083
50	8.645	9.771	9.170	9.056	9.160
$LSD_{0.05}$	0.372				0.162
Means (t ha^{-1})	8.412	9.055	8.972	8.730	
$LSD_{0.05}$	0.231				

Straw yield

Among the flax cultivars, the Sakha-4 was notably superior in getting more straw yield (9.055 t ha^{-1}). However, it did not differ significantly with the cultivar Sakha-6 (8.972 t ha^{-1}), as compared to cultivar Sakha-1 with the lowest value for the said trait (8.412 t ha^{-1}) (Table 7). The straw increase in Sakha-4 could be because of the adaptation to environmental conditions and their superiority in other growth traits (Table 2). Abdel-Kader and Mousa (2019) and Leilah *et al*. (2019) also reported that the flax cultivars markedly varied in straw yield.

The adding of potassium fertilizer 50 kg ha^{-1} was considerably superior in the straw yield and recorded with the topmost mean (9.160 t ha^{-1}), with a nonsignificant difference with potassium fertilizer addition of 25 kg ha^{-1} (9.083 t ha^{-1}), as compared with the control treatment. It recorded with the lowest mean for the said trait (8.134 t ha^{-1}) (Table 7). The reason for an enhancement in the straw yield by adding the potassium fertilizer could be due to the dominance in the plant height and number of fruiting branches (Tables 3 and 4). The interaction between flax cultivars and potassium fertilizer levels also significantly affected straw yield (Table 7). The flax cultivar Sakha-4 fertilized with 50 kg ha^{-1} of potassium had the ultimate value for straw yield (9.771 t ha^{-1}), with the non-fertilized local cultivar giving the lowest straw yield (7.902 t ha^{-1}). These results agree with the observations of El-Borhamy and Khedr (2016), who noticed meaningful effects of potassium fertilizer on flax genotypes' straw yield.

Seed yield

The flax cultivar Sakha-1 surpassed all other cultivars in seed yield and achieved the highest mean (1.297 t ha^{-1}). Nonetheless, it showed no significant difference with two other cultivars Sakha-4 and Sakha-6 (1.208 and 1.197 t ha^{-1}, respectively), compared to the local flax cultivar achieving the lowest seed yield (1.102 t ha^{-1}) (Table 8). The explanation for a rise in the seed yield of cultivar Sakha-1 could be its superiority in the fruiting branches per plant, capsules per plant, and seeds per capsule (Tables 3, 4, and 5). These results closely agreed with the findings of Ajaj *et al*. (2020), Mohammed *et al*. (2020), Drej and Noaman (2021), and Katore *et al*. (2021), whose findings indicated the flax cultivars markedly varied in the seed yield.

Regarding potassium fertilizer, the results further revealed that addition of potassium fertilizer 25 kg ha^{-1} was supreme in seed yield, recording the ultimate mean (1.261 t ha^{-1}), but had a nonsignificant difference with the potassium dose 50 kg ha^{-1}. It recorded with 1.258 t ha^{-1} compared to the control treatment, recording the lowest mean seed yield (1.081 t ha^{-1}) (Table 8). This is due to the seed yield with potassium fertilizer 25 kg ha^{-1} providing superiority in the capsules per plant (Table 4). The interaction between both factors also had a notable effect on the seed yield (Table 8). Flax cultivar Sakha-1 fertilized with 50 kg ha^{-1} of potassium had the maximum seed yield (1.380 t ha^{-1}), as compared to the control treatment with the local flax cultivar, which had the minimum mean seed yield (0.997 t ha^{-1}). These results aligned with the

Table 8. Effect of potassium fertilizer levels on the seed yield of flax cultivars.

Potassium levels (kg ha^{-1})	Flax cultivars				Means (t ha^{-1})
	Sakha-1	Sakha-4	Sakha-6	Local	
0	1.163	1.063	1.101	0.997	1.081
25	1.350	1.299	1.272	1.125	1.261
50	1.380	1.262	1.219	1.185	1.258
$LSD_{0.05}$	0.290				0.140
Means (t ha^{-1})	1.297	1.208	1.197	1.102	
$LSD_{0.05}$	0.170				

Table 9. Effect of potassium fertilizer levels on the oil percentage of flax cultivars.

Potassium levels	Flax cultivars				Means (%)
(kg ha^{-1})	Sakha-1	Sakha-4	Sakha-6	Local	
0	31.01	30.61	30.82	27.94	30.09
25	31.45	31.12	31.21	28.34	30.53
50	32.18	30.22	32.04	29.72	31.04
$LSD_{0.05}$	1.17				0.54
Means (%)	31.81	30.65	31.35	28.66	
$LSD_{0.05}$	0.68				

findings of Bakry *et al*. (2015) and El-Borhamy and Khedr (2016), which mentioned the noteworthy effect of potassium fertilizer on the seed yield of flax.

Seed oil percentage

For seed oil percentage, flax cultivar Sakha-1 showed the highest oil percentage (31.81%); however, the said genotype has a nonsignificant difference with cultivar Sakha-6 (31.35%), as compared to the local cultivar, recording the lowest mean (28.66%) (Table 9). The difference of flax cultivars in the seed oil may be due to their difference in the genetic makeup in the biosynthesis of fatty acids, which is the basic unit for the biosynthesis of oil. El-Gedwy *et al*. (2020) also reported a significant difference among the flax cultivars in the seed oil content.

The potassium fertilizer (50 kg ha^{-1}) was substantially superior in the seed oil and gave the topmost percentage (31.04%). Although, it was not significantly different with potassium fertilizer 25 kg ha^{-1} and provided 30.53% versus the control treatment, giving the lowest percentage (30.09%). The increased content of oil is attributable to the of K-photosynthesis activity and increasing of metabolic products and their transmission from the sources to the sinks, positively reflecting the rise in fatty acids' biosynthesis, elevating oil content. The interaction between the flax cultivars and potassium fertilizer levels also revealed significant effects in the oil content. The Cultivar Sakha-1 and potassium level 50 kg ha^{-1} had the highest value (32.18%), while the local flax cultivar with no potassium level had the lowest mean for oil content (27.94%) (Sahito *et al*., 2022).

Fiber length

For the fiber length, cultivar Sakha-4 showed notable superiority and gave the topmost mean for the said trait (86.42 cm), compared with the cultivar Sakha-1, revealing the lowest fiber length (80.29 cm) (Table 10). The reason for an increase in the fiber length of cultivar Sakha-4 is due to its superiority in the plant height (Table 2). These results agreed with the findings of Abdel-Kader and Mousa (2019).

On potassium fertilizer levels, the fiber length markedly rose with an increased level of potassium fertilizer. The addition of potassium 50 kg ha^{-1} achieved the highest average (87.42 cm), compared with the control treatment, achieving the lowest fiber length (77.63 cm) (Table 10). The increase may be due to the superiority of the same level of potassium fertilizer in plant height (Table 2). The interaction between the flax cultivars and potassium fertilizer levels also notably affected the fiber length. Cultivar Sakha-4 fertilized at the rate of 50 kg ha^{-1} of potassium achieved the supreme mean value (93.25 cm), whereas the local cultivar with control treatment achieved the lowest fiber length (75.42 cm). These results aligned with the findings of El-Borhamy and Khedr (2016).

Fiber yield

For the fiber yield, the flax cultivar Sakha-4 significantly exceeded other cultivars in the fiber yield by showing the maximum mean (1.869 t ha^{-1}) (Table 11). However, the said genotype differed nonsignificantly from the Sakha-6 and local cultivars (1.852 and 1.802 t ha^{-1}, respectively), compared with cultivar Sakha-1, indicating the minimum fiber yield

Table 10. Effect of potassium fertilizer levels on the fiber length of flax cultivars.

Potassium levels (kg ha^{-1})	Flax cultivars				Mean (cm)
	Sakha-1	Sakha-4	Sakha-6	Local	
0	77.13	80.61	77.37	75.42	77.63
25	81.23	85.41	91.99	88.13	86.69
50	82.51	93.25	87.52	86.43	87.42
$LSD_{0.05}$	1.29				0.59
Means (cm)	80.29	86.42	85.62	83.32	
$LSD_{0.05}$	0.74				

Table 11. Effect of potassium fertilizer levels on the fiber yield of flax cultivars.

Potassium levels (kg ha^{-1})	Flax cultivars				Means (t ha^{-1})
	Sakha-1	Sakha-4	Sakha-6	Local	
0	1.668	1.743	1.673	1.631	1.678
25	1.757	1.847	1.990	1.906	1.875
50	1.785	2.017	1.893	1.869	1.891
$LSD_{0.05}$	0.210				0.101
Means (t ha^{-1})	1.736	1.869	1.852	1.802	
$LSD_{0.05}$	0.113				

(1.736 t ha^{-1}). The reason for an escalation in the fiber yield of cultivar Sakha-4 is its superiority in the plant height, straw yield, and fiber length, which eventually enhanced the fiber yield (Tables 2, 7, and 10). These results were in line with the findings of Leilah *et al*. (2019), Amangaliev *et al.* (2023), Bakry *et al.* (2024), and El-Bassiouny *et al*. (2024**)** who also reported the flax cultivars varied substantially in fiber yield.

On potassium fertilizer levels, the fiber yield notably declined with an increased level of potassium fertilizer (50 kg ha^{-1}), which showed the highest mean value for the fiber yield (1.891 t ha^{-1}) (Table 11). However, the said treatment has no meaningful difference with the second dose of potassium fertilizer (25 kg ha^{-1}), which showed 1.875 t ha^{-1}, compared to the control treatment. It recorded with the lowest fiber yield (1.678 t ha^{-1}). The reason for the rise is the superiority of the same level of potassium fertilizer in plant height, straw yield, and fiber length (Tables 2, 7, and 10). The interaction between flax cultivars and potassium levels also remarkably influenced the fiber yield. Flax cultivar Sakha-4 fertilized with 50 kg ha^{-1} of potassium achieved the utmost value for the said trait (2.017 t ha^{-1}), while the local cultivar with control treatment achieved the lowest fiber yield (1.631 t ha^{-1}).

CONCLUSIONS

The presented study revealed the four flax cultivars differed for growth and yield-related traits, seed oil content, and stem fiber production. The potassium levels also notably affected all the traits of the flax cultivars. For seed oil and fiber production, flax cultivars Sakha-1 and Sakha-4 require further exploring as a promising breeding material to improve these two qualitative traits.

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