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Yield and Quality of sugar beet as affected by potassium and salicylic acid fertilization levels in saline soil

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IN THE AL-HAMUL district of Kafr El-Sheikh Governorate, Egypt, two field experiments were conducted in the 2020/2021 and 2021/2022 seasons, to study the impact of combining K-fertilizer and salicylic acid spraying on sugar beet growth, yield and quality in saline soil. The present work included sixteen treatments, which were combinations of four K-fertilizer treatments: (24 kg K_2SO_4/fed; 48 kg K_2SO_4/fed; 24 kg K_2SO_4/fed + two sprays potassein and 48 kg K_2SO_4/fed + two sprays potassein) and four foliar doses of salicylic acid: (zero, 100, 150 and 200 ppm/fed). A strip plot design was utilized with three replicates. The results showed that sugar beet fertilization with 48 kg K_2SO_4/fed + two sprays of potassein produced the highest values of root diameter, fresh and foliage fresh weights/plant, root, top, and sugar yields/fed, potassium content, sucrose and extracted sugar percentages while significantly reducing proline and sodium contents in comparison to other potassium treatments in both seasons. Spraying beets with 200 ppm salicylic acid produced higher values of root diameter, fresh and foliage weights/plant, sucrose, extracted sugar percentages and quality index as well as higher yields of root, top and sugar/fed. However, sodium, alpha amino-N contents and sugar lost to molasses % were insignificantly affected in both seasons. The combination of adding beet plants with 48 kg K_2SO_4/fed + two sprays of potassien along with spraying 200 ppm salicylic acid/fed recorded the highest values of root diameter, proline content, root and top yields/fed in both seasons.

Keywords: Potassium treatments, Saline soil, Spraying salicylic acid, Sugar beet.

1. Introduction

Sugar beet is one source of sugar production in Egypt and can adapt to different climatic and soil conditions (Amer et al. 2019). Despite its salt tolerance, sugar beet is sensitive to salinity during germination, which can significantly reduce water availability, decrease stored reserves, affect protein structure, and cause ionic imbalance and osmotic stress (Sadeghi et al. 2015; Gahzy et al. 2020; Gahzy et al. 2022). Studies have shown that fertilization with potassium (Nada et al. 2022), and salicylic acid can help plants tolerate salt stress or mitigate its effects. In this context, Moustafa and El–Masry (2006) indicated that increasing potassium levels to 48 kg K_2O/fed led to higher yields of root and sugar/fed, sucrose%, impurities contents and improved quality index while, Celik et al. (2010) found that the higher sugar beet potassium content was associated with the higher rate of potassium fertilization, which could have some effect of extracted sugar from sugar beet pulp with increased sugar loss to molasses%. They added that increasing potassium fertilization rates led to increases in beet yield and quality. Also, Enan, (2011) noted that sufficient potassium levels could enhance salt resistance and that applying 24 kg K_2O/fed+ two foliar doses of potassien gave the

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higher values of the root, foliage fresh weights/plant, purity and sucrose percentages, root and sugar yields/fed in saline soil conditions. Similarly, Mehran and Samad (2013) observed that increasing potassium rates gave the highest root and foliage fresh weights/plant and sugar yield/fed. While Enan, (2016) showed that applying 75 kg K_2SO_4/fed significantly decreased root impurities contents, reducing sugar loss to molasses (%), while improving the quality index and extracted sugar (%) increase in sandy soil. Previous research has shown that salicylic acid (C_7H6O_3) acts as a plant hormone, can regulate various physiological processes and enhance stress tolerance by increasing the activity of antioxidant enzymes, as pointed out by (Axu et al. 2007; Moosavi, 2012 and Abido et al. 2015; Mansour et al. 2020). Merwad and Abdel-Fattah (2015) found that fertilizing sugar beet with 200 kg K/ha^{-1} and spraying 1000 mg/l of salicylic acid led to the highest root and sugar yields/fed, sucrose and extracted sugar percentages, and improved quality index, nevertheless roots impurities contents decreased. Similarly, Abd El-Aal et al. (2020) demonstrated that increasing foliar doses of salicylic acid up to 100 ppm can improve the growth, sucrose, purity percentages, yield, and quality of sugar beet in saline soil. Therefore, this study aims to investigate the combined effect of potassium fertilizer and salicylic acid on the growth, yield, and quality of sugar beet in such conditions.

2. Materials and Methods

In Al-Hamul district, (latitude of 310.24 N and longitude of 310.04 E with 14 meters elevation over the sea level) of Kafr El-Sheikh Governorate, Egypt, located in Kafr El-Sheikh Governorate, Egypt, two field experiments were conducted during the 2020/2021 and 2021/2022 seasons, to study the impact of combining potassium fertilizer and salicylic acid spraying on growth, yield and quality of sugar beet (*Beta vulgaris* var. Saccharifera, L.) in saline soil.

2.1 Treatments

The present work included sixteen treatments, which were combinations of four K-fertilization treatments: (24 kg K_2SO_4/fed; 48 kg K_2SO_4/fed; 24 kg K_2SO_4/fed + two sprays potassein and 48 kg K_2SO_4/fed + two sprays potassein) and four foliar doses of salicylic acid consisting of levels (without, 100, 150 and 200 ppm/fed), was sprayed after thinning and again month later.

A strip plot design in three replicates was utilized. The vertical plots were dedicated to potassium treatments, while the horizontal plots were occupied by the four spray levels of salicylic acid. The sub-plot area was 21.60 m^2, consisting of 6 ridges of 6 m in length and 60 cm in width, with 20 cm between hills. Seeds of the multi-germ sugar beet variety "Hosam" were soaked in water for 24 hours before sowing to ensure a better initial stand and were sown in the second week of September during the two growing seasons and harvested at 210 days after planting. Plants were thinned at the 4-leaf stage to ensure one plant per hill. Phosphorus fertilizer as calcium superphosphate (15% P_2O_5) at 200 kg/fed was applied during seedbed preparation. Nitrogen fertilizer was applied as ammonium nitrate (33.5% N) as a soil application at 90 kg N/fed in two equal doses, after thinning (4-true leaf stage) and one month later.

Potassium fertilizer as soil application was applied in two equal doses, the 1st at preparing the seedbed and the second after thinning with the first dose of nitrogen fertilizer. While Potassien-N compounds, (a nutrient solution containing 320 g/l K_2O + 50 g amide nitrogen), were sprayed twice; after 50 and 70 days from sowing at the rate of (3 l/fed). The physical and chemical properties of the soil at the experimental site were analyzed according to the methods described by Black et al. (1981) and Jackson (1973), respectively. The physical and chemical analyses of the soil (the upper 30 cm) are given in Table 1.

2.2 Studied traits

To analyse the sugar beet plants, samples were randomly taken from each subplot after 105 days from sowing to determine Proline content (u moles/g leaf fresh weight) using the method of Bates et al. (1973). At harvest, ten guarded plants were randomly selected from the middle ridges of each subplot to measure the following traits:

1. Root diameter/plant (cm)
2. root and foliage fresh weights/plant (g).
3. The quality traits were determined at the Beet Laboratory in Al-Hamul Sugar Factory, Delta Sugar Company, Kafr El-Sheikh Governorate Egypt. Impurities in terms of sodium, potassium, and alpha-amino N concentration in roots were estimated as (meq/100 g beet). The sodium and potassium were determined in the digested solution using "Flame-

photometer". While Alpha-amino N was determined using Hydrogenation according to the method described by Cook and Scott (1993).

4. Sucrose % was polarimetrically measured using the methods of A.O.A.C. (2005).

according to the following equation

Sugar yield/fed (ton) = root yield (ton) x extracted sugar %.

5. Sugar lost in molasses % = 0.14 × (K + Na) + 0.25 × (α-amino – N) + 0.5, as described by Devillers (1988).

6. Extracted sugar % = sucrose% - SLM - 0.6, as described by Dexter et al. (1967).

7. Quality index = (Extracted sugar % ÷ sucrose) × 100

8. Root and top yields/fed (ton).

9. Sugar yield/fed (ton) was calculated

2.3 Statistical analyses

The obtained data were statistically analysed according to the technique "MSTAT-c" computer software package, using analysis of variance (ANOVA) for A strip plot design as published by Gomez and Gomez (1984), drug meth According to Snedecor and Cochran's (1980) calculations, the least significant differences between treatment means at a 5% level of probability were determined.

Table 1: Some physical and chemical properties of the experimental soil site in 2020/2021 and 2021/2022 seasons.

2020/2021 season								
Coarse sand (%)	**Fine sand %**	**Silt (%)**	**Clay (%)**		**Texture**	**O.M (%)**	**$CaCO_3$ (%)**	
1.7	11.2	30.7	56.4		Clayey	0.45	4.90	
pH (1:2:5)	**EC (dS/m)**	**Soluble cations (meq/l^{-1})**				**Soluble anions (meq/l^{-1})**		
		Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**HCO_3^{-}**	**Cl^{-}**	**SO_4^{--}**
8.04	6.89	14.3	13.4	39.1	2.1	5.1	38.1	25.7
Available Macronutrients (mg/kg)								
N	**P**	**K**	**ESP%**			**SAR%**		
60	3.28	159	12.74%			10.48%		
2021/2022 season								
Coarse sand, %	**Fine sand %**	**Silt (%)**	**Clay (%)**		**Texture**	**O.M (%)**	**$CaCO_3$ (%)**	
1.8	12.6	32.5	53.1		Clayey	0.75	5.10	
pH (1:2:5)	**EC (dS/m)**	**Soluble cations (meq/l^{-1})**				**Soluble anions (meq/l^{-1})**		
		Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**HCO_3^{-}**	**Cl^{-}**	**SO_4^{--}**
7.98	6.94	13.87	12.85	40	2.77	5.50	41	22.99
Available Macronutrients (mg/kg)								
N	**P**	**K**	**ESP%**			**SAR%**		
70	4.36	164	13.20%			10.92%		

* SAR=Na/SQRT (Ca^{+2} + Mg^{+2})/2

* ESP = 1.95 + 1.03 SAR

Results and Discussion

1. Proline content, root diameter, fresh and foliage weights/pant

The results in Table 2 reveal that proline content, root diameter and the weights of root fresh and foliage/plant of sugar beet were significantly impacted by K-fertilization treatments during both growing seasons. Supplying sugar beet plants with (48 kg K_2SO_4 + two sprays of potassein) was accompanied by a significant decrease in proline content, where this dose application was proved to be significantly more effective in increasing growth traits compared to the other combination, whether applied alone or combined with potassien in both seasons. The results suggest that proline accumulation in plants is positively correlated with stress, which is beneficial in plants exposed to various stress conditions. Furthermore, the significant impact of potassium fertilizer on plant growth can be attributed to its effects on photosynthesis, protein synthesis, control of ionic balance, and regulation of plant stoma as noted by Enan, (2016). In both seasons' taproot diameter, root fresh and foliage weights/plant were increased gradually due to increasing foliar doses of salicylic acid. However, an insignificant difference in proline content was found among the studied treatments. Spraying beet plants with 200 ppm salicylic acids resulted in higher values of root diameter, fresh and foliage weights/plant compared with those supplied with 150 ppm salicylic acid. This finding is in agreement with those reported by Hasegawa et al. (2000) stated that the transpirational flux required to maintain the plant's water status is the cause of the transport of salt into the roots and up to the shoots. Uncontrolled transpiration can result in harmful ion accumulation in the plant's aerial portions. Salicylic acid has a significant function as a potent ameliorator for stress circumstances that cause a rapid reaction to salinity by reducing ion flux to the shoots, stomatal closure, and changes in the permeability of the plant membranes as noted by Karasavina, (2007).

The interactions effect

The amount of proline content was significantly influenced by the first-order interaction of potassium and salicylic acid fertilization levels in two seasons shown in Fig 1. Increasing the salicylic acid up to 200 ppm resulted in a significant reduction in proline content when beets were fertilized with (48 kg K_2SO_4 + two sprays of potassien) in both seasons. This decrease in proline content may suggest that both potassium fertilizers and foliar application of salicylic acid play an influential role in increasing the salt resistance of sugar beet. Enan (2011) has previously established that sufficient levels of potassium can reduce the harmful effect of salinity while improving plant growth properties and enhancing stress tolerance by increasing the activity of antioxidant enzymes. Additionally, Abido et al. (2015) have reported that proline accumulation protects cells against stress damage.

Table 2: Effect of potassium and spraying salicylic acid fertilization levels on proline content (u moles/g leaf fresh weight), root diameter (cm), root and foliage fresh weight/plant of sugar beet in 2020/2021 and 2021/2022 seasons.

Used treatments	Proline content (u moles/g leaf fresh weight)		Root diameter (cm)		Root fresh weight g/plant		Foliage fresh weight g/plant	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
(A) Potassium fertilization levels (kg/fed)								
24 kg K_2SO_4	3.49	3.37	8.26	8.16	519.50	522.75	231.72	252.96
48 kg K_2SO_4	3.26	3.19	9.17	9.18	538.08	531.33	283.09	264.07
24 kg K_2SO_4 + two sprays potassein	2.58	2.48	10.14	10.08	547.67	544.83	303.36	274.11
48 kg K_2SO_4 + two sprays potassein	2.08	2.05	10.90	10.86	650.92	642.42	378.46	373.18
LSD at 0.05%	**0.17**	**0.15**	**0.58**	**0.56**	**93.73**	**74.66**	**88.82**	**76.40**
(B) Salicylic acid spraying levels (ppm)								
0	2.94	2.87	8.67	8.66	478.25	469.83	246.48	225.57
100	2.91	2.83	9.07	9.00	548.75	521.75	274.41	271.89
150	2.86	2.79	9.76	9.70	573.42	572.17	313.47	299.23
200	2.70	2.59	10.97	10.90	655.75	677.58	362.26	367.64
LSD at 0.05%	**NS**	**NS**	**0.38**	**0.41**	**33.74**	**33.73**	**29.88**	**31.53**
A×B	**	**	**	**	**NS**	**NS**	**NS**	**NS**

Figure 2 revealed that thickness of the root significantly affected by the interaction between potassium and salicylic acid levels. The thickest root was produced when plants were fertilized with 48 kg K_2SO_4 + two sprays of potassien, along with spraying 200 ppm salicylic acid/fed. This resulted in wider distances between cambium layers, allowing for better storage of sugar. This finding is consistent with conducted by Merwad and Abdel-Fattah (2015).

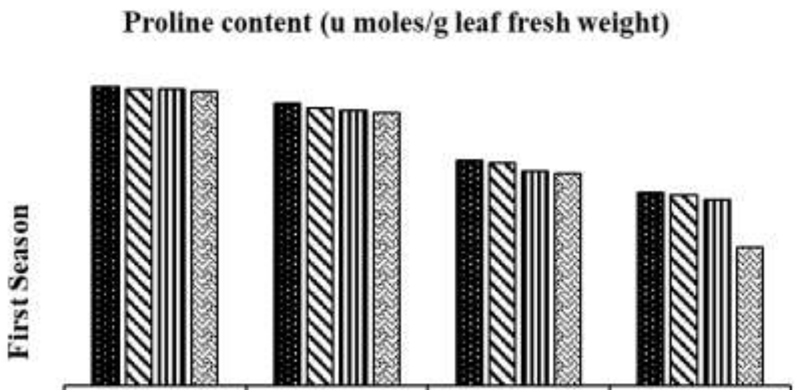
2. **Sucrose %, potassium, sodium and alpha-amino N contents**

The results in Table 5 point to sucrose%, potassium, sodium, and alpha-amino contents were significantly affected by all K-fertilizer treatments in both seasons. When beet plants were fertilized with a combined application of 24 and/or 48 kg K_2SO_4 + two sprays of potassien, the sucrose% increased significantly compared to individual soil applications of potassium or combined with sprayed potassien under saline soil. Additionally, the application of 48 kg K_2SO_4 + two sprays of potassien increased K and α-amino N contents while reducing sodium content compared to the other treatments during the two seasons. These observations align with Enan, (2011).

Furthermore, Table 5 also indicates that raising salicylic acid levels from zero to 200 ppm/fed in the two growing seasons resulted in the highest sucrose%

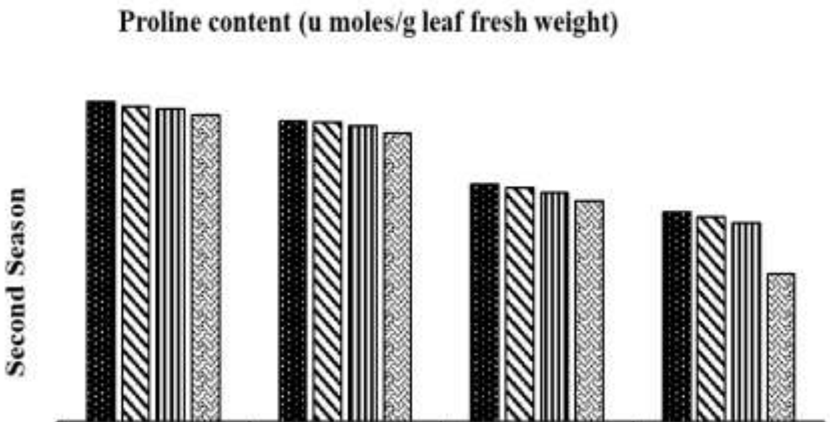
and potassium content values. However, the application of salicylic acid did not show a significant effect on sodium and alpha-amino contents in both seasons. These findings are consistent with those reported by Merwad and Abdel-Fattah (2015).

According to Table 5, the above-mentioned traits were insignificantly affected by the interaction of potassium and salicylic acid fertilization levels in Table5.



	24 kg K2SO4	48 kg K2SO4	24 kg K2SO4 + two sprays potassein	48 kg K2SO4 + two sprays potassein
Salicylic acid spraying levels (ppm) 0	3.52	3.32	2.65	2.27
Salicylic acid spraying levels (ppm) 100	3.50	3.27	2.63	2.25
Salicylic acid spraying levels (ppm) 150	3.49	3.24	2.53	2.19
Salicylic acid spraying levels (ppm) 200	3.47	3.21	2.49	1.62

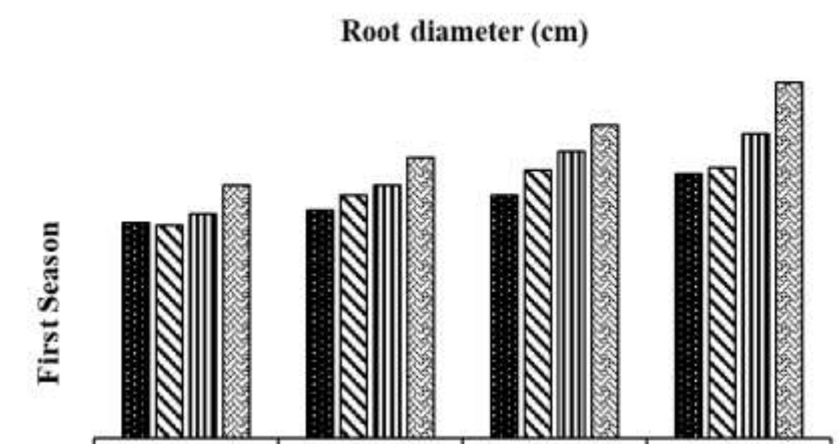
LSD at 0.05% 0.23



	24 kg K2SO4	48 kg K2SO4	24 kg K2SO4 + two sprays potassein	48 kg K2SO4 + two sprays potassein
Salicylic acid spraying levels (ppm) 0	3.44	3.24	2.56	2.25
Salicylic acid spraying levels (ppm) 100	3.39	3.22	2.51	2.20
Salicylic acid spraying levels (ppm) 150	3.36	3.18	2.46	2.14
Salicylic acid spraying levels (ppm) 200	3.30	3.10	2.37	1.59

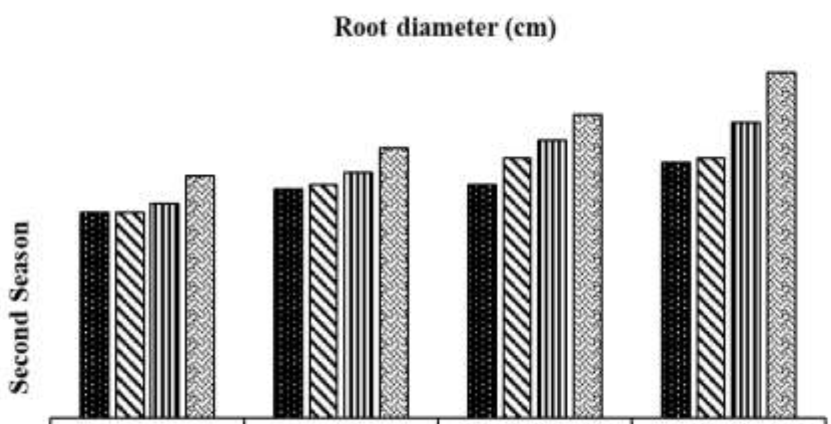
LSD at 0.05% 0.21

Fig. 1. A significant interaction between potassium fertilization levels and spraying salicylic acid on proline content (u moles/g leaf fresh weight) in sugar beet leaves during of 2020/2021and 2021/2022 seasons.



	24 kg K2SO4	48 kg K2SO4	24 kg K2SO4 + two sprays potassein	48 kg K2SO4 + two sprays potassein
Salicylic acid spraying levels (ppm) 0	7.86	8.32	8.86	9.66
Salicylic acid spraying levels (ppm) 100	7.76	8.88	9.78	9.87
Salicylic acid spraying levels (ppm) 150	8.19	9.26	10.48	11.11
Salicylic acid spraying levels (ppm) 200	9.23	10.24	11.45	12.98

LSD at 0.05% 0.76



	24 kg K2SO4	48 kg K2SO4	24 kg K2SO4 + two sprays potassein	48 kg K2SO4 + two sprays potassein
Salicylic acid spraying levels (ppm) 0	7.71	8.59	8.77	9.59
Salicylic acid spraying levels (ppm) 100	7.74	8.76	9.75	9.75
Salicylic acid spraying levels (ppm) 150	8.06	9.23	10.43	11.09
Salicylic acid spraying levels (ppm) 200	9.12	10.13	11.38	12.98

LSD at 0.05% 0.83

Fig. 2. A significant interaction between potassium and spraying salicylic acid fertilization levels on sugar beet root diameter (cm) in 2020/2021 and 2021/2022 seasons.

Table 5: Effect of potassium and spraying salicylic acid fertilization levels on sucrose%, potassium, sodium and alpha-amino N contents (meq /100 g beet) of sugar beet in 2020/2021 and 2021/2022 seasons.

Used treatments	Sucrose %		Potassium (meq/100 g beet)		Sodium (meq/100 g beet)		Alpha-amino N (meq/100 g beet)	
	1st season	2nd season	1st season	2nd Season	1st season	2nd season	1st season	2nd season
(A) Potassium fertilization levels (kg/fed)								
24 kg K_2SO_4	17.17	17.49	3.87	3.50	1.75	1.67	1.28	1.30
48 kg K_2SO_4	17.60	17.81	4.04	3.71	1.71	1.59	1.42	1.36
24 kg K_2SO_4 + two sprays potassein	18.20	18.36	4.17	4.53	1.56	1.36	1.60	1.50
48 kg K_2SO_4 + two sprays potassein	18.64	18.78	4.28	4.65	1.40	1.14	1.78	1.56
LSD at 0.05%	**0.53**	**0.58**	**0.05**	**0.16**	**0.17**	**0.21**	**0.04**	**0.03**
(B) Salicylic acid spraying levels (ppm)								
0	17.29	17.17	3.82	3.86	1.78	1.54	1.46	1.39
100	17.61	17.92	3.97	3.99	1.68	1.53	1.52	1.42
150	18.05	18.32	4.18	4.19	1.55	1.36	1.54	1.44
200	18.75	19.03	4.38	4.35	1.41	1.33	1.56	1.47
LSD at 0.05%	**0.31**	**0.25**	**0.13**	**0.24**	**NS**	**NS**	**NS**	**NS**
A×B	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

3. Extracted sugar, sugar lost to molasses percentages and quality index

The results collected over both seasons showed that extracted sugar and sugar lost in molasses% of sugar beet were increased with all K-fertilizer treatments, while the quality index don't reach the level of significance in either season (Table 6). Adding (48 kg K_2SO_4 + two sprays of potassien) without a significant difference between appling (24 kg potassium K_2SO_4 + two sprays of potassien) gave a significant increase in extracted sugar and sugar lost to molasses compared with the rest other combinations. These findings are similar to those described by Moustafa and El–Masry. (2006). In the same Table increasing salicylic acid rates from 0 to 200 ppm resulted in a significant increase in extracted sugar and quality index in both seasons. The increase amounted to 1.41% and 0.83%, and 1.81% and 0.94% for 1st and 2nd seasons, respectively compared to those that were untreated. Meantime, spraying salicylic acid insignificantly affected the sugar lost to molasses in either season. The plants that received 200 ppm of salicylic acid had higher percentages of extracted sugar and lower sugar lost to molasses values than those that received 150 ppm. This may be due to the role of salicylic acid in improving plant growth properties and enhancing stress tolerance through increasing the activity of antioxidant enzymes, which is in agreement with the findings of Abido et al. (2015). According to Table 6, the interaction between the studied factors did not significantly affect the technological traits mentioned above.

4. Root, top and sugar yields/fed (ton)

According to Table 7 data, root, top and sugar yields/fed were increased significantly by applying sole and combined K-fertilizer in both seasons. Fertilizing sugar beet with 48 kg K_2SO_4 + two sprays of potassien resulted in a significant increase in these traits compared to adding 24 kg K_2SO_4 + two sprays of potassien. This increase was observed in the first and second seasons, with (1.92, 1.93 tons of roots), (0.45, 0.44 tons of foliage) and (0.38 and 0.40 tons of sugar), respectively. These findings suggest that using potassium and two sprays of potassien can lead to thicker and heavier roots, higher sucrose content and increased extracted sugar percentages compared to using potassium alone or applying 24 kg K_2SO_4 + two sprays of potassien (Tables 3, 5, and 6). These results align with those obtained by Enan (2011), who explained that the foliar doses of potassien are complementary with soil adding of K_2SO_4 in saline soil, which supports the beet plants to withstand external stresses and results in improved growth traits and increased root, top, and sugar yields/fed.

In the same Table, it was observed that supplying beets with 200 ppm salicylic acid foliar dose resulted in a significant increase in root, top, and sugar yields/fed compared to other concentrations in both seasons. This positive influence of salicylic acid applied levels may be due to its ability to produce a protective effect on plants under stress factors. This favorable effect of salicylic acid was also reported by Abd El-Aal et al. (2020).

The interaction between K-fertilizer treatments and salicylic acid levels significantly affected root and top yields ton/fed, as shown in Table 7.

Table 6: Effect of potassium and spraying salicylic acid fertilization levels on extracted sugar, sugar lost in molasses percentages and sugar beet quality index in 2020/2021 and 2021/2022 seasons.

Used treatments	Extractable sugar %		Sugar lost to molasses %		Quality index	
	1st season	2nd Season	1st season	2nd season	1st season	2nd season
(A) Potassium fertilization levels (kg/fed)						
24 kg K_2SO_4	14.96	15.34	1.61	1.55	87.14	87.73
48 kg K_2SO_4	15.34	15.63	1.66	1.58	87.15	87.72
24 kg K_2SO_4 + two sprays potassein	15.98	16.06	1.70	1.70	87.40	87.71
48 kg K_2SO_4 + two sprays potassein	16.30	16.47	1.79	1.71	87.42	87.70
LSD at 0.05%	**0.54**	**0.59**	**0.02**	**0.04**	**NS**	**NS**
(B) Salicylic acid spraying levels (ppm)						
0	15.04	14.96	1.65	1.60	86.99	87.16
100	15.33	15.69	1.67	1.63	87.08	87.59
150	15.77	16.09	1.69	1.64	87.32	87.78
200	16.45	16.77	1.70	1.66	87.73	88.10
LSD at 0.05%	**0.26**	**0.25**	**NS**	**NS**	**0.19**	**0.23**
A×B	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

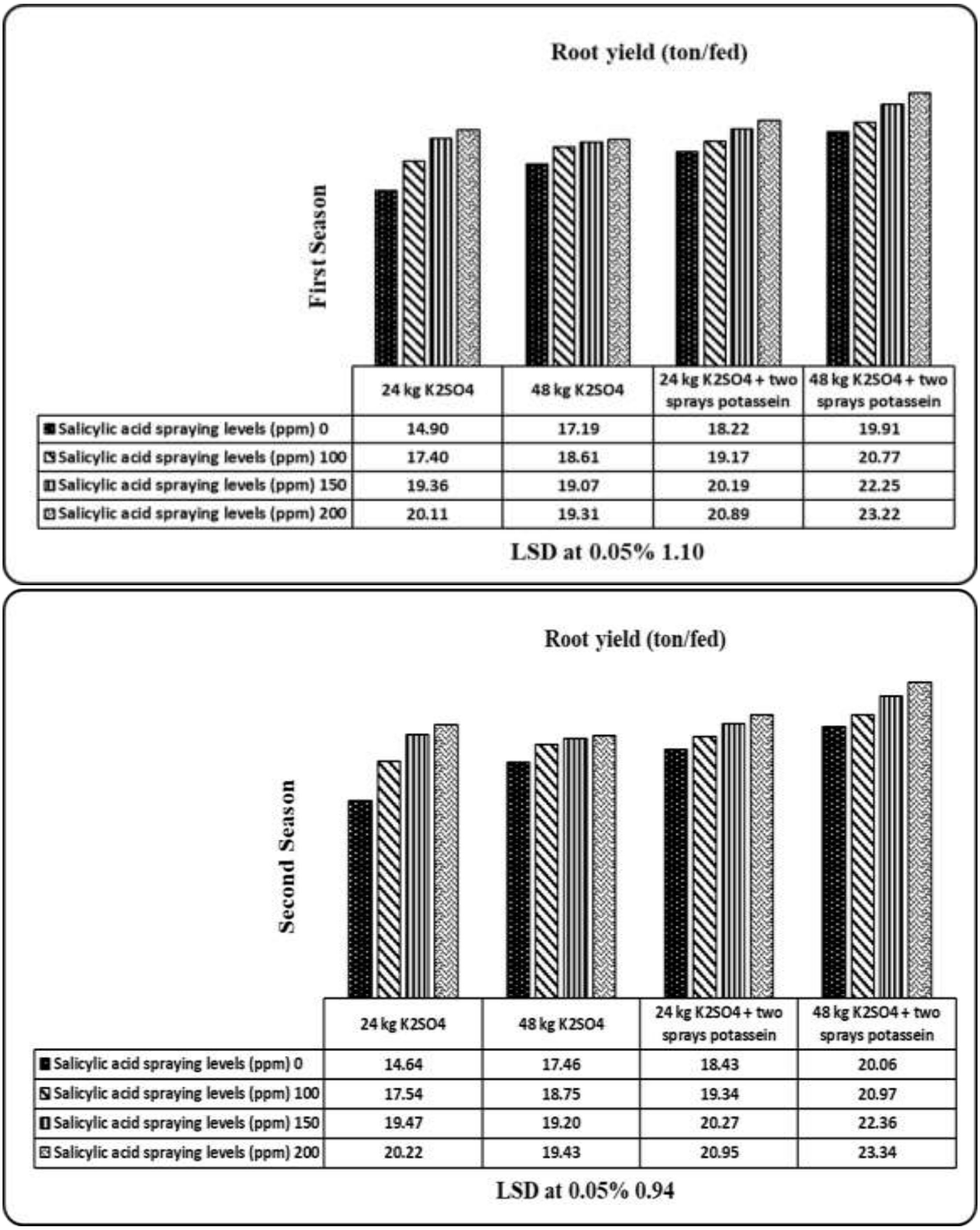
Table 7: Effect of potassium fertilization levels and salicylic acid on root, top and sugar yields (ton/fed) of sugar beet in 2020/2021 and 2021/2022 seasons.

Used treatments	Root yield/fed (ton)		Top yield/fed (ton)		Sugar yield/fed (ton)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
(A) Potassium fertilization levels (Kg/fed)						
24 kg K_2SO_4	17.94	17.97	7.35	7.47	2.69	2.76
48 kg K_2SO_4	18.55	18.71	8.23	8.38	2.85	2.93
24 kg K_2SO_4+ two sprays potassein	19.62	19.75	8.53	8.70	3.14	3.18
48 kg K_2SO_4+ two sprays potassein	21.50	21.69	8.98	9.14	3.40	3.47
LSD at 0.05%	**1.36**	**1.16**	**0.51**	**0.52**	**0.24**	**0.20**
(B) Salicylic acid spraying levels (ppm)						
0	17.38	17.47	7.45	7.59	2.62	2.62
100	18.81	18.98	8.11	8.25	2.89	2.98
150	20.04	20.15	8.60	8.76	3.17	3.25
200	20.71	20.81	8.94	9.09	3.41	3.49
LSD at 0.05%	**0.44**	**0.72**	**0.32**	**0.31**	**0.09**	**0.14**
A×B	**	**	**	**	**NS**	**NS**

Interactions effect

Figure 3 revealed that there was in significant variation in the root yield/fed of beets that were sprayed with 150 and/or 200 ppm salicylic acid this was observed when the plants were fertilized with either 24 or 48 kg K_2SO_4 individually or a combination of (24 kg K_2SO_4 + two sprays of potassien) in both seasons. However, the variance in root yield between the two levels of salicylic acid was significant when the other K-fertilization treatments were used in both seasons. Increasing salicylic acid levels from 0 to 200 ppm resulted in a significant increase in root yield/fed of approximately (3.31 and 3.28 tons) in the case beets were fertilized with 48 kg K_2SO_4 + two sprays of potassien compared to all other combinations in both seasons. These results could be attributed to the role of potassium as a soil application and potassine as a complementary spray that contains amide nitrogen enhancing amount along with foliar doses of salicylic acid, as reported by Enan, (2011) and (Merwad and Abdel-Fattah 2015).

According to the data presented in Fig. 4 the differences in top yield between beet plants foliar with 150 ppm and those received with 200 ppm salicylic acid/fed were insignificant when sugar beet was fertilized with 24 kg K_2SO_4 + two sprays of potassien in both seasons. However, there was a significant difference in this trait between the two salicylic acid doses under other potassium fertilization treatments in both seasons. The highest yield was achieved when 48 kg K_2SO_4 + two sprays of potassien was applied along with 200 ppm of salicylic acid/fed as a foliar application, indicating the importance of adding soil potassium sulfate and spraying potassien supported by amide nitrogen, in addition to spraying higher dose of salicylic acid, which plays various physiological roles in plant growth, photosynthesis, and nutrient uptake by Janda et al. (2007) and Celik et al. (2010).



First Season

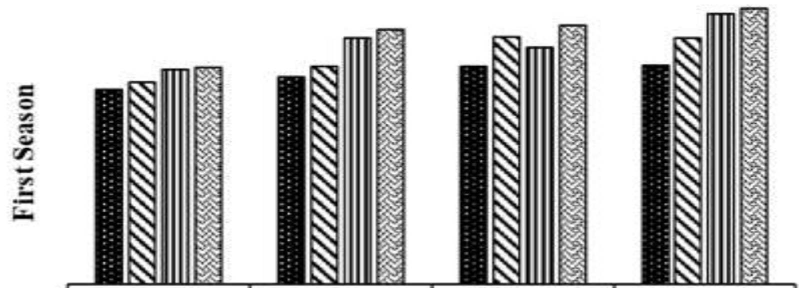
	24 kg K2SO4	48 kg K2SO4	24 kg K2SO4 + two sprays potassein	48 kg K2SO4 + two sprays potassein
Salicylic acid spraying levels (ppm) 0	14.90	17.19	18.22	19.91
Salicylic acid spraying levels (ppm) 100	17.40	18.61	19.17	20.77
Salicylic acid spraying levels (ppm) 150	19.36	19.07	20.19	22.25
Salicylic acid spraying levels (ppm) 200	20.11	19.31	20.89	23.22

Second Season

	24 kg K2SO4	48 kg K2SO4	24 kg K2SO4 + two sprays potassein	48 kg K2SO4 + two sprays potassein
Salicylic acid spraying levels (ppm) 0	14.64	17.46	18.43	20.06
Salicylic acid spraying levels (ppm) 100	17.54	18.75	19.34	20.97
Salicylic acid spraying levels (ppm) 150	19.47	19.20	20.27	22.36
Salicylic acid spraying levels (ppm) 200	20.22	19.43	20.95	23.34

Fig. 3. A significant interaction between potassium fertilization levels and spraying salicylic acid on sugar beet root yield (ton/fed) in 2020/2021 and 2021/2022 seasons.

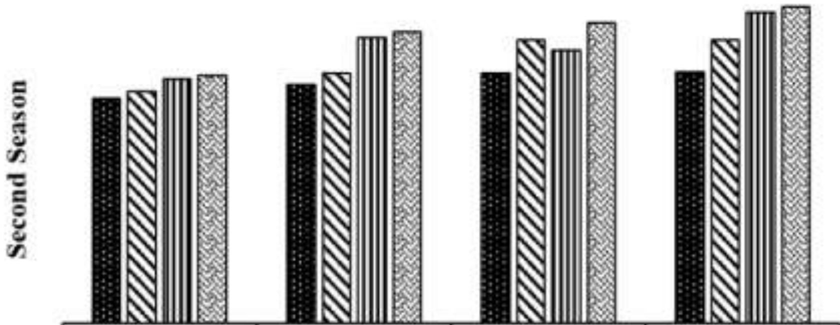
Top yield (ton/fed)



	24 kg K2SO4	48 kg K2SO4	24 kg K2SO4 + two sprays potassein	48 kg K2SO4 + two sprays potassein
Salicylic acid spraying levels (ppm) 0	6.90	7.37	7.73	7.79
Salicylic acid spraying levels (ppm) 100	7.18	7.73	8.77	8.74
Salicylic acid spraying levels (ppm) 150	7.62	8.76	8.41	9.61
Salicylic acid spraying levels (ppm) 200	7.70	9.05	9.21	9.78

LSD at 0.05% 0.64

Top yield (ton/fed)



	24 kg K2SO4	48 kg K2SO4	24 kg K2SO4 + two sprays potassein	48 kg K2SO4 + two sprays potassein
Salicylic acid spraying levels (ppm) 0	7.07	7.51	7.88	7.92
Salicylic acid spraying levels (ppm) 100	7.30	7.87	8.91	8.93
Salicylic acid spraying levels (ppm) 150	7.70	8.98	8.58	9.78
Salicylic acid spraying levels (ppm) 200	7.80	9.17	9.45	9.95

LSD at 0.05% 0.62

Fig. 4. A significant interaction between potassium fertilization and spraying salicylic acid levels on sugar beet top yield/fed (ton) in 2020/2021 and 2021/2022 seasons.

Conclusion

To reduce the negative impact of soil salinity and achieve optimal yields of beet roots and sugar per fed fertilizing beet plants with 48 kg/fed K_2SO_4 + two sprays of potassien along with spraying 200 ppm salicylic acid. This approach is recommended based on the present work's conditions

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