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Original Research Article

Influence of potassium and boron on growth and chemical composition of Cucumber (*Armenia sp.*) irrigated by saline water

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Abstract

Field experiments were conducted at farmer's field, Kerdasa, El-Giza governorate, Egypt during two winter seasons of (2019/2020) to study the effects of soil-applied potassium fertilization (0, 50, 75, 100 kg K₂O fed⁻¹) and boron foliar spray (0, 50, 100 and 150 ppm) and their interaction on growth and chemical composition of cucumber plant irrigated by saline water. The results indicated that soil application of potassium and boron foliar spray successfully mitigated the deleterious effects of salt stress and influenced the growth and nutrient content of the cucumber plant. Soil application of 100 kg K₂O fed⁻¹ combined with 150 ppm boron foliar spray improved the growth and chemical constituents of cucumber, in terms of chlorophyll (SPAD), the tissue water content of leaves and fruit, fresh and dry weight, fruit length and diameter, and nutrient content (N, P, and K) of fruits in both the first and second cut, while reduced the sodium content. The combined treatment of potassium at 100 kg K₂O fed⁻¹ and boron spraying at 150 ppm was found to be more effective for the cucumber plant to enhance the growth performance and the nutrient content as compared with the control under saline water irrigation conditions.

Keywords Cucumber, Potassium, Boron, Saline water, Nutrient content.

Introduction

Adequate water and nutrient supply are important factors affecting optimal plant growth and successful crop production. Water and salinity stress are the severe limitation of crop growth especially in arid and semiarid regions of the world as they have a vital role in plant growth and development at all growth stages. Salinity stress disturbs the uptake and accumulation of essential nutrients. Generally, Ca²⁺ and K⁺ decrease in plants under saline conditions (Al-Harbi 1995).

Cucumber is one of the most popular vegetables belongs to the Cucurbitaceae family. Cucumber is a rich source of vitamin B, vitamin C, and minerals such as nitrogen, phosphorus, potassium, calcium, and iron. The cucumber plant has been classified as salt-sensitive crop for salinity.

Potassium (K) is called a non-constitutive element as it does not form components/ compounds in the plant system but acts as a plant nutrient with a vital role in metabolism, including protein synthesis, plant water balance maintenance, and transportation of water and nutrients. Plants need K to regulate

some vital activities such as enzyme activation, photosynthesis, osmo-regulation, stomatal movement, energy transfer, phloem transport, cation-anion balance, and stress resistance (Marschner, 2012). Hai and Dong (2019) Suggested that the dry weight of Chinese cabbage increased with the application of K⁺ under salt stress. The addition of K⁺ increased K⁺ concentrations and suppressed sodium (Na⁺) concentration, which eventually increased the K⁺/Na⁺ ratios in roots or shoots. Application of K⁺ enhanced the uptake of K⁺ and suppressed the uptake of Na⁺. Moreover, the ratios of shoot-K⁺/root-K⁺ increased considerably, but the ratios of shoot-Na⁺/root-Na⁺ decreased in response to K⁺ application.

The importance of Boron is also well documented for a great variety of physiological processes in plants, and it seems to exert different effects such as root elongation, indole-3-acetic acid oxidase, sugar translocation, carbohydrate metabolism, nucleic acid synthesis, and pollen tube growth (Goldbach and Wimmer, 2007). Moreover, more than 90% of the boron is found in cell walls. Its functions are also related to cell wall synthesis, lignifications, and maintenance of cell wall structure (Hänsch and Mendel, 2009). Its deficiency predominantly damages actively growing organs such as shoot and root tips

and effects flower retention, pollen formation, pollen tube growth or germination, nitrogen fixation, and nitrate assimilation (Camacho-cristobal et al., 2008).

Ismail (2003) emphasized the fact that B and K contents for both maize and sorghum increased with excess B treatments. Furthermore, excess B treatment increased B and K contents in radish (Tariq and Mott, 2006). Additionally, it was noted that B and K concentrations of tomato fruit increased when increasing K treatments were applied to the soil together with foliar B (Huang and Snapp, 2009). The shoot and root growth of bean (Samet et al., 2013) and cucumber (Çikili et al., 2013) were impressed by excess B but added K to the growth media mitigated the detrimental effect of excess B. In the present study, the role of K on the alleviation of B toxicity was investigated in pepper, as a B-sensitive plant. The objectives were to explore the possibility of using saline water for supplemental irrigation of cucumber plants through the application of potassium and boron fertilizers.

Materials and Methods

Field experiments were conducted at farmer's field, Kerdasa, El-Giza governorate, Egypt during two winter seasons of

(2019/2020) to study the effects of soil-applied potassium and boron foliar spray and their interaction on the growth and chemical composition of cucumber plant irrigated by saline water. Some physical and chemical properties of a representative soil sample used in the experimental soil were determined before cultivation according to Rebecca (2004) and presented in Table 1.

Nitrogen fertilizer in the form of nitrate ammonium (33% N) at the rate of 80 kg N fed⁻¹ was added in two equal doses. The first one was applied after thinning and the other 20 days later. The recommended dose of phosphorus fertilizer applied as calcium super phosphate (15.50% P₂O₅) at a rate of 100 kg fed⁻¹ during preparation of the experiment. Potassium fertilizer in the form of potassium sulphate (48 % K₂O) at different rates of 0, 50, 75, and 100 kg K₂O fed⁻¹ (fed= feddan) addition of soil applications. Foliar application of boron at the rates 0, 50, 100 and 150 ppm B as Boric acid at 20 and 30 days of sowing. The experiment irrigated with groundwater (EC) 2.36 dS m⁻¹, (TDS) 1510.0 mg/l, (SAR) 19.20, (ESR) 2.88 and (ESP) 39.24.

Table 1. Initial physical and chemical soil properties of the experimental soil site

Particle size distribution (%)			Texture class	pH (1: 2.5)	EC (dS m ⁻¹) Soil paste	Organic Matter (%)	CaCO ₃ (%)
Sand	Silt	Clay					
31.72	41.95	28.97	Clay Loamy	7.32	1.43	0.98	2.13
Cations (me L ⁻¹)				Anions (me L ⁻¹)			
Na ⁺	K ⁺	Ca ⁺⁺	Mg ⁺⁺	CO ₃ ⁻	HCO ₃ ⁻	Cl ⁻	SO ₄ ⁻
3.6	0.61	2.55	1.37	0.00	1.22	3.67	3.24

The experimental design was a split block design, with three replicates. All agriculture practices were done according to plant needs. Plants were harvested on 10 and 20 September in 1st and 2nd seasons respectively. The plant samples were collected from each treatment randomly at 30 days after sowing and harvest.

Leaf greenness present in a plant was determined with the Minolta-SPAD® Chlorophyll Meter (Minolta Camera Co., Osaka, Japan). The SPAD-502 chlorophyll meter measures the chlorophyll absorbance in the red and near-infrared regions and calculates a numeric SPAD value which is proportional to the amount of chlorophyll in the leaf Minolta (1989). SPAD values were determined for each pot, using the upper, young fully expanded leaves of four plants. Minerals content as nitrogen, phosphorus, potassium, and sodium in shoots and fruits were estimated in the plant digest according to the method described by Faithfull (2002).

Statistical analysis

The obtained data were statistically analyzed for two successive seasons. For comparing the means, the Least Significance Difference (LSD at 5 %) test was used according to the procedure outlined by Gomez and Gomez (1984).

Results and Discussion

Photosynthetic pigments and Tissue water content of leaves

Data in Table 2 showed that the highest values of SPAD Chlorophyll reading at the first and second cut as affected by potassium application at a rate of 100 kg fed⁻¹ with foliar application of boron at a rate of 150 ppm were 59.80 and 58.37 at the first and second cut, respectively. Results are in agreement with those obtained by Marschner, 2012) who reported that potassium assumes basic parts in compound actuation, protein union, photosynthesis, osmoregulation, stomatal development, vitality exchange, phloem transport, cation-anion balance, and stress resistance. Also, data illustrated that tissue water content in leaves at first and second cut enhanced by the application of potassium at a rate of 100 kg fed⁻¹ with foliar application of boron. This means that boron and potassium may play a significant role in carbohydrate metabolic and translocation in plants and as an activator for many enzymes which promote plant growth and production (EL-Shahawy et al., 2002). Pucke (2010) stated that high salinity degrades chlorophyll, thus concentrations of chlorophyll components of the photosynthetic apparatus are normally used to quantify leaf senescence in salt-stressed plants.

Table 2. Chlorophyll, Proline, and tissue water content of leaves as affected by K and B under saline water condition.

Treatments		SPAD reading		Tissue Water Content (%)	
K	B (ppm)	Cut st	Cut nd	Cut st	Cut nd
0 kg K ₂ O fed ⁻¹	0	45.60	41.50	84.68	81.24
	50	50.70	45.73	86.60	84.41
	100	52.80	49.97	84.91	84.53
	150	56.63	50.80	84.02	81.84
50 kg K ₂ O fed ⁻¹	0	47.60	41.73	82.45	83.87
	50	53.63	46.33	85.74	83.46
	100	54.23	51.73	82.48	81.59
	150	59.73	52.07	85.28	82.90
75 kg K ₂ O fed ⁻¹	0	50.13	42.27	86.07	81.66
	50	53.87	48.53	85.36	81.95
	100	55.57	53.70	84.78	83.90
	150	59.80	58.37	83.54	81.48
100 kg K ₂ O fed ⁻¹	0	51.57	45.23	84.11	84.01
	50	54.00	48.97	84.01	68.83
	100	55.63	54.97	81.83	79.98
	150	58.00	55.13	84.35	82.80
LSD 0.05					
Potassium (K)		0.49	1.37	0.17	0.13
Boron (B)		1.09	1.44	0.23	0.11
Interaction (K*B)		1.20	2.30	0.39	0.23

Growth characters

The effect of different rates of potassium application with boron applied as foliar on the fresh and dry weight of Cucumber (*Armenia sp.*) are illustrated in Table 3, data indicated that the addition of potassium sulfate at the rates of 0, 50, 75, and 100 kg fed⁻¹ gradually stimulate the fresh and dry weight at the first and second cut of cucumber plant under saline water irrigation. Results observed that maximum increase of fresh and dry weight of cucumber fruits was noticed at a rate of 150 ppm boron particularly in the second cut, explaining the role of boron for improving and enhancing the plant growth. Data also indicated that the addition of potassium sulfate combined with boric acid stimulates the both fresh and dry weight of two cuts, respectively. Total dry mass production can be increased by increasing the utilization of potassium fertilization on the plant under salt stress compared with the lower content of potassium fertilizer (Wang et al., 2013). Similar results were obtained by Saif (1991) reported that a foliar application of boron at the rate, 0.5 kg fed⁻¹ gave the highest value of top fresh weight plant⁻¹.

Regarding to the Tissue water content of cucumber fruits as affected by application of potassium sulfate with boron applied a foliar spray data in Table 3 showed that application of potassium at a rate of 100 kg fed⁻¹ with foliar application of boron remarkable increase of tissue water content particularly with a rate of 150 ppm underground water irrigation. Salt stress caused a great lessening in growth such as leaf area, fresh and leaves dry weight. These changes were related to a diminishing in relative water content and potassium content (Ghoulam et al., 2002). Salinity stressed adversely the relative water contents and water-retaining capacity but plant water relation in Mungbean plant has been

improved significantly by the application of the higher amount of potassium (Kabir et al., 2004). Boron foliar spray mitigates the deleterious effects of salt stress and enhances growth performance and productivity (Hellal et al., 2015).

Fruit length and diameter

With respect to the fruit length and diameter of cucumber fruits as affected by application of potassium sulfate combined with boron applied as foliar spray in Fig.1 represented fruit length and diameter of cucumber fruits. Results observed that potassium application (75 kgK₂O fed⁻¹) with foliar application of boron stimulates fruit length and diameter at first and second cut particularly with boron a foliar application (100 ppm) under saline water irrigation. Potassium assumes an especially basic part in plant development, digestion, and enormously to the survival of plants that are under different biotic and abiotic stresses (Pettigrew, 2008).

Nutrient composition

Concerning the effect of saline water irrigation on nutrients content, the high values of potassium and sodium concentrations were recorded in fruits at first and second cut compared with control plants. Data in Table 5 showed a gradual increase of potassium concentration in fruits at first and second cut by application of K fertilization. Also, a foliar application of boron stimulates potassium translocation in the plant. Therefore, the data in Table 5 illustrated that the potassium application proves a remarkable increase in leaves and fruits at first and second cut compared with control plants particularly at the rate 100 kg K₂O fed⁻¹ with boron foliar at a rate of 150 ppm.

Table 3. Fresh and dry weight and tissue water content of fruits as affected by K and B under saline water condition

Treatments		Fresh weight (g)		Dry weight (g)		Tissue Water Content (%)	
K	B (ppm)	Cut st	Cut nd	Cut st	Cut nd	Cut st	Cut nd
0 kg K ₂ O fed ⁻¹	0	54.1	110.4	2.09	4.06	96.13	96.32
	50	61.5	126.9	2.17	4.93	96.46	96.11
	100	63.5	157.4	2.21	4.94	96.52	96.86
	150	71.0	193.7	2.98	6.43	95.81	96.68
50 kg K ₂ O fed ⁻¹	0	75.1	178.8	3.18	5.61	95.76	96.86
	50	80.1	214.4	3.21	6.46	95.99	96.98
	100	80.8	275.4	3.34	8.45	95.87	96.93
	150	87.8	302.2	4.06	9.12	95.38	96.98
75 kg K ₂ O fed ⁻¹	0	93.7	287.3	3.45	7.08	96.32	97.54
	50	95.9	289.7	4.74	8.58	95.06	97.04
	100	106.4	352.5	5.00	11.37	95.30	96.77
	150	117.3	406.9	6.14	12.61	94.77	96.90
100 kg K ₂ O fed ⁻¹	0	95.5	349.2	4.64	8.75	95.14	97.49
	50	96.1	422.3	5.76	9.63	94.01	97.72
	100	118.9	452.5	6.71	10.19	94.36	97.75
	150	126.1	579.8	7.28	12.75	94.22	97.80
LSD 0.05							
Potassium (K)		0.125	0.289	0.097	0.356	0.031	0.013
Boron (B)		0.195	0.264	0.106	0.203	0.007	0.005
Interaction (K*B)		0.310	0.535	0.197	0.541	0.036	0.017

Table 4. Nitrogen and phosphorus of leaves as affected by K and B under saline water condition

Treatments		N content (%)				P content (%)			
K	B (ppm)	Leaves		Fruits		Leaves		Fruits	
		Cut st	Cut nd	Cut st	Cut nd	Cut st	Cut nd	Cut st	Cut nd
0 kg K ₂ O fed ⁻¹	0	1.80	0.77	1.01	2.10	0.27	0.24	0.11	0.16
	50	2.30	1.46	1.40	2.24	0.39	0.24	0.25	0.31
	100	2.59	1.98	1.51	2.63	0.41	0.30	0.35	0.39
	150	2.89	2.33	1.62	2.81	0.43	0.30	0.41	0.46
50 kg K ₂ O fed ⁻¹	0	2.13	1.20	1.10	2.13	0.34	0.25	0.13	0.16
	50	2.33	1.54	1.40	2.24	0.40	0.26	0.31	0.33
	100	2.64	2.01	1.55	2.70	0.43	0.29	0.36	0.40
	150	3.10	2.48	1.88	2.90	0.44	0.33	0.42	0.47
75 kg K ₂ O fed ⁻¹	0	2.24	1.31	1.21	2.22	0.35	0.27	0.24	0.26
	50	2.41	1.64	1.45	2.33	0.35	0.28	0.32	0.35
	100	2.71	2.03	1.61	2.76	0.48	0.26	0.37	0.41
	150	3.16	2.52	1.93	2.92	0.52	0.35	0.41	0.50
100 kg K ₂ O fed ⁻¹	0	2.28	1.36	1.31	2.23	0.39	0.25	0.24	0.30
	50	2.58	1.74	1.47	2.52	0.39	0.26	0.35	0.37
	100	2.78	2.29	1.61	2.80	0.51	0.26	0.38	0.42
	150	3.18	2.70	1.99	2.93	0.55	0.39	0.44	0.54
LSD 0.05									
Potassium (K)		0.021	0.026	0.006	0.008	0.005	0.002	0.016	0.009
Boron (B)		0.066	0.094	0.019	0.025	0.009	0.006	0.049	0.039
Interaction (K*B)		0.085	0.116	0.024	0.031	0.014	0.007	0.063	0.046

Table 5. Potassium and sodium content and Na/K ratio of fruits as affected by K and B under saline water condition

Treatments		K content (%)		Na content (%)		K/Na ratio	
K	B (ppm)	Cut st	Cut nd	Cut st	Cut nd	Cut st	Cut nd
0 kg K ₂ O fed ⁻¹	0	1.53	2.07	0.21	0.11	7.2	18.9
	50	2.15	2.46	0.13	0.08	17.1	29.6
	100	2.72	2.74	0.11	0.07	24.9	41.2
	150	3.12	3.38	0.08	0.05	37.6	65.5
50 kg K ₂ O fed ⁻¹	0	1.77	2.28	0.16	0.10	10.8	22.1
	50	2.21	2.56	0.12	0.08	18.5	32.7
	100	2.84	3.03	0.11	0.06	26.6	49.4
	150	3.16	3.50	0.08	0.05	39.6	73.1
75 kg K ₂ O fed ⁻¹	0	1.90	2.42	0.15	0.09	12.5	27.8
	50	2.42	2.56	0.12	0.08	21.0	33.1
	100	2.86	3.05	0.09	0.06	32.9	53.5
	150	3.18	3.64	0.08	0.05	40.4	76.1
100 kg K ₂ O fed ⁻¹	0	2.09	2.45	0.13	0.09	15.6	28.3
	50	2.29	2.65	0.11	0.07	20.3	38.3
	100	3.10	3.29	0.08	0.06	37.0	59.7
	150	3.77	3.92	0.06	0.04	63.6	88.7
LSD 0.05							
Potassium (K)		0.015	0.009	0.002	0.001		
Boron (B)		0.053	0.029	0.004	0.003		
Interaction (K*B)		0.065	0.036	0.006	0.003		

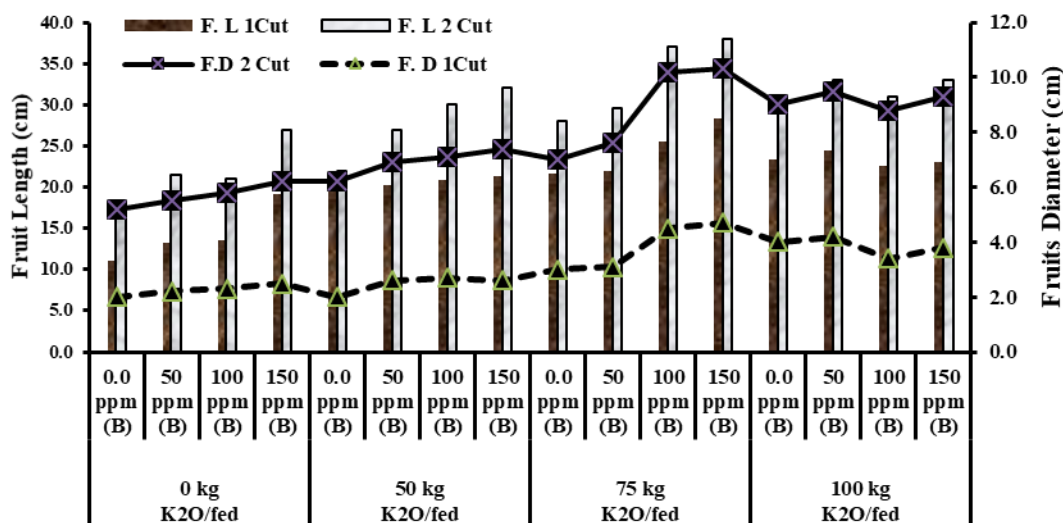


Fig. 1 Fruit length and diameter as affected by K and B under saline water condition.

Potassium content was significantly increased in plants due to foliar application of boron under saline irrigation water conditions. potassium (K) is important at the assume roles in the physiological procedures for protein formation, transportation about water, carbohydrates and nutrient, photosynthesis, N utilization, enhanced of early growth, and increased of disease and insect resistance (Yawson et al., 2011).

Sodium content was higher in plants as affected by saline water irrigation conditions; however, B application significantly reduced Na content in leaves and fruits at the

first and second cut. Data in Table 5 showed that the soil application of potassium with boron foliar spray led to a gradual decrease of sodium concentration in fruits cucumber at the first and second cut. These effects appeared clearly by application of K fertilization at a rate of 100 kg K₂O fed⁻¹ with boron foliar at a rate of 150 ppm. Increasing boron application decreased sodium content to some extent. It was 0.06 and 0.04 % at the first and second cut, respectively. Tariq et al. (1993) showed that the application of boron decreased sodium content in sugar beetroot. Similar results have also been reported by Javaheripour et al. (2005) they reported that application of 10 and 20 g boric acid ha before

sowing did not increase the sodium content over the control. Potassium: sodium ratio in Table 5 significantly increased in fruits at the first and second cut. These results suggest preferential transportation of K to cucumber leaves as a mechanism of salt tolerance. K is responsible for stomatal regulation, which is the principal mechanism controlling water balance and nutrient transportation in plants (Camacho et al., 2000). A high K/Na ratio leads to a favorable ionic balance with increased K uptake. Selectivity for K instead of Na could play an important role in salt tolerance because a high K/Na ratio is much more important than a low Na concentration in many species (Ashraf, 2004).

Conclusion

Potassium plays an important role in some physiological procedures such as protein formation, transportation of water, carbohydrates and nutrient, photosynthesis, N utilization, enhanced early growth, and increased disease and insect resistance. However, boron is considered a key role in a diverse range of plant functions including cell wall formation and stability, maintenance of structural and functional integrity of biological membranes. Therefore, It turned out from the study, the combined application of potassium (100 kg K₂O fed⁻¹) and spraying boron at 150 ppm was found to be more effective for the cucumber plant to improve growth performance and the nutrient content as compared with the control under saline water irrigation conditions.

Conflict of Interest

The author hereby declares no conflict of interest.

Consent for publication

The author declares that the work has consent for publication.

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