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Effect of some Treatments on Reducing Salinity Injuries Effect on Growth, Yield and Quality of Eggplant

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ABSTRACT

A field experiment was carried out at a private Farm in Rowad Village belong to Sahl El-Husseiniya, Sharkia Governorate during the two growing seasons of 2016 and 2017 to study the effect of spraying potassium silicate and adding ammonium thiosulfate (ATS)as soil drenching at three levels on vegetative growth, yield and its components and chemical constituents of eggplant grown under salinity soil(Black Beauty cultivar). The experiment was carried out by using split-plots system in a randomized complete blocks design with three replications. The main plots were arranged with potassium silicate treatments. While, the sub-plots assigned to ammonium thiosulfate levels. The obtained results of this investigation can be summarized as follows: Foliar spraying eggplant plants with potassium silicate levels significantly improved vegetative growth, the yield and its components along with chemical constituents either in the leaves or in the fruits compared with control treatment during both seasons. The highest values of these traits were resulted from using concentration of 6 cm potassium silicate/L in both seasons. Concerning to the effect of ammonium thiosulfate ,it can said that vegetative growth, yield and its components and chemical constituents of either the leaves or in the fruits of eggplant were significantly influenced by different ammonium thiosulfate (ATS) levels adding as drenching around the plants in the both seasons. The maximum values of these characters were produced from using 15 L/fed or 10 L/fed of ATS, respectively in both seasons.While the favourable results on the growth,yield and its components as well as the chemical constituents in the leaves or the fruits were obtained from the interaction between the treatment of foliar spray with 6 cm potassium silicate and adding 15 L/fed from ammonium thiosulfate as soil drenching to obtain the highest results. For that, it could be recommended that foliar spraying eggplant plants grown under salinity soil with 6 cm potassium silicate/L 3 times with using 15 L ATS/fed as soil drenching to enhance vegetative growth characters, yield and its components and chemical constituents of eggplant fruits under the environmental condition of this research.

Keywords: Eggplant, foliar spraying, potassium silicate, ammonium thiosulfate, growth, yield, chemical composition.

INTRODUCTION

Eggplant (Solanum melongea L.) is one of the oldest and popular vegetable crops in Egypt. It is cultivated for local consumption as well as for exportation. It is grown in most cultivated area in Egypt. Eggplant fruits contain a considerable amount of carbohydrates, protein and vitamins (Mahamoud, 2000).

Increasing eggplant production under saline conditions facing an important problem. Because, salinity is individual of the main abiotic stresses into arid and semi-arid regions that sustainability diminished the yield of major crops by extra 50%. Whereas, salinity conditions cause a decrease in uptake availability of most nutrients to plants and this due to soil fixation (Hassan, 1994). Moreover, all soil types contain soluble salts of a multifaceted nature when soil and environmental conditions allow soil salinity concentrations to reach a high level in this case, they become a major threat to land degradation and crop productivity (Munnus, 2002).

Tolerance of plants is determined to environmental stress through its nutritional state. One of the mechanisms to improve the ability of plants to tolerate salinity is through the application of potassium, which appears to have beneficial effects of potassium enrichment reduces the negative effects of salinity in plants by increasing transport and maintaining water balance within plants (Greenwood and Karpinets, 1997).

The beneficial effects of silicon (Si) are mainly linked with high deposition in plant tissues, enhance its strength and stiffness, this increase led to mechanical strength reduces housing, pest attacks and increases the light receiving position of the plant, increase photosynthesis and promote growth (Epstein, 1999), also supposed to reduce transpiration from the cuticle thus increasing resistance to salinity (Matoh *et al*., 1986). Some studies suggested that Si also acting a vigorous role in the biochemical processes in the plant and could play a responsibility in the intracellular production of organic compounds (Fawe 1998 and Ma *et al*., 2006). Many researchers mentioned that, the role of silicon in plant resistance to both biotic and abiotic stress including drought (Hanafy *et al*., 2008 and Crusciol *et al*., 2009). Silicon has been shown to have several distinct advantages in improving plant growth, chemical composition and productivity as well as fruit quality of several plants (Romero-Aranda and Cuartero, 2006 on tomato ; Buck *et al*., 2008 on rice ; Lynch, 2008 on grapes and banana ; Crusciol *et al*., 2009 on potato ; Abou-Baker *et al*., 2011 on faba bean and Kamal, 2013 on sweet pepper). Rakha (2014) showed that foliar application of potassium silicate significantly increased the most of yield parameters and enhanced fruit quality of eggplant as compared with the control treatment. Hussein and Muhammed (2017) revealed that spraying eggplant plants by potassium silicate (1.5 g/L) gave the highest plant height, leaves number per plant, leaf area, chlorophyll content, plant yield, fruits number per plant, P and K percentages in fruits.

Ammonium thiosulfate (ATS) is the unique ammonium thiosulfate plant nutrient solution involved in unlocking the full potential of crops through the addition of sulfur, allowing crop to attain the maximum yield. It is a clear liquid solution that helps augment crop yields by fulfilling the plants natural need for sulfur, and aids in maintaining necessary sulfur levels in soils. ATS not only supplies two essential plant nutrients, nitrogen and sulfur but also provides nitrogen stability when combined or applied with ammonium. Sales of ATS have steadily increased owing to its natural advantages; a) Compatibility with most fluid NPK sources. b) More rapid oxidation than elemental sources. c) Higher analysis than other fluid sulfur sources. d) ATS can enhance micronutrient availability, alkaline soil, saline soil, slow soil urease, slow nitrification and improve the availability of phosphorus fertilizers (Goos, 1995). Many studies demonstrated that ammonium thiosulfate has been shown to have several distinct advantages in improving plant growth, chemical composition and productivity as well as fruit quality of several plants (Kim and Guak, 2010 on apple ; Wilson *et al*., 2011 on sunflower and Seehuber *et al*., 2012 on plum). Ismail (2013) showed that plant height, number of leaves/plant, plant leaf area, fresh weight of leaves, dry weight of leaves, total chlorophyll, N, P and K percentages in eggplant leaves were significantly influenced by different ATS levels. The highest values of these traits were resulted from using 30 L/fed.

Therefore, the aim of this investigation was to determine the effect of potassuim silicate and ammonium thiosulfate (ATS) on reducing salinity injury effect on vegetative growth, the yield and its components along with chemical constituents of eggplant fruits under the ecological condition of Sahl El-Husseiniya, Sharkia Governorate.

MATERIALS AND METHODS

The present study was carried out during 2016 and 2017 seasons at a private Farm in Rowad Village belong to Sahl El-Husseiniya, Sharkia Governorate. The goal of this trial was to clarify the effect of potassium silicate and ammonium thiosulfate (ATS) levels on vegetative growth, yield and its components and chemical constituents of eggplant, Black Beauty cultivar.

The experiment layout was a split-plots system in a randomized complete blocks design with three replications. The main-plots were arranged with four potassium silicate levels as foliar application as follows:

1- Without (control treatment) spraying by tap water.
2- Spraying by potassium silicate (2 cm/L).
3- Spraying by potassium silicate (4 cm/L).
4- Spraying by potassium silicate (6 cm/L).

Potassium silicate compound was used as foliar spray three times after transplanting.,i.e (25, 40 and 55 days from transplanting).

The sub-plots were assigned to ammonium thiosulfate(ATS) contain (12 unit N – 26 unit S) at levels of 0, 5, 10, and 15 L/fed. Ammonium thiosulfate (ATS) was applied separately drenching on the rout zone around the plants 4 times as follows; 25 % at 15 day after transplanting, 25 % at 30 day after transplanting, 25 % at 45 day after transplanting and 25 % at 60 day after transplanting.

Each experimental unit contains 4 rows, 3.75 m long and 0.70 m width occupying an area of 10.5 m^2 (*i.e.* 1/400 feddan). The preceding winter crop was garlic (*Allium sativum* L.) in both seasons.

The experiments were carried out in a clay loam soil with medium fertility. Soil samples were randomly selected from the experimental field area at a depth of 0 to 50 cm prior to soil preparation to determine physical and chemical soil characteristics as shown in Table 1.

The common recommended mineral fertilizers (N, P and K) were applied at the rate of 450 kg ammonium sulfate (20.5 % N), 250 kg calcium superphosphate (15.5 % P_2O_5) and 150 kg potassium sulfate (48.52 % K_2O). All doses of these fertilizers were applied as following; 30 % at 4 weeks after transplanting, 35 % at 8 weeks after transplanting and 35 % at 12 weeks after transplanting.

Table 1. Physical and chemical soil characteristics of the experimental sites during the two growing seasons.

Soil analyses		2016	2017
A: Mechanical analysis			
Clay (%)		49.00	55.0
Silt (%)		30.40	29.4
Fine sand (%)		18.70	12.7
Coarse sand (%)		1.90	2.89
Texture class		Clay	Clay
Organic matter (%)		1.14	2.91
B: Chemical analyseis			
pH (1 : 2.5)		8.12	8.11
E.C. ds m^{-1} (1 : 5)		5.07	4.90
Saturation percentage (SP %)		72.00	71.50
Available N (ppm)		46.50	48.1
Available P (ppm)		4.30	4.70
Exchangeable K (ppm)		375	226
Cations (meq/100 g soil)	Ca^{++}	1.25	4.25
	Mg^{++}	0.67	2.41
	Na^{+}	3.25	2.93
	K^{+}	0.31	0.16
Anions (meq/100 g soil)	CO_3^{--}	-	-
	HCo_3^{-}	0.94	4.61
	Cl^{-}	2.66	2.73
	So_4^{--}	1.88	2.39

The transplanting was carried out during the first week of May in both seasons. The seedlings (40 days old) transplanted on both sides of the ridges at 50 cm apart. The harvest was done after 85 days from transplanting(every 5 days intervals until 45 day from beginning the harvest) in the both seasons of this study. The common agricultural practices for plantation eggplant was doing according to the recommendations of Ministry of Agriculture were followed, except the factors under study.

The data on the Studied characters:

A- Vegetative growth characters:

At 65 days after transplanting a random sample of four guarded plants was taken from the inner rows from each sub-plot to estimate plant vegetative growth characters as follows:

1- Plant height (cm).
2- Number of leaves/plant.
3- Fresh and dry weight of leaves (g).

B- Yield and its components:

The harvest was done after 85 days from transplanting and continue 45 days through 9 pickings (the fruits were harvested every 5 days).

1- Early yield weight in t/fed (first 3 pickings). 3
2- Yield weight in t/fed (from the fourth picking till end of harvesting).
3- Total yield weight in t/fed (1 + 2).

Random samples of fruits at harvesting time (from the fourth picking) were in use from each sub-plot to decide the following traits:

1- Average fruit weight (g).
2- Average fruit diameter (cm).
3- Average fruit length (cm).

C- Chemical constituents:

Random samples of leaves at 65 days after transplanting were taken from each sub-plot to determine the following traits:

1-Total nitrogen (%) was determined according to the method described by Pregle (1945) using micro-Kjeldahl.

2-Phosphorus (%) was determined colorimetrically using the chlorostannus reduce molybdo phosphoric blue color method in sulphoric system as described by Jackson (1967).

3-Potassium (%) was determined using a flame photometer according to Black (1965).

4-Proline % in the leaves was estimated according to A.O.A.C. (1990).

Random samples of fruits at harvesting time (from the fourth picking) were taken from each sub-plot to determine the following traits:

1- Total nitrogen (%).

2- Phosphorus (%).

3- Potassium (%).

4-Total soluble solids (TSS %) was estimated using Gali 110 refractometer as mentioned by Brown and Zerban (1938).

5- Total iron was measured in the digested fruit samples using an Atomic Absorption spectrophotometer according to Chapman and Pratt (1961) .

D- Economic feasibility:

The economic feasibility of eggplant plants as affected by potassium silicate and ammonium thiosulfate (ATS) levels as well as their interaction.

E-Statistical analyses: All data of this study were statistically analyzed according to the technique of variance for the split-plot design (Gomez and Gomez, 1984) by means of "MSTAT-C" Computer software package. LSD method was used to examination the differences among means of the treatment at 5 % level of probability (Snedecor and Cochran, 1980).

RESULTS AND DISCUSSION

A- Vegetative growth:

1- Effect of potassium silicate levels:

The data presented in Table 2 show that foliar spraying eggplant plants with potassium silicate (PS) levels caused significant increases on vegetative growth characters (plant height, number of leaves/plant, fresh and dry weight of leaves of eggplant after 65 days after transplanting) compared with the control treatment in the two seasons of this study. The highest values of these growth traits were obtained from foliar spraying eggplant plants with 6 cm potassium silicate/L, followed by spraying with 4 cm potassium silicate/L, then spraying with 2 cm potassium silicate/L 3 times every 15 days in both seasons. Adversely, the lowest means of studied growth traits of eggplant were produced from without spraying eggplant with potassium silicate (control treatment) in both seasons.

The enhancing effect of foliar spraying eggplant plants with PS may be due to the merge beneficial effects of K and Si, where K mitigates the unfavorable effects of salinity in plants by increasing translocation and maintaining water balance (Greenwood and Karpinets, 1997). In addition, Si enhancing strength and rigidity of plant and consequently increasing mechanical strength reduces housing, pest attacks and increases light receiving position from the plant, increasing photosynthesis and promoting growth (Epstein, 1999). Also, Si will play an active role in the biochemical processes of the plant and can play a role in cell production of organic compounds (Ma *et al*., 2006). The obtained findings are in harmony with those of Rakha (2014) on eggplant and Hussein and Muhammed (2017)on eggplant.

Table 2. Plant height, number of leaves/plant, fresh and dry weight of leaves of eggplant after 65 days after transplanting as affected by potassium silicate and ammonium thiosulfate (ATS) levels as well as their interaction during 2016 and 2017 seasons.

Characters Treatments	Plant height (cm)		Number of leaves/plant		Fresh weight of leaves (g)		Dry weight of leaves (g)	
	2016	2017	2016	2017	2016	2017	2016	2017
				A- Potassium silicate levels.				
Without (control)	42.52	43.87	35.63	36.92	70.68	73.46	12.61	13.39
2 cm/L	45.06	46.35	39.46	41.84	84.10	86.45	15.84	16.84
4 cm/L	46.79	48.95	48.26	49.86	93.65	95.85	17.69	18.66
6 cm/L	53.06	55.68	62.56	64.16	108.02	111.11	20.85	21.84
F. test	*	*	*	*	*	*	*	*
LSD at 5 %	0.67	0.58	0.30	0.22	0.43	0.46	0.37	0.41
				B- ATS levels:				
0 L/fed (control)	43.36	45.15	40.96	43.36	80.05	82.72	14.34	15.45
5 L/fed	45.52	47.25	44.68	46.06	87.14	89.43	16.34	17.41
10 L/fed	48.03	50.14	48.26	49.91	92.11	94.31	17.33	18.26
15 L/fed	50.52	52.21	52.01	53.46	97.15	100.41	18.98	19.61
F. test	*	*	*	*	*	*	*	*
LSD at 5 %	0.44	0.40	0.43	0.47	0.65	0.59	0.47	0.43
C- Interaction: A× B	*	*	*	*	*	*	*	*

ATS = Ammonium thiosulfate (12 – 0 – 0 – 26 NPKS)

2- Effect of ammonium thiosulfate (ATS) levels:

The obtained results as presented in Table 2 show that, in both seasons, using ammonium thiosulfate (ATS) at different levels caused significant increases on vegetative growth characters i.e. plant height, number of leaves/plant, fresh and dry weight of leaves of eggplant after 65 days from transplanting. The highest values of these growth traits were obtained from using ammonium thiosulfate as soil drenching (ATS) at the highest level (15 L/fed) in both seasons. This treatment followed by using ATS at the level of 10 L/fed, then using ATS at the level of 5 L/fed in both seasons. On the contrast, without using ATS produced the lowest means of all studied growth traits of eggplant in both seasons.

These results may be due to ammonium thiosulfate (ATS) helps in increase the growth rate by satisfying the plants natural need for sulfur and the positive active of sulfur on enhancing the uptake rate from the soil and the reflect of that on the growth . In addition the advantages of ATS in enhance micronutrients availability in saline soil and improve the availability of phosphorus fertilizers (Goos, 1995) as well as enhanced micronutrients availability and soil pH change due to it was content of S and SO4. These results are in agreement with those obtained by Ismail (2013).

3- Effect of the interaction between potassium silicate and ammonium thiosulfate levels:

The interaction between potassium silicate and ammonium thiosulfate (ATS) levels had a significant effect on most studied characters as shown from data in Table 3. The authors have enough reported the significant interaction between potassium silicate and ammonium thiosulfate (ATS) levels on plant height, number of leaves/plant, fresh and dry weight of leaves of eggplant after 65 days after transplanting . The favourable interaction treatment that produced the highest values was by foliar spraying eggplant plants with 6 cm potassium silicate/L beside fertilizing with 15 L ATS/fed in both seasons of this study. The second best interaction treatment was foliar spraying with 6 cm potassium silicate/L besides fertilizing with 10 L ATS/fed. On the other hand, the lowest means of traits were resulted from control treatment of both studied factors (without spraying with potassium silicate and without using ATS) in both seasons.

These results may be due to the role of potassium silicate in active the biochemical processes in the plants and might play a position in the intracellular creation of organic compounds (Fawe 1998 and Ma *et al*., 2006). Moreover, ATS enhance physico – chemical and biological characteristics of soils, also it enhance micronutrient availability under saline soil and improved pH of soil.

B- Yield and its components:

1- Effect of potassium silicate levels:

As shown from data in Table 6, foliar spraying eggplant plants with potassium silicate (PS) at various levels caused significant increases on yield and its components i.e. early yield weight (the first 3 pickings ton/fed), yield weight (from the fourth picking till end of harvesting ton /fed), total yield/fed, fruit weight, diameter and length of eggplant fruits compared to the control treatment. Spraying eggplant plants with the highest level of potassium silicate (6 cm/L) produced the highest values of these traits of yield and its components three times during in both seasons. The second best level of potassium silicate was 4 cm/L and followed by 2 cm/L concerning its effect on yield and its components in both seasons. However, the lowest values of yield and its components were resulted from the control treatment (without spraying with potassium silicate) in both seasons.

Table 3. Plant height, number of leaves/plant, fresh and dry weight of leaves of eggplant after 65 days after transplanting as affected by the interaction between potassium silicate and ammonium thiosulfate (ATS) levels during 2016 and 2017 seasons.

Treatments		Plant height (cm)		Number of leaves/ plant		fresh weight of leaves (g)		dry weight of leaves (g)	
		16	17	16	17	16	17	16	17
Without (control)	0 L ATS/fed	40.21	41.02	32.32	33.41	62.43	64.36	10.51	11.61
	5 L ATS/fed	41.4	43.32	34.41	35.72	68.32	71.41	12.32	13.36
	10 L ATS /fed	43.11	44.34	37.61	38.65	72.21	74.56	13.46	13.96
	15 L ATS /fed	45.10	46.42	38.02	39.81	79.36	83.37	14.31	14.61
2 cm PS/L	0 L ATS/fed	42.31	44.11	34.42	38.52	73.14	76.62	13.23	14.32
	5 L ATS/fed	44.32	45.51	38.05	40.52	82.21	84.21	15.31	16.24
	10 L ATS /fed	46.41	47.73	40.31	42.63	88.61	90.13	16.51	17.36
	15 L ATS /fed	47.11	48.01	44.72	45.50	92.44	94.23	18.34	19.42
4 cm PS/L	0 L ATS/fed	43.21	45.78	41.71	43.67	85.31	87.71	15.34	16.53
	5 L ATS/fed	46.23	47.65	45.92	46.33	92.36	94.19	17.16	18.31
	10 L ATS /fed	47.36	49.66	50.31	51.99	96.51	97.41	18.21	19.46
	15 L ATS /fed	50.21	52.67	55.57	57.64	100.61	103.52	19.73	20.33
6 cm PS/L	0 L ATS/fed	47.31	49.32	55.32	57.73	99.13	102.21	18.44	19.34
	5 L ATS/fed	50.12	52.56	60.46	61.66	105.11	107.31	20.57	21.71
	10 L ATS /fed	55.14	58.78	64.81	66.36	111.61	114.54	21.17	22.26
	15 L ATS /fed	59.61	61.79	69.36	70.76	116.16	120.12	23.24	24.06
F. test		*	*	*	*	*	*	*	*
LSD at 5 %		1.517	1.684	0.270	0.656	2.595	1.338	1.247	0.182

The enhancing effect of foliar spraying eggplant plants with PS might be due to the merge beneficial effects of K and Si, where K mitigates the unhelpful effects of salinity in plants by rising translocation and maintaining water balance (Greenwood and Karpinets, 1997). Also, Si acting a dynamic position in the biochemical processes of a plant and may play a responsibility in the intracellular fusion of organic compounds (Ma *et al*., 2006). These results are in harmony with those of Rakha (2014) on eggplant and Hussein and Muhammed (2017) on eggplant.

2- Effect of ammonium thiosulfate (ATS) levels:

Ammonium thiosulfate (ATS) applied separately as drenching of the soil at different levels i.e. 0, 5, 10, and 15 L/fed exhibited significant effect on fruit yield and its components i.e. early yield ton/f ed, total yield ton/fed, average fruit weight, diameter and length of eggplant fruit in both growing seasons as shown from data in table 6. Fertilizing eggplant plants with the highest level of ATS (15 L/fed) produced the highest values of these traits of the yield and its components. While, fertilizing eggplant plants by way of 10 L ATS/fed ranked the second value and followed by fertilizing with 5 L ATS/fed relating to its effect on yield and its components in both seasons. Conversely, the control treatment (without fertilizing with ATS) resulted in the lowest means of yield and its components in both seasons .

These results may be due to ammonium thiosulfate (ATS) helps in increase crop yields by satisfying the plants natural need for sulfur, and aids in maintaining necessary sulfur levels in soils. In addition the advantages of ATS in enhance macronutrients availability in saline soil and improve the availability of phosphorus fertilizers (Goos, 1995) as well as enhanced micronutrients availability and soil pH change due to it was content of S and SO_4. These results are in agreement with those obtained by Ismail (2013) on eggplant.

3- Effect of the interaction between potassium silicate and ammonium thiosulfate levels:

The interaction between potassium silicate and ammonium thiosulfate (ATS) levels had a significant effect on most studied characters on fruit,yield and its components as well as its quality as shown from data in Table 7. The authors have enough reported the significant interaction between potassium silicate and ammonium thiosulfate (ATS) levels on early yield weight, yield weight, total yield weight, diameter and length of eggplant fruit. The favourable interaction treatment that produced the highest values of early yield weight (first 3 pickings), yield weight (from the fourth picking till end of harvesting) and total yield of early yield and yield weight was foliar spraying eggplant plants with 6 cm potassium silicate/L besides fertilizing with 15 L ATS/fed in both seasons of this study. The second best interaction treatment was foliar spraying with 6 cm potassium silicate/L besides fertilizing with 10 L ATS/fed. Conversely, the lowest means of yields traits were created from control treatment of both studied factors (without spraying with potassium silicate and without using ATS).

These results may be due to the role of potassium silicate in active the biochemical processes of plants and might play imperative role in the intracellular production of organic matters (Ma *et al*., 2006). Moreover, ATS enhance physico – chemical and biological characteristics of soils, also it enhance micronutrient availability of saline soil and improved pH of soil.

C- Chemical constituents:

1- Effect of potassium silicate levels:

Chemical constituents of the leaves after 65 days from transplanting.,.i.e (nitrogen, phosphorus, potassium and proline percentages) and also the chemical content of fruits taken from the fourth picking to determine (nitrogen, phosphorus , potassium, total soluble solids percentages and total iron content) showed significant influences by foliar spraying eggplant plants with potassium silicate at various levels in both seasons as shown in Tables 4 and 8. The highest values of chemical constituents of the leaves after 65 days from transplanting and the fruits taken at the fourth picking were achieved when spraying eggplant plants with 6 cm potassium silicate/L in both seasons. While, spraying with 4 cm potassium silicate/L ranked the second after spraying with 6 cm potassium silicate/L and followed by spraying with 2 cm potassium silicate/L in both seasons. On the contrary, the lowest values from chemical constituents of the leaves as well as fruits were formed from without spraying eggplant with potassium silicate (control treatment) in both seasons. Concerning proline percentage in the leaves after 65 days from transplanting, it had a converse trend of other studied chemical constituents in both seasons.

The enhancing effect of foliar spraying eggplant plants with PS might be due to the merge beneficial effects of K and Si, where K mitigates the unhelpful effects of salinity in plants by rising translocation and maintaining water balance. Also, Si acting a dynamic position in the biochemical processes of a plant and may play a responsibility in the intracellular fusion of organic compounds (Ma *et al*., 2006). The obtained results are in accordance with those of Hussein and Muhammed (2017) on eggplant.

Table 4. Nitrogen, phosphorus, potassium and proline percentages in leaves of eggplant after 65 days after transplanting as affected by potassium silicate and ammonium thiosulfate (ATS) levels as well as their interaction during 2016 and 2017 seasons.

Characters	N (%)		P (%)		K (%)		Proline (%)	
Treatments	2016	2017	2016	2017	2016	2017	2016	2017
A- Potassium silicate levels.								
Without (control)	2.15	2.22	0.295	0.299	2.715	2.735	10.67	10.45
2 cm/L	2.43	2.47	0.316	0.328	3.095	3.050	9.66	9.46
4 cm/L	2.77	2.75	0.326	0.342	3.188	3.230	8.66	8.49
6 cm/L	3.19	3.27	0.364	0.375	3.326	3.353	7.73	7.51
F. test	*	*	*	*	*	*	*	*
LSD at 5 %	0.02	0.03	0.012	0.019	0.004	0.003	0.08	0.07
B- ATS levels:								
0 L/fed (control)	2.44	2.49	0.310	0.320	2.935	2.985	9.76	9.45
5 L/fed	2.54	2.59	0.319	0.331	3.032	3.055	9.41	9.21
10 L/fed	2.72	2.76	0.331	0.342	3.096	3.130	8.89	8.73
15 L/fed	2.87	2.87	0.341	0.349	3.170	3.198	8.65	8.51
F. test	*	*	*	*	*	*	*	*
LSD at 5 %	0.02	0.03	0.018	0.015	0.006	0.003	0.05	0.05
C- Interaction: A× B	*	*	*	*	*	*	*	*

ATS = Ammonium thiosulfate (12 – 0 – 0 – 26 NPKS)

Table 5. Nitrogen, phosphorus, potassium and proline percentages in leaves of eggplant after 55 days after transplanting as affected by the interaction between potassium silicate and ammonium thiosulfate (ATS) levels during 2016 and 2017 seasons.

Treatments		N (%) 16	N (%) 17	P (%) 16	P (%) 17	K (%) 16	K (%) 17	Proline (%) 16	Proline (%) 17
Without (control)	0 L ATS/fed	2.02	2.11	.288	.291	2.61	2.65	11.35	10.98
	5 L ATS/fed	2.10	2.19	.294	.295	2.69	2.70	10.94	10.63
	10 L ATS /fed	2.19	2.27	.298	.301	2.75	2.76	10.36	10.23
	15 L ATS /fed	2.28	2.31	.300	.309	2.81	2.83	10.04	9.96
2 cm PS/L	0 L ATS/fed	2.22	2.31	.301	.308	2.91	2.94	10.23	9.93
	5 L ATS/fed	2.32	2.42	.310	.329	2.95	2.98	9.86	9.74
	10 L ATS /fed	2.54	2.54	.321	.335	3.01	3.09	9.42	9.23
	15 L ATS /fed	2.62	2.62	.332	.342	3.15	3.19	9.13	8.93
4 cm PS/L	0 L ATS/fed	2.52	2.44	.311	.327	3.02	3.10	9.24	9.03
	5 L ATS/fed	2.64	2.52	.321	.335	3.19	3.21	8.92	8.86
	10 L ATS /fed	2.91	2.93	.332	.348	3.25	3.28	8.36	8.12
	15 L ATS /fed	3.01	3.11	.343	.356	3.29	3.33	8.11	7.94
6 cm PS/L	0 L ATS/fed	3.02	3.11	.341	.354	3.20	3.25	8.24	7.87
	5 L ATS/fed	3.11	3.22	.352	.366	3.30	3.33	7.92	7.61
	10 L ATS /fed	3.22	3.32	.374	.387	3.36	3.39	7.45	7.33
	15 L ATS /fed	3.42	3.43	.390	.391	3.43	3.44	7.32	7.21
F. test		*	*	*	*	*	*	*	*
LSD at 5 %		0.062	0.084	1.630	1.155	1.660	0.084	0.175	0.191

2- Effect of ammonium thiosulfate (ATS) levels:

Concerning the effect of adding ammonium thiosulfate (ATS) as soil drenching at different levels on chemical constituents of leaves after 65 days from transplanting i.e. nitrogen, phosphorus, potassium and proline percentages as well as in the fruits at the fourth picking to determine each of (nitrogen, phosphorus , potassium, total soluble solids percentages and total iron content), it was found that the treatments induced significant values for all results in both seasons as shown in the data presented at Tables 4 and 8. The highest values of chemical constituents of leaves after 65 days from transplanting and on the fruits obtained from the fourth picking as a result of adding 15 L from ATS/fed were obtained when fertilizing eggplant plants in both seasons. Whereas, using 10 L ATS/fed ranked secondly after using 15 L ATS/fed and followed by using with 5 L ATS/fed in both seasons. In contrast, the lowest values of chemical constituents of leaves and fruits were formed from the control treatment (without ATS and spraying with tap water) in both seasons. Relating to proline percentage in the leaves after 65 days after transplanting, it had a converse trend from the other studied chemical constituents in both seasons.

Table 6. Early yield weight/fed, yield weight/fed, total yield/fed, fruit weight, diameter and length of, eggplant as affected by potassium silicate and ammonium thiosulfate (ATS) levels as well as their interaction during 2016 and 2017 seasons.

Characters Treatments	Early yield weight (t/fed) 2016	Early yield weight (t/fed) 2017	Yield weight (t/fed) 2016	Yield weight (t/fed) 2017	Total yield (t/fed) 2016	Total yield (t/fed) 2017	Fruit weight (g) 2016	Fruit weight (g) 2017	Fruit diameter (cm) 2016	Fruit diameter (cm) 2017	Fruit length (cm) 2016	Fruit length (cm) 2017
A- Potassium silicate levels.												
Without (control)	1.645	1.736	3.455	3.629	5.100	5.365	28.38	30.20	2.883	2.915	9.25	9.48
2 cm/L	1.986	2.048	4.141	4.270	6.127	6.318	34.18	35.36	3.013	3.070	10.08	10.44
4 cm/L	2.282	2.353	4.775	5.000	7.057	7.353	40.47	41.94	3.090	3.203	10.77	11.04
6 cm/L	2.549	2.500	5.106	5.398	7.655	7.898	44.39	45.41	3.213	3.263	11.51	11.86
F. test	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	0.068	0.069	0.268	0.035	0.045	0.055	0.690	1.014	1.600	0.095	0.07	0.04
B- ATS levels:												
0 L/fed (control)	1.827	1.869	3.806	3.957	5.633	5.826	32.22	33.72	2.927	3.035	9.45	9.74
5 L/fed	2.031	2.055	4.142	4.383	6.173	6.438	35.46	36.58	3.008	3.068	10.18	10.48
10 L/fed	2.188	2.265	4.553	4.759	6.741	7.024	38.21	39.85	3.098	3.143	10.68	11.06
15 L/fed	2.421	2.448	4.973	5.199	7.394	7.647	41.52	42.77	3.165	3.205	11.30	11.54
F. test	*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	0.047	0.044	0.043	0.052	0.041	0.054	0.63	0.64	0.016	0.186	0.050	0.060
C- Interaction: A× B	*	*	*	*	*	*	*	*	*	*	*	*

ATS = Ammonium thiosulfate (12 – 0 – 0 – 26 NPKS

These results may be due to ammonium thiosulfate (ATS) which helps in increase crop yields by satisfying the plants natural need for sulfur, and aids in maintaining necessary sulfur levels in soils.It is may be also that return to the enhancing effect on the growth with high values on number of leaves/plant as well as fresh and dry weight of leaves and the reflection of that on photosynthesis. In addition the advantages of ATS in enhance macronutrients availability in saline soil and improve the availability of phosphorus fertilizers (Goos, 1995) as well as enhanced micronutrients availability and regulated soil pH change and this due to rasing contents of S and SO_4 in the soil.These results are in agreement with those obtained by Ismail (2013) on eggplant.

Table 7. Early yield weight t/fed, yield weight t/fed, total yield t/fed, fruit weight, diameter and length of, eggplant as affected by the interaction between potassium silicate and ammonium thiosulfate (ATS) levels during 2016 and 2017 seasons.

Treatments		Early yield weight (t/fed)		Yield weight t/fed		Total yield weight t/fed		Fruit weight (g)		Fruit diameter (cm)		Fruit length (cm)	
		16	17	16	17	16	17	16	17	16	17	16	17
Without (control)	0 L ATS/fed	1.480	1.515	2.971	3.138	4.451	4.653	24.63	26.35	2.80	2.83	8.77	8.95
	5 L ATS/fed	1.573	1.617	3.219	3.427	4.792	5.044	26.74	28.85	2.86	2.90	9.07	9.35
	10 L ATS /fed	1.674	1.827	3.649	3.789	5.323	5.616	29.53	31.42	2.91	2.94	9.19	9.53
	15 L ATS /fed	1.854	1.986	3.982	4.161	5.836	6.147	32.61	34.15	2.96	2.99	9.97	10.09
2 cm PS/L	0 L ATS/fed	1.711	1.789	3.504	3.556	5.215	5.345	30.35	31.35	2.92	2.96	9.18	9.41
	5 L ATS/fed	1.901	1.947	3.834	4.006	5.735	5.953	32.42	33.49	2.97	3.03	9.77	10.24
	10 L ATS /fed	2.022	2.132	4.404	4.509	6.426	6.641	35.39	36.91	3.04	3.10	10.41	10.93
	15 L ATS /fed	2.313	2.324	4.820	5.010	7.133	7.334	38.42	39.71	3.12	3.19	10.95	11.19
4 cm PS/L	0 L ATS/fed	2.013	2.041	4.220	4.401	6.233	6.442	35.38	36.42	2.95	3.05	9.51	9.95
	5 L ATS/fed	2.174	2.314	4.650	4.817	6.824	7.131	39.45	40.36	3.03	3.09	10.61	10.85
	10 L ATS /fed	2.342	2.413	5.010	5.180	7.352	7.593	41.63	43.67	3.16	3.20	11.21	11.42
	15 L ATS /fed	2.603	2.637	5.218	5.607	7.821	8.244	45.42	47.31	3.22	3.26	11.71	11.94
6 cm PS/L	0 L ATS/fed	2.101	2.131	4.531	4.733	6.632	6.864	38.40	40.71	3.04	3.09	10.32	10.63
	5 L ATS/fed	2.474	2.341	4.867	5.282	7.341	7.623	43.22	43.62	3.17	3.25	11.25	11.49
	10 L ATS /fed	2.712	2.684	5.151	5.560	7.863	8.244	46.31	47.41	3.28	3.33	11.92	12.34
	15 L ATS /fed	2.910	2.845	5.874	6.018	8.784	8.863	49.63	49.91	3.36	3.38	12.55	12.94
F. test		*	*	*	*	*	*	*	*	*	*	*	*
LSD at 5%		0.199	0.200	0.268	0.102	0.131	0.101	2.25	2.93	0.18	0.27	0.278	0.112

Table 8. Nitrogen, phosphorus , potassium, total soluble solids (TSS) percentages and total iron (Fe) content in eggplant fruits at harvesting time as affected by potassium silicate and ammonium thiosulfate (ATS) levels as well as their interaction during 2016 and 2017 seasons.

Characters	N (%)		P (%)		K (%)		TSS (%)		Fe (ppm)	
Treatments	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
A- Potassium silicate levels.										
Without (control)	2.13	2.22	0.248	0.247	2.51	2.53	4.37	4.42	27.41	28.18
2 cm/L	2.37	2.34	0.267	0.271	2.60	2.60	4.54	4.60	29.47	30.32
4 cm/L	2.60	2.59	0.276	0.280	2.65	2.66	4.64	4.75	30.96	31.41
6 cm/L	2.78	2.89	0.307	0.316	2.70	2.69	5.12	5.20	33.15	32.63
F. test	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	3.88	0.07	3.33	2.24	2.08	1.96	1.31	1.95	0.26	0.58
B- ATS levels:										
0 L/fed (control)	2.27	2.31	0.248	0.252	2.53	2.54	4.40	4.47	28.64	28.95
5 L/fed	2.44	2.44	0.265	0.270	2.60	2.60	4.57	4.65	29.72	30.29
10 L/fed	2.55	2.55	0.287	0.289	2.65	2.65	4.75	4.84	30.68	31.08
15 L/fed	2.64	2.69	0.299	0.304	2.69	2.69	4.94	5.00	31.96	32.22
F. test	*	*	*	*	*	*	*	*	*	*
LSD at 5 %	1.04	3.54	3.33	2.24	2.08	1.90	3.54	1.06	0.21	0.48
C- Interaction: A× B	*	*	*	*	*	*	*	*	*	*

ATS = Ammonium thiosulfate (12 – 0 – 0 – 26 NPKS)

3- Effect of the interaction between potassium silicate and ammonium thiosulfate levels:

The interaction between potassium silicate and ammonium thiosulfate (ATS) levels had a significant effect on most studied characters of chemical contents either in leaves or fruits as shown in Tables 5 and 9. It can said that,the interaction between potassium silicate and ammonium thiosulfate (ATS) levels showed significant effect on chemical constituents of leaves after 65 days from transplanting.,i.e (nitrogen, phosphorus, potassium and proline percentages) and in the taken from the fourth picking fruits, i.e. (nitrogen, phosphorus , potassium, total soluble solids percentages and total iron content) .The favourable interaction treatment that produced the highest values was foliar spraying eggplant plants with 6 cm potassium silicate/L besides fertilizing with 15 L ATS/fed in both seasons of this study. The second best interaction treatment was foliar spraying with 6 cm potassium silicate/L besides fertilizing with 10 L ATS/fed in both seasons. On the other hand, the lowest values of yields traits were resulted from the control treatment (without spraying with potassium silicate and without using ATS).

These results possibly will be due to the responsibility of PS in activating the biochemical processes of plants and might play a position in the intracellular creation of organic compounds (Fawe 1998). Moreover, ATS enhance physico – chemical and biological characteristics of the soil, also it enhance micronutrient availability of saline soil and improved pH of the soil.

D- Economic feasibility:

The economic feasibility of eggplant plants as affected by spraying potassium silicate and adding ammonium thiosulfate (ATS) levels as well as their interaction are presented in Table 10. The results showed that the highest net return 10684 LE/fed over both seasons was obtained from foliar spraying eggplant plants with 6 cm potassium silicate/L and using 15 L ATS/fed as soil drenching, such treatment returns the highest benefit cost ratio (2.53) in comparison with the other treatments. Therefore, this treatment considered to be economical for eggplant production under soil salinity and the environmental condition of Sahl El-Husseiniya, Sharkia Governorate.

Table 9. Nitrogen, phosphorus , potassium, total soluble solids (TSS) percentages and total iron (Fe) content in eggplant fruits at harvesting time as affected by the interaction between potassium silicate and ammonium thiosulfate (ATS) levels during 2016 season.

Treatments		N (%) 16	N (%) 17	P (%) 16	P (%) 17	K (%) 16	K (%) 17	TSS (%) 16	TSS (%) 17	Fe (ppm) 16	Fe (ppm) 17
Without (control)	0 L ATS/fed	1.98	2.06	0.224	0.226	.44	2.46	4.18	4.20	26.36	27.24
	5 L ATS/fed	2.09	2.16	0.242	0.237	2.49	2.50	4.29	4.32	27.24	28.12
	10 L ATS /fed	2.17	2.25	0.256	0.253	2.53	2.55	4.44	4.53	27.91	28.95
	15 L ATS /fed	2.28	2.36	0.270	0.273	2.59	2.61	4.56	4.63	29.13	29.76
2 cm PS/L	0 L ATS/fed	2.12	2.18	0.241	0.246	2.51	2.50	4.28	4.37	28.35	29.14
	5 L ATS/fed	2.35	2.26	0.257	0.263	2.59	2.58	4.41	4.52	28.93	29.96
	10 L ATS /fed	2.47	2.39	0.278	0.281	2.63	2.64	4.65	4.69	29.74	30.54
	15 L ATS /fed	2.56	2.52	0.291	0.294	2.67	2.68	4.81	4.81	30.86	31.64
4 cm PS/L	0 L ATS/fed	2.40	2.37	0.255	0.258	2.58	2.59	4.35	4.43	29.51	30.35
	5 L ATS/fed	2.55	2.57	0.267	0.271	2.64	2.63	4.55	4.62	30.31	31.46
	10 L ATS /fed	2.67	2.63	0.286	0.291	2.69	2.70	4.71	4.82	31.43	31.27
	15 L ATS /fed	2.78	2.79	0.296	0.301	2.71	2.72	4.93	5.11	32.62	32.56
6 cm PS/L	0 L ATS/fed	2.58	2.61	0.272	0.281	2.61	2.62	4.79	4.89	31.32	30.41
	5 L ATS/fed	2.75	2.78	0.295	0.309	2.68	2.67	5.01	5.13	32.41	31.62
	10 L ATS /fed	2.87	2.91	0.325	0.329	2.73	2.72	5.21	5.32	33.65	33.57
	15 L ATS /fed	2.93	3.10	0.339	0.346	2.77	2.75	5.45	5.47	35.24	34.93
F. test		*	*	*	*	*	*	*	*	*	*
LSD at 5 %		3.88	5.62	3.33	2.47	2.08	3.85	1.31	3.95	0.75	1.70

Table 10. Economic feasibility of eggplant production as affected potassium silicate (PS) and ammonium thiosulfate (ATS) levels as well as their interaction over both seasons.

Treatments		Total yield (t/fed)(1)	Gross return (LE/fed)(2)	Treatment cost (LE/fed)(3)	Total variable cost (LE/fed)(4)	Net return (LE/fed)(5)	Benefit cost ratio(6)	Order
Without (control)	0 L ATS/fed	4.5520	9104	-	6536	2568	1.390	16
	5 L ATS/fed	4.9180	9836	125	6661	3175	1.470	15
	10 L ATS /fed	5.4695	10939	250	6786	4153	1.611	14
	15 L ATS /fed	5.9915	11983	375	6911	5072	1.730	12
2 cm PS/L	0 L ATS/fed	5.2855	10571	17.5	6553	4018	1.613	13
	5 L ATS/fed	5.8440	11688	142.5	6678	5010	1.750	11
	10 L ATS /fed	6.5335	13067	267.5	6803	6265	1.920	10
	15 L ATS /fed	7.2335	14467	392.5	6928	7539	2.088	6
4 cm PS/L	0 L ATS/fed	6.3375	12675	35	6571	6104	2.076	8
	5 L ATS/fed	6.9775	13955	160	6696	7259	2.084	7
	10 L ATS /fed	7.4725	14945	286	6822	8123	2.190	5
	15 L ATS /fed	7.7070	15414	410	6946	8468	2.219	4
6 cm PS/L	0 L ATS/fed	6.7480	13496	52.5	6588	6908	2.048	9
	5 L ATS/fed	7.4820	14964	177.5	6713	8251	2.229	3
	10 L ATS /fed	8.0535	16107	302.5	6838	9269	2.355	2
	15 L ATS /fed	8.8235	17647	427.5	6963	10684	2.534	1

(1) Eggplant total yield as average over both seasons. (2) Gross return as total yield(ton fed) x 2000 LE ton.(3)Treatment cost was calculated according to the following prices: Potassium silicate =35 LE/L; ATS=25 LE/L.(4) Total variable cost (LE Fed) include : Treatment cost plus land leasehold ,transplant,N,P and K Fertilizers, microelements,pesticides,labors and other cultural practices which equal nearly 6536 LE Fed.(5) = (2) – (4) .(6) = (2) / (4) .

CONCLUSION

According to the obtained data in this study, it could be recommended that foliar spraying eggplant plants with 6 cm potassium silicate/L three times for the treatment with applied 15 L ATS/fed separately drenching of soil around the plant four times for the treatment to enhance vegetative growth characters, yield and its components and chemical constituents of eggplant fruits under soil salinity as well as the environmental condition of Sahl El-Husseiniya, Sharkia Governorate.Moreover the highest gross return and net return were obtained from the same favourite treatments.

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تأثير بعض المعاملات التي تقلل من تأثير اضرار الملوحة على نمو ومحصول وجودة الباذنجان

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أجريت تجربة حقلية بمزرعة خاصة في قرية الرواد بسهل الحسينية - محافظة الشرقية خلال موسمي 2016 و2017 لدراسة تأثير مستويات من سيليكات البوتاسيوم وثيوسلفات الأمونيوم على النمو الخضري ، المحصول ومكوناته والمكونات الكيميائية للباذنجان صنف بلاك بيونى وكذلك العائد الاقتصادى. أجريت التجربة باستخدام تصميم القطع المنشقة بنظام القطاعات كاملة العشوائية في ثلاثة مكررات. تم تخصيص القطع الرئيسية لمستويات الرش الورقى بسيليكات البوتاسيوم. في حين وزعت مستويات ثيوسلفات الأمونيوم كاضافة ارضية في القطع المنشقة. ويمكن تلخيص أهم النتائج المتحصل عليها على النحو التالي: أدى الرش الورقى لنباتات الباذنجان بمستويات 6,4,2سم/لتر من سيليكات البوتاسيوم للتأثير المعنوى على صفات النمو الخضري ، المحصول ومكوناته والمكونات الكيميائية بالأوراق والثمار مقارنة بمعاملة المقارنة في كلا الموسمين. حيث نتجت أعلى القيم من تلك الصفات من الرش بـ 6 سم سيليكات البوتاسيوم / لتر لعدد ثلاث رشات في كلا الموسمين. كما تشير النتائج المتحصل عليها تأثر صفات النمو الخضري ، المحصول ومكوناته والمكونات الكيميائية لأوراق وثمار الباذنجان معنوياً نتيجة للتسميد بمستويات مختلفة من ثيوسلفات الأمونيوم في كلا الموسمين. حيث نتجت أعلى القيم لهذه الصفات عند استخدام 15 لتر من ثيوسلفات الأمونيوم / فدان يلى ذلك معاملة 10 لتر من ثيوسلفات الأمونيوم / فدان ، على التوالي في كلا الموسمين.ولكن كانت افضل المعاملات المتحصل عليها لانتاج اعلى القيم سواء للنمو و المحصول و مكوناتة ناتجة من التداخل بين الرش بـ 6 سم سيليكات البوتاسيوم / لتر لعدد ثلاث رشات مع اضافة15 لتر من ثيوسلفات الأمونيوم / فدان لعدد اربع رشات في كلا الموسمين. وعلية توصى النتائج المتحصل عليها من هذه الدراسة بالرش الورقى لنباتات الباذنجان بـ 6 سم سيليكات البوتاسيوم / لتر ثلاث رشات مع اضافة بـ 15 لتر ثيوسلفات الأمونيوم / فدان اربع رشات للتربة حول النبات لزيادة النمو الخضري والمحصول ومكوناته والمكونات الكيميائية لثمار الباذنجان تحت الظروف البيئية لهذا البحث.