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Using Nutrient Elements, Humic Acids and Amino Acids to Maximize Tomato Plants Production under Soil Salinity Conditions: 1. Effect on Growth and Macronutrient Status.

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ABSTRACT

A pot experiments were conducted at greenhouse of National Research Center. using sample collected from El Husseineya - Port Said, Egypt. Experiment was carried out to studies the best soil addition treatments maximized growth of tomato plants under soil salinity conditions. The treatments are: (Control, Humic acid 2%, Algae extract 2%, Potassium 500 ppm, Silica 8 mM, Proline 100 ppm).

Addition of humic acid increase percent of plant height and root length by 29.34%, 38.06% then potassium by 26.73%, 27.97% ,silica by 23.65%, 14.7% , algae 20.36%, 9.96% and finally proline 14.58%, 8.04%. Also, humic acid treatment gave best growth (fresh and dry weight) of tomato plants while the lowest one was proline treatment.

All soil additions give significant positive effect on N content compared with control, the increase ranged between 2.47% up to 4.51% in shoot and from 1.38% up to 3.22% in root. The maximum values of P content obtained using humic acid 0.44%, 0.33% for shoot and root coppered with control. The highest K concentration values in shoot and root of tomato plants were obtained by using K treatment (6.35%, 5.94%) while the lowest ones were attained by applying proline treatment (3.04%, 2.47%) for shoot and root respectively.

Generally, the best tretments were humic acid, potassium and algae which gave a significant increase in all the growth parameters and helped tomato plants grown in saline soil condition.
KEY WORDS: Algae, Humic acid, organic matter, Potassium, Proline, Salinity, Silica, Tomato.

Introduction

Tomato *(Lycopersicon esculentum Mill.),* belonging to the family Solanaceae, is one of the most important, popular, nutritious and palatable vegetables Egypt is one of the major tomato producing and exporting country. Most land is cropped at least twice a year, but agricultural productivity is limited by salinity, which afflicts an estimated 35% of cultivated land, and drainage problems. Tomato is one of the most important, popular, nutritious and palatable vegetables grown in Egypt. It plays a vital role in providing a remarkable quantity of vitamin A and vitamin-C in human diet. It can be eaten both in raw as well as ripe and after cooking. The production of tomatoes in Egypt was approximately 7 million metric Tons.

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Salinity in the soil causes limitation in the plant growth, productivity particularly in arid and semi-arid areas **(Shannon, 1998).** Salinity is the level of salt dissolved in water. Salinity can refer to the salt contained in the soil. Saline conditions are often found in lowland areas. High concentrations of salt can cause high amounts of Na^+ to accumulate easily in plant cells, which is toxic at high concentrations **(Mathius, 2014).**

Gupta, (1987) found that the organic and inorganic amendments are effective in the amelioration of saline soils. Organic matter decomposition and plant root action also help dissolve the calcium compounds found in most soils, thus promoting reclamation of saline soil.

The addition of organic matter or its extracts to the soil has a very important effect on the various physical, chemical, and biological properties of the soil, as it is an important source of many nutrients and an essential source of energy for soil organisms **(Tan, 2014; Al-Khafaji, 2015 and Abd El-Monem et al., 2008).** Some organic extracts (chelates) such as humic acid have a significant role in improving plant growth and increasing the efficiency of roots in absorbing water and dissolved nutrients, increasing the plant's ability to tolerate salt stress, and improving various physical, chemical, and biological properties of the soil **(Jasim et al., 2015 and Ragab et al., 2008).**

Potassium is one of the critical macro-elements for plant growth because it is involved in some physiological processes such as (1) biophysical processes in its role in controlling osmotic, cell turgor, pH stability, and (2) biochemical processes in its role in the activity of enzymes in synthesizing carbohydrates and proteins as well as increasing photosynthetic translocation **(Amisnaipa et al., 2009).** Adding K to the soil can neutralize the land from Na stress, and this works for some plants, including tomatoes **(Pujiasmanto et al., 2010).**

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).**

Proline is known to accumulate under conditions of environmental stresses to play a role in the process of osmotic adjustment in many crops **(Heuer, 1994).** Their main role is probably to protect plant cells against the ravages of salt by preserving the osmotic balance **(Heuer, 2003, Ashraf and Foolad, 2007).**

Algae have been used for the production of plant biostimulants, i.e. of bioproducts which contain substances "whose function, when applied to plants or the rhizosphere, is to stimulate natural processes, to enhance/benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, and crop quality". **(European Biostimulant Industry Council, EBIC 2014).** Algae contain important quantities of plant growth hormones, auxins, abscisic acid, cytokinins, gibberellins **(Tarakhovskaya et al., 2007).**

The aim of this investigation was evaluated of effect of some treatments for reducing salinity damage on Growth, Yield and Quality of tomato.

MATERIALS AND METHODS

Greenhouse experiment was conducted using saline soil to study the impact of some soil treatments (element nutrition and amino acid) to minimize adverse effect of salinity on plant growth.

Surface soil sample was collected from El Husseineya - Port Said, Egypt. Before being used, the soil samples were air dried, pulverized, sieved through a sieve 2mm, and thoroughly combined. The physic-chemical characteristics of the studied soil were determined according to international methods and summarized in Table (1).

Table (1): Some of the soil's physical and chemical features.

Physical properties							
Coarse sand	**Fine sand**	**Silt**	**Clay**	**Texture**	**Field capacity**	**Wilting point**	**Available water**
%					**%**		
6.73	23.90	30.27	39.10	**Clay loam**	32.43	13.44	18.99

Chemical properties						
pH (1:2.5)	**EC (dSm^{-1})**	**O.M**	**$CaCO_3$**	**Macronutrients ($mgkg^{-1}$)**		
		(%)		**N**	**P**	**K**
8.12	9.88	0.58	11.75	34.60	4.22	187.00

Cations ($meql^{-1}$)				**Anions ($meql^{-1}$)**			**Micronutrients ($mgkg^{-1}$)**			
Ca^{++}	**Mg^{++}**	**Na^{+}**	**K^{+}**	**HCO_3^{-}**	**Cl^{-}**	**$SO_4^{=}$**	**Fe**	**Mn**	**Zn**	**Cu**
12.55	22.10	63.34	0.81	9.77	57.20	31.83	6.12	2.88	0.59	1.18

Plastic pots with dimensions (20* 24 cm) were used. They were filled with 5 kg of soil that was mixed and homogeneous. The recommended fertilizer treatments for each pot were placed before planting, which are (ammonium sulfate 300 kgfed^{-1}) - potassium sulfate 200 kgfed^{-1} superphosphate 100 kgfed^{-1}500 ml l.

Tomato seedlings of hybrid Alicia variety, which were get from the Agricultural Research Center in El Husseineya, Port Said, planted on April 16th, by placing two seedlings in each pot, irrigated with 70% of field capacity and maintain the moisture level by irrigation every 4 days.

After two weeks from transplanting, on May 2, the treatments have been applied with 4 replicate for each treatment.

The treatments are:500 ml l for every pot from soluatian of water as control , Humic acid 2g l^{-1}, Algae extract 2%, Potassium 500 ppm as potassium nitrate, Silica 8 mM (as calcium silicate andProline 100 ppm

General photos for pot experiment.

All of the pots are placed in a randomized block pattern. On May 17^{th}, at the vegetative development stage, chlorophyll was detected in the leaves of tomato plants.

At the beginning of the flowering stage(June 24) plants were collected, after 68 days of transplanting, and deferent parameters were recorded (plant length - branches number per plant - leaves number per plant - fresh and dry weight) and determents (N, P, K, Na, Fe, Mn, Zn and Cu).

Analytical statistics: The findings were analyzed using **Snedecor and Cochran's (1982)** analysis of variance, and the treatments were compared using the L.S.D test at the 0.05 levels of probability.

RESULTS AND DISCUSSION

The experiment aims to apply some soil treatments that previous studies have referred to, with regard to their ability to reduce the harmful effects of salt on tomato plants, to choosing best treatment. Therefore, humic acid (H.A), algae, potassium as KNO_3, silica and proline were employed to investigate their impact on the development of tomato plants in a saline soil from El Husseineya area. To study its effect on the vegetative characteristics of tomato plants and the nutritional content under the influence of saline soil.

In many semi-arid locations, such as the Mediterranean, where salt has been a major limit in agricultural production, the tomato plant is regarded a significant greenhouse crop.

Vegetative growth:

Data presented in Table (2) and illustrated in Fig (1, 2) show the effect of soil treatments on plant height and root length of tomato plants. All treatment used are given significant increases compared with control. These increases can be attributed to improving effect of soil additions to help tomato plants for growth under salinity condition. The obtained data agree with those found by **Khaled and Fawy (2011), Hala Kandil et al., (2020), Chakraborty, et al., (2016), Ali et al., (2012) and Tala et al., (2013)** who found that addition humic acid, algae, potassium, silica and proline increased all growth parameters for corn, parsley, peanut and wheat respectively.

Data revealed that addition of humic acid increased plant height and root length by 29.34%, 38.06% followed by potassium 26.73%, 27.97% then silica by 23.65%, 14.7% then algae 20.36%, 9.96% and finally proline 14.58%, 8.04%. On the other hand leaf number gives non- significant increase with algae, silica and proline treatment compared with control.

The highest plant height, root length and leaf number recorded under humic acid treatment (43.2 cm, 11.5 cm and 13.66) respectively. This confirm with results by **Türkmen et al., (2004) and Paksoy et al., (2010)** who reported that the humic acid treatment improved the growth characteristics of plants growing in a saline environment. **Khaled and Fawy (2011)** also discovered that the most cost-effective treatment amounts should be selected and should not exceed 2 g humus kg^{-1} in soil and 0.1 percent in foliar treatment.

Table (2): Effect of some soil application on some growth parameters for tomato plant in El Husseineya soil.

Treatments	plant height (cm)	Root length (cm)	Leaf number per plant
Control	33.40^{f}	8.33^{f}	10.33^{b}
H.A	43.20^{a}	11.50^{a}	13.66^{a}
Algae	40.20^{d}	9.16^{d}	11.33^{b}
K	42.33^{b}	10.66^{b}	13.66^{ab}
Si	41.30^{c}	9.56^{c}	11.33^{b}
Proline	38.27^{e}	9.00^{e}	11.66^{b}
LSD	0.183	0.074	2.179

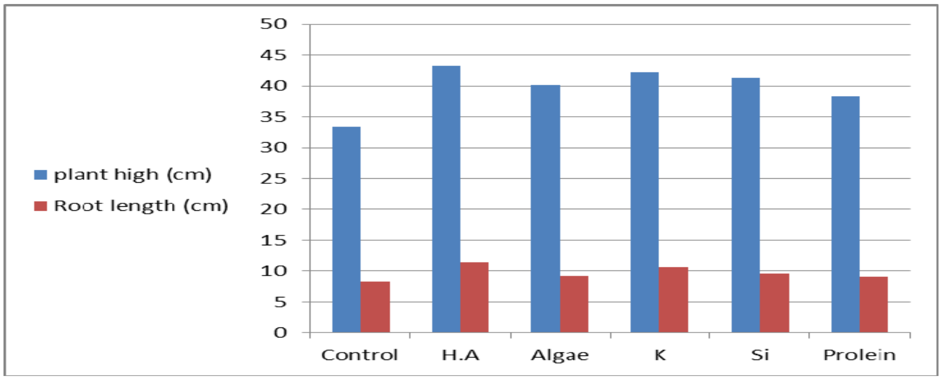

Fig. (1): Effect of some soil application on plant height and root length for tomato plant in El Husseineya soil.

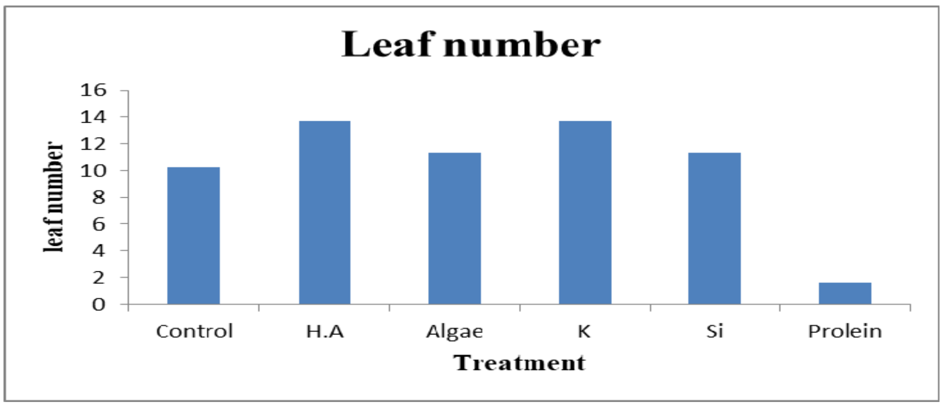

Fig. (2): Effect of some soil application on leaf number for tomato plant in El Husseineya soil.

Data of Fresh and dry weights are presented in table (3) and illustrated in figs (3 and 4). The obtained data indicated that fresh and dry weights of tomato plants grown under saline soil give positive response for all soil additions compared with control.

Data revealed an increasing in dry weight percentage of shoot and root tomato plants for humic acid (68% and 71.4%) these results confirm with **Ouni et al., (2014)** who reported that the direct actions for humic acid effects on germination, plant growth (root and shoot), and hormone-like activity on plants are attributable to their effects on germination.

In general, H.A treatment gave best growth (fresh and dry weight) of tomato plants and the lowest growth was attained under proline treatment as compared to other forms of therapy. These findings are consistent with previous findings by **Cimrin et al. (2010)** they found that Pepper plant growth was improved by humic acid treatment in terms of fresh and dry weight, shoot and root lengths, shoot breadth, cotyledon length and breadth, and hypocotyls length.

Table (3): Effect of soil treatments on Fresh and dry weight of tomato plant

Treatment	Fresh weight (g)		Dry weight (g)	
	Shoot	Root	Shoot	Root
Control	7.63^{f}	0.93^{e}	2.50^{d}	0.35^{d}
H.A	12.76^{a}	1.80^{a}	4.20^{a}	0.60^{a}
Algae	10.13^{d}	1.53^{b}	3.30^{bc}	0.53^{b}
K	11.40^{b}	1.31^{c}	3.75^{ab}	0.50^{b}
Si	10.63^{c}	1.23^{d}	3.50^{a-c}	0.43^{c}
Proline	9.36^{e}	0.83^{f}	3.00^{cd}	0.43^{c}
LSD	0.127	0.0178	0.723	0.032

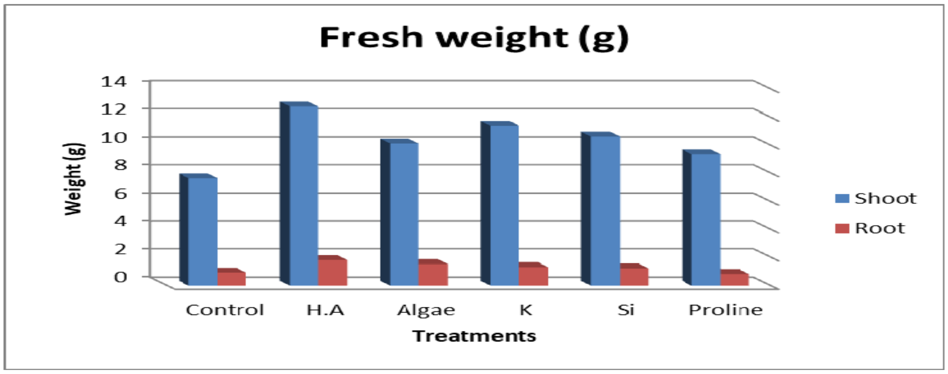

Fig. (3): Effect of soil treatments on fresh weight (shoot and root) for tomato plant

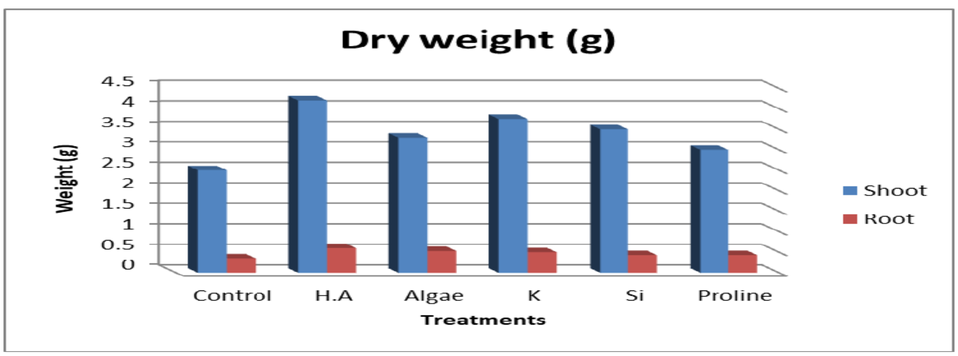

Fig. (4): Effect of soil treatments on dry weight (shoot and root) for tomato plant

Macronutrients:

Nitrogen (N), Phosphorus (P) and Potassium (K^+) are key macronutrients that have a role in a variety of plant processes, particularly storage and energy transport. Plant development requires soil macronutrients (N, P, and K).

Nutrients play a variety of roles in the structure, metabolism, and osmoregulation of plant cells in general **(Taiz and Zeiger, 2009).** Nutritional problems, which are caused by salinity's influence on the availability, absorption, and transport inside the plant, are one of the most significant salt stress impacts on plants **(Munns and Tester, 2008).** The negative effects of salinity on plant development and production are ascribed by nutrient shortage, ion toxicity, and osmotic stress **(Nublat et al., 2001)**.

Because more Na and Cl ions compete with nutrients like K^+, Ca^{2+}, and NO_3^-, salinity can create nutrition deficits or imbalances. On the other side, it has the potential to influence nutrient absorption and hinder nutrient translocation. Improved fertilizer management in arid and semiarid settings by a better knowledge of the function of mineral nutrients in plant tolerance to salt **(Hu et al., 2017).**

This part of the experiment was concerned with the effect of soil treatments on tomato plants' macronutrient (N-P-K).

Nitrogen (N):

Nitrogen makes for around 80% of total mineral nutrients. Its availability is the most extensively limiting factor for plant growth and productivity under salt stress. It has been discovered that the interaction between salinity and nitrogen occurs more frequently in soils that are low in nitrogen. Many researches have shown that salinity reduces nitrate content in plants while having little effect on total nitrogen content, and this might be the situation in this study **(Hu and Schmidhalter 2005).**

Data in table (4) and illustrated in Fig. (5) revealed that nitrogen content in shoot and root of tomato plants were significantly increased affected by all treatments as compared with control the increase ranged between 2.47% up to 4.51% in shoot and from 1.38% up to 3.22% in root.. Nitrogen contents were higher in shoot than in root for all treatments.

These results harmony with **Khaled and Fawy (2011)** who found that the corn absorption of nitrogen was enhanced when humus was applied to the soil, **Sabagh et al. (2017)** Explained that the effect of proline under saline conditions causes an increase in the nodule number and Nitrogen Fixation .Also, when proline was added, it was discovered that the loss of nitrogenase activity caused by salt could be overcome. **El-Lethy et al., (2013)** found that the potassium application, especially at 150 mg kg^{-1} soil had significantly caused increases in macro elements.

Humic acid gave the highest percentage of increase N compared to control (82.6%, 133%) for shoot and root and the lowest percentage increase values obtained at proline treatments (12.6%, 36.9%) for shoot and root respectively.

Turkmen et al. (2004) found that tomato grown on a saline medium supplemented with humic acid had a considerable improvement in mineral nutrient absorption. This is most likely related to the increased permeability of root cell membranes. The humic chemical may also function by promoting root development and proliferation. These effects are especially crucial for plant adaptation to harsh soil conditions like salinity.

Table (4): Effect of some soil addition on macronutrients content for tomato plant in El Husseineya soil.

treatments	N (%)		P (%)		K (%)	
	Shoot	Root	Shoot	Root	Shoot	Root
Control	2.47^e	1.38^f	0.2^f	0.18^d	3.18^e	1.91^f
H.A	4.51^a	3.22^a	0.44^a	0.33^a	5.17^b	4.35^b
Algae	3.45^d	2.15^d	0.36^c	0.27^b	4.02^d	3.67^c
K	3.93^a	2.82^b	0.38^b	0.29^b	6.35^a	5.94^a
Si	3.19^e	2.77^c	0.31^d	0.21^c	4.49^c	3.11^d
Proline	2.78^f	1.89^e	0.25^e	0.18^d	3.04^f	2.47^e
LSD	0.178	0.252	0.017	0.025	0.177	0.184

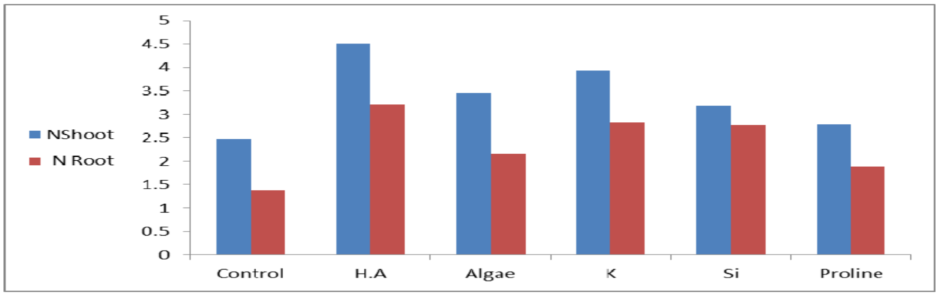

Fig. (5): Effect of some soil addition on nitrogen content for tomato plant

Phosphorus:

Depending on the plant type, growth stage, salt, degree of salinity, and P content throughout development, the interaction of phosphorus (P) with salt in plant nutrition is quite complicated and often confusing **(Ashraf et al., 2009).**

Phosphate absorption and buildup in soil-grown crops is hampered by salinity, which limits phosphate availability **(Prasad et al., 2014).**

Because of ionic strength effects, sorption processes in soil solution, and low solubility of Ca-P minerals in salty soils, mineral nutrients such as P availability is reduced.

Data in table (4) and illustrated in Fig. (6) revealed that significant differences in P content in shoot and root of tomato plant. Phosphorus content value in shoot under all treatments higher than P content value in root under the same treatment. The maximum increase values of P content obtained using humic acid (0.44%, 0.33%) for shoot and root compared with control, similar results obtained by **Turkmen et al. (2004),**

In case of potassium treatment et was (0.38%, 0.29%) these results confirmed with **El-Lethy et al., (2013)** who found that potassium application, especially at 150 mg/kg soil had significantly caused increases in macro elements (N and P), in case of algae et was (0.36%, 0.27%) these results agree with **Atzori et al., (2020)** who found that algae application showed high P uptake efficiency, in case of silica et wase (0.31%, 0.21%) these results are in line with **Murillo-Amador *et al*., (2007)** who improved cowpea and kidney bean growth, physiological parameters, balanced nutrition, and nutrient intake. Final proline case an increase with(0.25%, 0.18%) these results agree with Exogenous proline, according to **Hossain and Fujita (2010),** protects against salt-induced oxidative damage by lowering H2O2 and lipid peroxidation levels while also improving antioxidant defence and methylglyoxal detoxification systems.

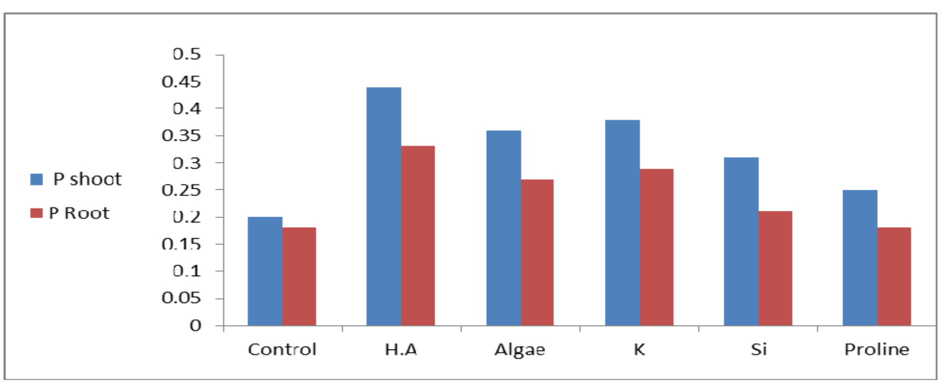

Fig. (6): Effect of some soil addition on phosphorus content for tomato plant in El Husseineya soil.

Potassium:

Potassium is an essential macronutrient for plant growth, development, production, and quality, as well as for plant survival under abiotic stress, as stress disrupts plant physiological systems, root and shoot elongation, enzyme activity, water and assimilate transfer, protein synthesis, photosynthetic transport, and chlorophyll content are all negatively affected by stress **(Véry and Sentenac, 2003; Pettigrew, 2008 and Gerardeaux et al., 2010).** Because potassium competes with sodium for binding and maintaining plant water status, it helps for salinity tolerance **(Capula-Rodrguez et al., 2016).**

The influence of different treatments on potassium content of shoot and root of tomato plants grown on El-Husseniya soil are presented in Table (4) and illustrated in Fig. (7). Data show that the application of different treatments when compared to control, generated a considerable rise in K concentration in the shoot and root of tomato plants and potassium concentration in shoot is bigger than root under the same treatments.

The highest K concentration values in shoot and root of tomato plants were obtained by using K treatment (6.35%, 5.94%) for shoot and root respectively. While the lowest ones were attained by applying proline treatment (3.04%, 2.47%) for shoot and root respectively.

Plants suffer from K shortage when they are exposed to high salt. As a result, boosting the K-nutritional status of plants under salinity stress mitigates the negative impacts of Na^+ through a variety of mechanisms, including $K^+ = Na^+$ discrimination **(Rodriguez-Navarro, 2000; Rubio et al., 2009).** Furthermore, **(Shabala and Pottosin, 2014)** discovered that high K^+ availability improves plant development under salt stress, but low K^+ salt stress is harmful.

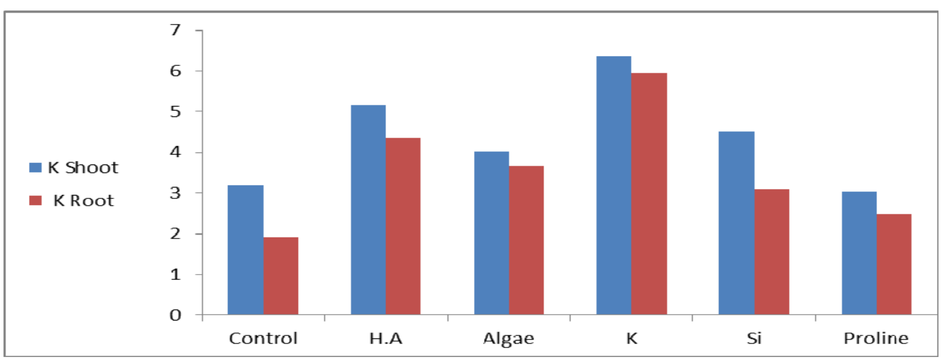

Fig. (7): Effect of some soil addition on potassium content for tomato plant in El Husseineya soil.

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