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Effect of Organic Acids, Calcium Humate and Bio-fertilizers Application on some Soil Properties and Yield Productivity under Saline Soil Conditions

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ABSTRACT

The use of organic acids, calcium humate (Ca-H) and cyanobacteria are among the soil conditioners which may be regarded a specific management strategy for enhancing saline soil properties, which can negatively impact crop yield. A field experiment was conducted in saline soil of Sahl EL-Hussynia farm, Agric. Res. Station in EL-Sharkia Governorate, Egypt. Rice crop (*Oryza sativa* Giza 178) was cultivated during summer season and wheat crop *(Triticum sativa* cv Giza 168) during winter season to study the effectiveness of different organic acids (salicylic, citric, ascorbic, and tartaric) and Ca-H as well as inoculation with or without cyanobacteria to enhance the chemical properties of salt-affected soil and the productivity of the rice and wheat crops system, as well as the total nutrient content. Results indicated that electric conductivity (EC) and soil reaction (pH) decreased inversely to organic matter content (OM) and yield components as well as their nitrogen and potassium (NK) content application of the studied treatments as compared to control at two seasons. Moreover, sodium adsorption ratios (SAR) decreased with the application of the applied treatments. However, salicylic acid (SA) was superior in the presence of calcium humate as compared to other organic acids or control treatments. In contrast, rice and wheat yields (straw and grains) as well as their total content of macronutrients (N and K) increased considerably in response to applied SA and Ca-H and inoculation with cyanobacteria in comparison to other treatments and/or the control treatment during both seasons studied. In conclusion, application of organic acids, especially SA in combination with Ca-H and inoculation with cyanobacteria improved the chemical properties of saline soil, which were reflected in the yield components of rice and wheat crops as well as the total macronutrient content under experimental conditions.

Keywords: Organic acids, Calcium humate, Cyanobacteria, Saline soil.

1. Introduction

In arid and semi-arid regions, salinity is one of the main abiotic stresses that negatively influence crop productivity and quality. In Egypt the total salt affected area are about 0.9 Mg ha (Bayoumi, 2019). The majority of Egypt's salt-affected soils are in the northern-central Nile Delta and on its eastern and western sides (El- Bordiny and El- Dewiny, 2008). Crop development and production are negatively impacted by abiotic factors like salinity on a worldwide scale. These conditions limit physiological and biochemical processes in plants and cause an ion imbalance (Munns and Tester, 2008; Hafez and Abou El- Hassan, 2015). Plant development, morphology and survival are all impacted by salt stress because of the way it disrupts the cellular ion balance, leading to ion toxicity, osmotic stress and the generation of reactive oxygen species (ROS) (El-Beltagi and Mohamed, 2013). Salt - impacted soils cause to absorb greater rates of Na and exclude K in plants, resulting in poor K^+/ Na^+ discrimination under salt stress which diminish yield- associated features and eventually grain yield (Shabala and Munns, 2012).

Reclamation of saline-sodic soils may be possible with different methods which include physical and chemical amelioration. Removal and replacement of soluble sodium (Na^+) by altering the ionic composition of soil solution are crucial to the success of any approach. Moreover, the application of soil conditioner such as organic acids, humic substances, sodic and saline-sodic soils may have their

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physical and chemical properties enhanced by adding polyamine carboxylic acid and hydrolytic polymeric anhydrate (i.e., pH, EC, and SAR), physical characteristics such as water retention, infiltration rate and bulk density (Yan *et al*., 2005). In addition, growers have increasingly turned to humic substances rather than other substances because of the good impact these compounds have on the outward development of plants.

Salicylic acid (SA) has been studied extensively in recent years owing to its role as an endogenous signal directing local and systemic plant defense responses against pathogens and abiotic stresses. Because of its significance in the defense system against biotic and abiotic stressors, the plant phenol salicylic acid (SA) is now used as an internal regulator hormone as has been confirmed by Kobeasy *et al*. (2011). Abdul Qudos (2015) added that the application of SA as a foliar spray substantially mitigated the deleterious effects of salinity stress and increased chlorophyll content, soluble carbohydrates, proline, and free amino acids, according to the study. Salicylic acid resulted in an increase in plants' ability to withstand dryness by decreasing their generation of reactive oxygen species (ROS) thanks to the actions of antioxidant enzymes. It also promoted plant development by increasing the transport of soluble carbohydrates to developing cells which led to enhancement plant growth. (Metwally *et al*., 2003).

Citric acid (CA) is a natural substance; some studies indicate that it may be beneficial to plants when used in lower concentrations. (Paliyath *et al*., 2008). It is worth noting that citric acid, tartaric acid, and oxalic acid, when applied to soil at various concentrations, can enhance the concentration of available nutrients. When the concentration of acids was lowered to 1 mmol/L, both the total and maximal discharge of soil nutrients decreased significantly, with citric acid having the greatest effect (Lv *et al*., 2015).

One of the most vital antioxidants in plant cells, ascorbic acid (AA), is produced in the mitochondria and then shuttled to other parts of the cell. By directly scavenging reactive oxygen species, ascorbic acid plays a powerful function in protecting cell membranes (Gill and Tuteja, 2010). In this concern, Azzedine *et al*. (2011) reported the increased leaf area, improved pigment content and stimulated proline accumulation were cited as mechanisms by which (AA) application ameliorated the negative impact of salt stress on plant development.

Tartaric acid (TA) is the major last product of ascorbic acid (AA) degradation. As a result, it is considered a "specialized primary metabolite," one that is produced during carbohydrate metabolism but has no clear role in basic metabolic pathways and is found only in a small subset of plant species. Tartaric acid is able to stimulate biosynthesis enzymes and other metabolic processes in fruits (Burbidge *et al*., 2021). When applied to plants, humic acid boosts their antioxidant activity, yield and vegetative development (Yasser *et al*., 2011). HA's adsorption of cations is multifaceted, including interactions with Ca^{2+} (humic acid aggregates or with amine groups) and other cations (Sharma *et al*., 2011).

In addition, humic substances have a strong affinity for weak acids containing a phenolic hydroxyl, carboxyl group or amino sulfhydryl. The majority of alkaline cations (Na^{+}, K^{+}, Ca^{2+}, Mg^{2+}) are retained by simple cation exchange with COOH groups to form RCOONa, RCOOK (Zhang *et al*., 2013). Results suggest that HA (K-Humate) might be a useful management tool for ensuring the long-term health of the soil environment (Gümü and Seker, 2015). Furthermore, calcium is added to soil raise its pH and when combined with humate, to provide a supply of chelated calcium and calcium humate (Zein El-abdeen *et al*., 2018).

Calcium is required by the plant during the growth stage due to its role as a second mediator in signal conduction, one of the environmental factors and responses involved in plant growth and development. Calcium ions are vital ions main walls, cell membranes, fruit growth and cellular development, and they facilitated increased plant growth and nutrition absorption (Pilbeam and Morely, 2007; Shafeek *et al*., 2013).

Several species of cyanobacteria can acclimate to fluctuating salinity conditions when distributed over a wide range of salt concentrations. Their use in agricultural soil salinization remediation has been proven. In addition, voids regarding the extensive use of cyanobacteria in the remediation of salt-affected soil are acknowledged (Francisco *et al*., 2020). Moreover, the use of biofertilizers resulted in an increase in carbon, nitrogen, phosphate, potassium, magnesium, calcium, zinc, iron, copper, and manganese, whereas the use of cyanobacteria resulted in a reduction in sodium ion, electrical conductivity (EC) and pH. Improvements in plant growth indices and soil microbial activity were observed. Therefore, cyanobacteria species have potential for efficient exploitation in phytoremediation and enhanced productivity of salty soils (Soniya *et al*., 2021).

Therefore, the purpose of this study is to evaluate the efficacy of using organic acids, calcium humate, and cyanobacteria in mitigating the negative effects of soil salinity properties as well as improving some soil chemical properties and the availability of macronutrients (N and K) as reflected in the productivity of both rice and wheat crops.

2. Materials and Methods

An experiment was conducted at the research field of Sahel El- Hussainiya, El-Sharkia Governorate. This institute farm is located at 31 02, 50" N latitude and 32 00, 22.8 E longitude during two successive growing seasons cultivated with rice crop (*Oryza sativa* L Giza 178) at summer season 2019 and wheat (*Triticum aestivum* L Giza 168) at winter season (2019 - 2020). This study was conducted to evaluate the effectiveness of organic acids (salicylic, citric, ascorbic, tartaric) and calcium humate (Ca-H) with incubation by cyanobacteria under saline soil conditions and to evaluate the improvement of some chemical properties, nutritional value and yield characteristics of both rice and wheat crops. Seven treatments and three replications were used in the split-split plot design of the field experiment. A surface soil sample (0-15 cm) was collected, air- dried, pulverized, thoroughly mixed, and sieved through a 2 mm mesh, kept and analyzed according to the methods described by Page *et al*. (1982) and Cottenie *et al*. (1982). Some physical and chemical soil properties were recorded prior to sowing in Table (1).

Table 1: Some physical and chemical properties of the experimental soil.

Soil characteristics	Value	Soil characteristics	Value
Particle size distribution (%)		**Soluble cations (soil paste mmolec^{1})**	
Sand	25.05	Ca^{2+}	19.43
Silt	18.75	Mg^{2+}	27.87
Clay	56.20	Na^{+}	83.00
Textural class	Clay	K^{+}	0.86
Soil chemical properties		**Soluble anions (soil paste, mmole$_c$^{1})**	
pH (1:2.5) Soil extract susp.	8.21	CO_3^{2-}	0.0
Organic matter %	0.62	HCO_3^{-}	6.79
ECe (dS/m, soil paste extract)	10.93	Cl^{-}	80.9
SAR	17.10	SO_4^{2-}	43.47

Soil available macro & micronutrients (mg Kg^{-1})

N	P	K	Fe	Mn	Zn	Cu
42.2	4.9	182	3.66	0.92	0.54	0.94

Table 2: Some chemical properties of calcium humate applied in this study.

Parameters	Values	Nutrients (mg L^{-1})	Values	Nutrients (mg L^{-1})	Values
pH	7. 40	**P**	14.6	**Fe**	2.90
O.C (%)	0.58	**K**	0.90	**Mn**	0.10
O.M (%)	1.00	**Na**	0.99	**Zn**	-
N (%)	1.40	**Ca**	6000	**Cu**	0.10
C/N ratio	0.42	**Mg**	240		

2.1. Treatments

The experiment involved the following treatments:

1- Control (untreated),

Organic acids treatments applied at rate of 0.3g L^{-1} including:

2- Salicylic acid (SA)
3- Citric acid (CA)
4- Ascorbic acid (AA)
5- Tartaric acid (TA)
6- Calcium humate (Ca-H) was applied at a rate of 4% (v/v).
7- Cyanobacteria was applied at a rate of 200 g fed^{-1}.

2.2. Organic acids application

Organic acids were applied at a rate of 300 mg L^{-1} as well as calcium humate (Ca-H) 40 L fed^{-1} as sprayed on soil surface at three doses 30, 45 and 60 days from sowing also while Cyanobacteria was applied to soil after one month from sowing.

2.3. Fertilizers application

Mineral fertilizers were applied at recommended doses for rice and wheat crops, recommendations are based on the use of fertilizers in experiments carried out by the Ministry of Agriculture of Egypt. During soil preparation calcium super phosphate (15% P_2O_5) was applied at a rate of 100 Kg $fed.^{-1}$, while potassium sulphate (48% K_2O) was administered at a rate of 50 kg fed^{-1} in two equal divided portions prior to sowing and 45 days after sowing, at a rate of 50 kg fed^{-1}. Nitrogen was applied as ammonium nitrate (33.5% N) at a rate of 200-300 kg fed^{-1}, divided into four equal dosages applied 15, 30, 45, and 60 days after sowing.

2.4. Examined parameters

I. Soil samples

After harvesting, samples of soil were taken from depths ranging from 0 to 15 cm then dried, crushed and sieved through a 2 mm screen in order to examine specific chemical properties of the soil, according to Cottenie *et al*. (1982) as follows:

1- Electrical conductivity (EC, dSm^{-1}) in soil water extract at ratio of 1:5.
2- Soil pH was measured in 1:2.5 soil water suspensions.
3- Organic matter content (OM%).
4- Available N, P, K, Na Ca and Mg (mg Kg^{-1}).

The different criteria are currently recognized in the salinity index. Sodium Adsorption Ratio (SAR) defined according to Sumner (1993); Rengasamy and Churchman (1999); Quirk (2001) as in the following Equation:

$$SAR= Na^{+}/\sqrt{Ca^{2+} + Mg^{2+}/2}$$

Where:
SAR = Sodium adsorption ratio, $(cmol\ kg^{-1})^{0.5}$
Na^{+}, Ca^{2+}, Mg^{2+} = Measured soluble Na^{+}, Ca^{2+} and Mg^{2+}, respectively, cmol kg^{-1}.

II. Plant samples

At harvest, samples were taken of the plants to analyze their nutritional and yield composition. Nitrogen and potassium concentrations were determined by grinding and digesting oven-dried plant samples with a combination of H_2SO_4 and H_2O_2, according to Page *et al*. (1982).

Statistical analysis

Obtained data were subjected to statistical analysis according to Snedecor and Cochran (1980) and the treatments were compared by using L.S.D. at 0.05 level of probability.

3. Results and Discussion

3.1. Soil chemical properties

3.1.1. Effect of organic acids and calcium humate on soil chemical properties under inoculation with cyanobacteria

Data in Table (3) displays the impact of the investigated treatment on the pH, EC, O.M, and N and K availability of the soil.

3.1.2. Soil reaction

Concerning the effect of applying different organic acids on soil reaction (pH), obtained data showed little decrease either in the presence or absence of Ca-H and inoculation. However, salicylic acid shows some differences between treatments compared to control. These results agreed with those obtained by Welch *et al*. (2002); Liu *et al*. (2012) and Monowara *et al*. (2019).

Table 3: Effect of different organic acids and calcium humate on some chemical soil parameters without or with inoculation by cyanobacteria at two cultivation seasons.

Treatment			Rice					Wheat				
Organic acids 300 (mg kg^{-1})	Calcium humate	Inoculation	pH (1:2.5)	EC (dSm^{-1})	OM (%)	N (mg Kg^{-1})	K (mg Kg^{-1})	pH (1:2.5)	EC (dSm^{-1})	OM (%)	N (mg Kg^{-1})	K (mg Kg^{-1})
Cont.	Without	Without	8.20	9.10	0.72	42	288	8.23	8.40	0.65	75	265
SA			8.02	8.74	0. 82	52	409	8.22	8.36	0.75	98	385
CA			8.18	9.04	0. 77	49	395	8.21	8.38	0.68	95	365
AA			8.14	9.02	0. 75	44	393	8.18	8.34	0.71	94	378
TA			8.16	9.06	0.78	47	392	8.20	8.36	0.69	88	375
Mean			8.16	8.99	0.75	47	375	8.21	8.36	0.70	90	354
Cont.		With	8.17	9.08	0. 72	47.5	325	8.20	8.36	0.71	85	298
SA			8.09	9.12	0. 89	57	495	8.12	8.54	0.86	99	465
CA			8.20	9.06	0. 83	50.5	419	8.16	8.76	0.77	95	410
AA			8.15	8.94	0. 87	49.5	402	8.10	8.84	0.74	94	389
TA			8.11	9.06	0. 87	49	409	8.11	8.70	0.73	91	395
Mean			8.14	9.05	0.84	50.5	410	8.14	8.62	0.76	93	391
Total Mean			8.15	9.02	0.75	49	393	8.17	8.48	0.73	93	373
Cont.	With	Without	7.92	6.57	0.89	51	338	7.85	8.20	0.78	99	311
SA			7.73	5.78	1.27	69	632	7.49	5.73	1.47	132	624
CA			7.78	6.20	1.32	59	624	7.74	5.75	1.12	115	585
AA			7.89	6.25	1.05	54.2	593	7.80	6.53	0.94	112	558
TA			7.85	6.46	0.94	56	575	7.69	7.04	0.84	109	564
Mean			7.83	6.25	1.09	58	552	7.71	6.65	1.03	113	528
Cont.		With	7.88	6.17	0.96	56	493	7.91	6.52	0.84	115	463
SA			7.76	6.14	1.10	79	764	7.76	5.90	1.29	129	644
CA			7.84	5.85	1.11	66	663	7.86	6.04	1.00	122	650
AA			7.83	6.42	0.90	57.5	538	7.81	6.16	1.42	105	511
TA			7.88	6.07	1.13	59	585	7.84	6.16	1.01	115	524
Mean			7.84	6.07	1.04	63.5	609	7.84	6.16	1.11	117	558
Total Mean			7.84	6.16	1.07	61	581	7.78	6.40	1.07	115	543
Without			7.99	7.62	0.92	25.5	464	7.96	7.51	0.87	102	441
With			7.99	7.56	0.94	57	510	7.99	7.39	0.94	105	475
L.S.D at 0.05 %												
Organic acids (A)			0.17	0.22	0.06	0.70	16.44	0.12	0.13	0.06	1.44	15.35
Calcuim Humate (B)			0.11	0.14	0.04	0.44	10.02	0.08	0.08	0.39	0.91	9.08
A*B			0.25	0.31	0.02	0.99	22.49	0.17	0.18	0.09	2.03	21.71
Inoculation (C)			0.11	0.14	0.04	0.44	10.02	0.08	0.08	0.39	0.91	9.08
A*C			0.25	0.31	0.02	0.99	22.49	0.17	0.18	0.09	2.03	21.71
B*C			0.16	0.02	0.06	0.63	14.17	0.11	0.12	0.05	1.29	13.73
ABC			0.35	0.43	0.13	1.41	31.07	0.24	0.26	0.12	2.87	30.70

3.1.3. Electric conductivity

With regard to soil electric conductivity (EC), results showed that there is no significant effect of organic acids compared to control, under conditions of inoculation with/ without cyanobacteria. On the other hand, the results showed some decreases in the EC values in all treatments, under conditions of Ca-H. In addition, the effect of inoculation with cyanobacteria had a positive effect, as the values also decreased compared to the absence of cyanobacteria, so were significant decreased soil EC from 9.10 to 5.78 dSm^{-1} at the first season and from 8.23 to 5.73 dSm^{-1} at the second season in the upper layer (0 to 15 cm). Furthermore, Buckau *et al.* (2000) suggested that different salts such as Ca-H, can be used to increase soil fertility. In this concern, Ounia *et al.* (2014) added that apart from replacing/neutralizing the Na^+, the addition of Ca-based compounds enhanced near-surface soil physical quality and decreased surface sealing and crusting.

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3.1.4. Organic matter

Regarding to soil organic matter content (OM), data showed increases due to application of organic acids, especially of salicylic acid compared to control. On the other hand, when adding Ca-H, the values of organic matter increased significantly compared to the control. However, inoculation with cyanobacteria did not show clear response to the effect of organic matter in the soil, but this effect was due to addition of Ca-H, which is likely affect saline soil in improve its chemical properties. This means that Ca-H has reduced the effect of salinity on organic matter because it is considered an organic substance and therefore it benefits micro-organisms, as declared by Khaled and Fawy (2011).

3.1.5. Available nutrients

Regarding nitrogen and potassium availability in soil after harvested, data shows in Table (3) declared significant increase for all treatments in the values of nitrogen and potassium compared to control. Also, preference was given to the treatment with salicylic acid, as mentioned previously as salicylic acid is resistant to salinity and therefore has a clear effect on availability of elements in soil. These results coincided with those obtained by Seddik *et al*. (2016). As far as the treatment with Ca-H was also better than without Ca- H for the same reasons previously mentioned, as it had an effect on ground solution and therefore on reducing salinity so that sodium is not the dominant ion as explained by Monowara *et al*. (2019) who reported that the addition of organic amendments can increase the concentration of Ca^{2+} in soil solution, thereby displacing Na^{+} and reducing salinity.

The results also showed a relative increase of inoculation with cyanobacteria compared to absence of inoculation and the effect was clear in soil cultivated with the rice crop, due to the presence of a relationship between cyanobacteria and rice crop, where cyanobacteria are used as biological fertilization when cultivating rice may be can adapt to fluctuating salinity conditions (Francisco *et al*., 2020). Moreover, cyanobacteria can increase the levels of carbon, nitrogen, phosphate, potassium, magnesium, calcium, zinc, iron, copper, and manganese in soil, whereas sodium ion, electrical conductivity, and pH levels decrease. (Soniya *et al.,* 2021).

3.1.6. Sodium adsorption ratio

From the aforementioned, in order to complete the picture, sodium adsorption ratio (SAR) was estimated, which is considered among parameters that express salinity of soil to study and reflection of added treatments on SAR, as shown in Fig. (1). It shows in general that the values of SAR were decreased as compared to control treatment. However, applied treatments caused also, decreased in SAR values especially salicylic acid. The effect of organic acids and Ca-H on soil SAR under without/ with inoculation by cyanobacteria in two seasons. The results showed clear effect on the soil SAR values, as it decreased compared to control in all treatments. This agreed with Hussain *et al*. (2001) who reported that which was that using organic products reduced SAR in salty and acidic soils. Also, Fig. 1 showed that the treatments, such as Ca-H, organic acids, and cyanobacteria injection, worked well together to lower the salinity of the soil, which reflected on the SAR values of the soil. Amer and Hashem (2018) and Zaka *et al*. (2018) who found that the significant effect of gypsum addition on soil salinity for SAR and ESP may be caused by the release of calcium from gypsum, which increases the concentration of Ca^{+2} in the soil solution, this replaces exchangeable sodium and improves the chemical and physical properties of the soil. El-Kamar (2020) added that the used of bio-fertilizer lowered SAR in the upper layer (0–20 cm) from 15.90 to 12.10 and from 16.90 to 13.20 in the first and second seasons, respectively. The useful effect of bio-fertilizer on SAR may be because adding bio-fertilizer changes the physical and chemical properties of the soil.

Based on the previously mentioned, the information of percentages increases in decrease of the SAR ratio for each of the control and salicylic acid, relative to the initial soil with the treatments in both crops. The percentages were 44.5% (without Ca-H) and 49.7% (with Ca-H) for control treatments, 56.6% (without Ca-H) and 58.2% (with Ca-H) for each of the control and salicylic acid, respectively, in the rice crop. But in the wheat crop, the ratios were 53.4% (without Ca-H) and 55.9% (without Ca-H) 63.1% (without Ca-H) and 63 .6% (with Ca-H) for each of the control and salicylic acid, respectively.

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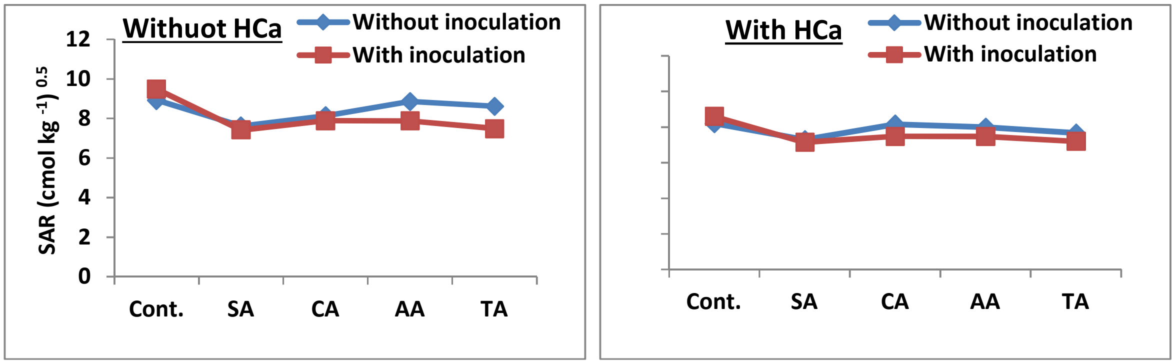
First season (Rice)



Second season (Wheat)

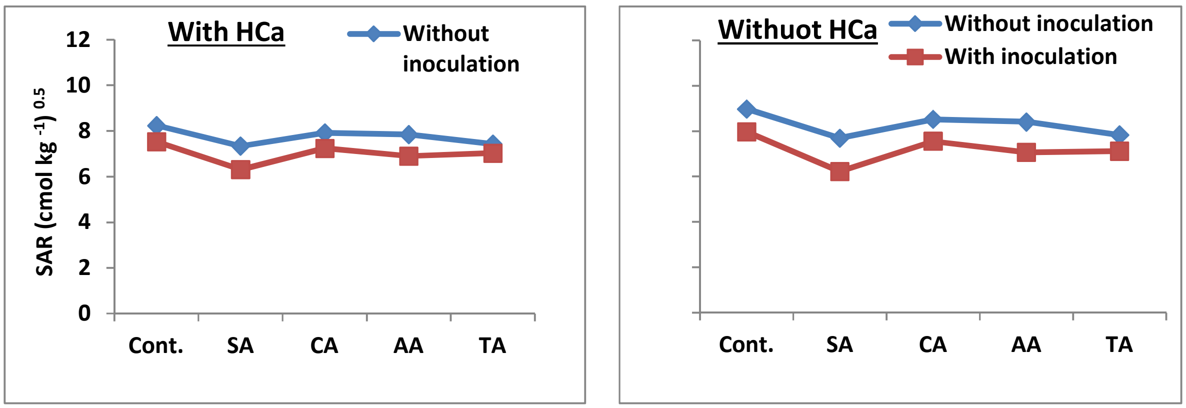


Fig. 1: Effect of applied organic acids and calcium humate on soil SAR under without or with inoculation by cyanobacteria at the two seasons.

3.2. Plant parameters

From the previously discussed the effects of the treatments on chemical properties of soil, it was found necessary to see their reflection on some plant parameters such as yield, grain and straw, as well as the status of micronutrients elements.

3.2.1. Yield components

Data in Table (4) showed clear increases in the yield components (biological yield, grain, and straw) under influence of organic acid treatments compared to the control, whether without Ca-H or in the presence of Ca-H on rice and wheat crops under conditions of inoculation with cyanobacteria. In general, salicylic acid (SA) treatment was higher than anther organic acids. This confirms the effect of (SA) on plant behavior under salinity conditions, where it acts as a salinity resistor through the plant's absorption in the form of silicate, which gives the plant hardness to resist conditions of external environment and this has a direct effect on plant, thus the plant's resistance to salinity this was evident in both rice and wheat crops. This agreed with the result of Srivastava and Dwivedi (2000) who explanted that application of salicylic acid has been reported to increase plant tolerance to numerous abiotic stresses. salicylic acid modifies some physiological functions of plants, it also agreed with results of Seddik *et al*. (2016) who declared that salicylic acid is more efficient than other organic acids which was reflected on the growth behavior of plant. This may have an effect on plant physiology and enzymes, which give the plant resistance to salinity and external conditions, and thus give a better effect on the plant compared to its counterpart. In addition to this, SA enhanced the activities of antioxidant enzymes and proline accumulation that confer tolerance to plants and enhanced the yield characteristics (Alyemeni *et al*., 2014).

Table 4: Responses of rice and wheat yields to applied organic acids and calcium humate under with inoculation with cyanobacteria.

Treatment			Rice			Wheat		
Organic acids 300 (mg kg^{-1})	Calcuim humate	Inoculation	Biological Yield	Grains	Straw	Biological Yield	Grains	Straw
			(Ton fed^{-1})					
Cont.	Without	Without	4.45	1.75	2.70	3.47	1.37	1.69
SA			7.41	2.56	4.85	5.20	2.93	2.27
CA			6.01	2.18	3.82	4.59	1.93	2.66
TA			5.05	1.90	3.15	4.83	2.04	2.79
AA			5.11	1.89	3.22	4.76	2.48	2.28
Mean			5.61	2.06	3.55	4.57	1.95	2.54
Cont.		With	4.96	1.85	3.11	3.81	1.49	2.32
SA			8.29	2.69	5.60	7.06	2.47	4.59
CA			6.59	2.41	4.18	5.66	2.28	3.38
TA			5.66	2.20	3.46	5.40	2.34	3.06
AA			5.91	2.39	3.51	5.29	2.40	2.89
Mean			6.28	2.31	3.97	5.45	2.20	3.25
Total mean			5.94	2.18	3.76	5.01	2.07	2.89
Cont.	With	Without	4.81	1.82	2.99	3.53	1.55	1.98
SA			9.93	2.77	7.15	7.45	2.94	4.51
CA			6.57	2.27	4.30	6.59	2.32	4.27
TA			6.17	2.46	3.71	6.75	2.65	4.10
AA			6.19	2.25	3.93	6.33	2.21	4.12
Mean			6.73	2.32	4.42	6.13	2.33	3.80
Cont.		With	5.36	1.99	3.37	3.55	1.65	1.89
SA			10.96	2.80	8.16	8.06	3.24	4.82
CA			7.13	2.51	4.62	7.11	2.73	4.38
TA			7.39	2.75	4.63	7.22	2.88	4.35
AA			7.11	2.48	4.63	7.00	2.61	4.39
Mean			7.59	2.50	5.08	6.59	2.62	3.97
Total mean			7.16	2.41	7.16	6.36	2.48	3.88
Without			6.17	2.19	3.99	5.35	2.14	3.17
With			6.94	2.41	4.53	6.02	2.41	3.61
L.S.D at 0.05 %								
Organic acids (A)			0.97	0.42	0.81	0.27	0.30	0.18
Calcuim Humate (B)			0.62	0.27	0.51	0.17	0.12	0.19
A*B			1.38	0.60	1.15	0.38	0.26	0.24
Inoculation (C)			0.62	0.27	0.51	0.17	0.12	0.19
A*C			1.38	0.60	1.15	0.38	0.26	0.24
B*C			0.87	0.38	0.73	0.24	0.16	0.27
ABC			1.95	0.85	1.63	0.54	0.37	0.60

The effect of Ca-H was also clear in increasing yield components as it may acts as a support for plant to improve plant's physiological condition and thus resistance to salinity. These agreed with the results of Canellas *et al*. (2008) who found that increased crop growth and production are likely the result of better nutrient absorption, which is facilitated by HA's ability to drive root development and modify root shape through organic acid exudation. The favorable effect on rice and wheat yield, its components grown on this salt-affected soil may be attributable to the application of Ca-H, which increased Ca^{+2} and replaced absorbed Na^{+}, thereby improving the soil's chemical and physical characteristics and leading to the favorable effect on plant growth and yield, Ghafoor *et al*. (2008) and Amer and Hashem (2018). Increased crop yields may also result from the use of humic compounds having auxin-like actions, which encourage cell elongation, apical dominance, and roots (Atiyeh *et al*., 2002 and Nardi *et al*., 2002). Also, the stimulatory impact of HA on plant yield and quality may be due, in part, to the fact that humic compounds improved absorption of mineral nutrients by increasing cell permeability (Dursun *et al*., 2002 and Zandonadi *et al*., 2007). Moreover, the influence of HA, Ca-H on respiration and photosynthesis, the stimulation of nucleic acid metabolism and the hormonal activity of HA are among the factors that have been used to describe the effect of HA on plant growth parameters and the formation of a complex between HA, Ca-H and mineral ions, the catalysis of HA, Ca-H by the enzymes in the plant. (Türkmen *et al*., 2004). These results agreed with those of Zein El-abdeen *et al*. (2018) who reported that the growth of fava beans was greatly stimulated by either Ca-H alone or in combination with mineral nitrogen fertilizer.

As for cyanobacteria inoculation, its effect was clear on increasing yield compound by cyanobacteria inoculation compared to without inoculation, which also confirms that cyanobacteria influence soil salinity and plant resistance to salinity, as there is a direct effect of cyanobacteria on plant as it is a nitrogen fixer and thus works to increase chlorophyll and thus excess dry matter. Because of their ability to fix atmospheric nitrogen and enhance soil structure and water retention capacity, cyanobacteria are among the most well-known photosynthetic microorganisms employed in agriculture (Hegazi *et al*. 2010 and Sahu *et al*., 2012). The interaction between organic acids forms in combination with Ca-H and the presence of inoculation with cyanobacteria were more significant as compared to the control.

3.2.2. Total nutrients content

Data in Table (5) showed the effect of organic acids and Ca-H on total content of nutrient elements in rice and wheat crops under with/ without cyanobacteria inoculation. Regarding the total content of nitrogen and potassium obtained, results showed an increase in both under every treatment compared to control. Where the treatment with organic acids gave significantly effects and increase in the total content of nitrogen and potassium. The increase was as follows: Salicylic acid > citric acid > ascorbic acid > tartaric acid. Also, the treatment with salicylic acid was more effective than the rest of organic acids. This perhaps due to improvement of physiological processes within the plant that lead to translocate from external elements in soil into the plant and translocate from roots to leaves, which appears in the total content of nutrients.

Concerning the treatment with Ca-H, it has a clear effect on the total content of nitrogen and potassium. This may be due to an improvement in plant physiology because of adding the treatments. The increase in total content in response to Ca-H is likely attributable owing to the humic substances ability to spark microbial activity (Mayhew, 2004), enhancing cell membrane permeability and absorption of water and nutrients (Sibanda and Young, 1986; Valdrighi *et al*., 1996). In this concern, Selim and Mosa (2012) showed that the influence of humic substances, increasing the mineral fertilization application rates increased the concentrations of nitrogen and potassium in broccoli crowns. These effects are primarily attributable to soil nutrient availability increases. In addition, the stimulation of N uptake by HA may be a result of HA's effect on nitrate carrier proteins and/or the modification of certain kinetic parameters following HS application (Cacco *et al*., 2000). Also, some researchers attributed the positive effects of Ca- H to its influence on plant roots (Atiyeh *et al*., 2002 and Türkmen *et al*., 2004) and for metabolism of soil microbial population and soil physical conditions (Chen and Aviad, 1990; Muscolo *et al*., 1999 and Zandonadi *et al*., 2007). Organic acid and Ca-H may also facilitate faster root development and larger root volumes in hydroponic systems; this may be the consequence of improved nutrient uptake and utilization. It seems to reason that if plants are able to absorb more nutrients, their root systems would expand to accommodate the additional demand. Because of its role as a second messenger, calcium is important in signaling nutrient availability and fluctuations therein, which improves nutrient absorption by roots and their translocation throughout the plant (Kudla *et al*., 2018).

Concerning, the inoculation with cyanobacteria, it gave an increase in the total content of both nitrogen and potassium, and it was better than without inoculation. This confirms its effect on the plant under salinity conditions, and also indicates that the plant is highly efficient in absorbing elements, as well as improving plant metabolism, which is reflected in the total content of nutrients in plant. These results agreed with those obtained by Mohsen *et al*. (2016). Data also indicated that there were significant differences among all treatments in total nitrogen and potassium and dry matter contents in plants. The treatment with cyanobacteria was superior one regarding total, N and K contents in plants. Therefore, the effect of bio-fertilizer on N and K concentration may be attributable to the function of nitrogen bacteria in increasing endogenous phytohormones, which play a crucial role in the formation of a highly active root system, the increase of nutrient assimilation and photosynthesis rate, and the translocation of substances and their accumulation on different plant prates. These results are in agreement with those found by Nisha *et al*. (2017); Zaka *et al*. (2018) and Helmy *et al*. (2013). The interaction between organic acid combined with Ca-H and the presence on inoculation with cyanobacteria were highly significant on the N and K total content during the two seasons.

Table 5: Total contents of macronutrients in both straw and grains of rice and wheat plants as affected by different organic acids and calcium humate under without or with inoculation with cyanobacteria.

Treatment			Rice				Wheat			
			Straw		Grain		Straw		Grain	
Organic acids 300 ($mg\ kg^{-1}$)	Calcuim humate	Inoculation	N	K	N	K	N	K	N	K
			($Kg\ fed^{-1}$)							
Cont.	Without	Without	35.74	47.67	95.55	19.85	43.91	25.85	106.13	9.18
SA			84.55	120.20	144.73	45.19	79.91	61.03	206.07	36.92
CA			64.22	93.91	124.30	46.79	77.70	61.93	152.65	36.04
AA			51.60	76.73	123.10	38.24	72.91	51.05	132.01	29.06
TA			50.04	66.28	114.30	38.09	57.98	39.29	127.79	29.06
Mean			56.34	79.44	120.67	37.32	66.09	45.07	144.94	28.06
Cont.		With	48.30	72.45	107.10	41.92	60.92	50.69	94.31	21.23
SA			115.25	129.36	221.28	57.58	155.25	107.04	151.31	33.22
CA			76.36	100.04	161.32	45.51	108.59	73.10	143.18	28.69
AA			61.01	85.30	159.14	38.77	89.42	67.54	135.60	25.56
TA			57.56	73.63	147.36	36.20	75.87	63.74	131.17	26.23
Mean			70.22	92.09	157.27	44.18	95.93	72.05	131.10	26.99
Total mean			63.11	85.68	138.37	40.70	80.72	57.90	138.01	27.51
Cont.	With	Without	93.41	95.91	148.76	43.60	52.86	58.28	120.94	22.11
SA			191.73	309.48	278.25	101.28	156.09	187.32	272.56	61.80
CA			148.03	155.25	222.45	77.15	135.49	135.49	231.38	44.84
AA			118.42	131.67	210.97	74.51	119.55	125.58	207.59	46.79
TA			122.26	116.49	194.54	62.48	113.40	120.33	185.77	35.22
Mean			122.26	116.49	194.54	62.48	113.40	120.33	185.77	35.22
Cont.		With	98.49	121.86	173.82	55.02	55.19	59.18	139.99	26.40
SA			238.25	399.36	292.24	109.37	156.01	191.46	311.62	78.92
CA			172.35	207.63	241.56	91.56	153.57	159.10	249.08	57.39
AA			152.12	183.92	252.46	86.67	146.94	137.80	249.08	50.78
TA			168.76	157.42	213.89	71.82	137.36	122.62	218.69	43.85
Mean			163.11	207.10	233.58	82.03	128.27	132.43	233.69	51.47
Total mean			142.40	158.59	213.63	71.95	121.02	126.55	209.73	43.34
Without			89.29	97.97	157.61	49.90	89.73	82.70	165.35	31.63
With			127.16	149.58	195.43	64.05	112.10	102.23	182.41	39.23
L.S.D at 0.05 %										
Organic acids (A)			1.49	1.25	1.30	1.22	36.46	0.76	0.79	0.57
Calcuim Humate (B)			0.94	0.79	0.82	0.80	23.06	0.48	0.50	0.36
A*B			2.10	1.77	1.84	1.72	51.56	1.08	1.11	0.81
Inoculation (C)			0.94	0.79	0.82	0.80	23.06	0.48	0.50	0.36
A*C			2.10	1.77	1.84	1.72	51.56	1.08	1.11	0.81
B*C			1.33	1.12	1.16	1.09	32.61	0.68	0.71	1.15
ABC			2.97	2.50	2.60	2.43	72.91	1.52	1.58	1.15

4. Conclusion

Application of organic acids in combination with calcium humate and inoculation with cyanobacteria was generally, helpful in improving the properties of saline soil, which was positively reflected on the yield components as well as on their total content of macronutrients. Results also, revealed that EC, pH values and SAR decreased as well as organic matter content in the soil, yield components, NPK availability in soil and total content in both crops of macronutrients increased by applied salicylic acid in combination with calcium humate and inoculation with cyanobacteria. Accordingly, for saline clay soil, organic acids, calcium humate and inoculation with cyanobacteria can be used as soil conditioners to improve the chemical properties of saline soil and reflected on the productivity of rice and wheat crops.

References

Abdul Qudos, A.M.S., 2015. Effects of salicylic acid on growth, yield and chemical contents of pepper (*Capsicum annuum L*) plants grown under salt stress conditions. International Journal of Agriculture and Crop Sciences 8 (2): 107- 113. activity. Int. J. Envir. Sci. Tech. DoI. 10.1007/s 13762-017-1419-7.

Alyemeni, M.N., H. Qaiser, L. Wijaya and S. Hayat, 2014. Effect of salicylic acid on the growth, photosynthetic efficiency and enzyme activities of leguminous plant under cadmium stress. Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 42 (1): 440- 445. https://doi.org/10.15835/nbha4229447

Amer, M. M. and I. M. Hashem, 2018. Impact of salt affected soils at Kafr El -Sheikh Governorate. Egypt. J. Soil Sci., 58 (2): 177- 191.

Atiyeh, R.M., C.A. Edwards, J.D. Metzger, S. Lee and N.Q. Arancon, 2002. The influence of humic acids derived from earthworm-processed organic wastes on plant growth. Bioresource Technol., 84: 7- 14.

Azzedine, F., G. Hocine and B. Mebarek, 2011. Improvement of salt tolerance in durum wheat by ascorbic acid application. Journal of Stress Physiology and Biochemistry, 7 (1): 27- 37.

Bayoumi, M.A.O., 2019. Impact of Mole Drains and Soil Amendments Application on Management of Salt Affected Soils J. Soil Sci. and Agric. Eng., Mansoura Univ., 10(4): 209 – 217.

Buckau, G., R. Artinger, P. Fritz, S. Geyer, J. Kim and I. Wolf, 2000. Origin and mobility of humic colloids in the Gorleben aquifer system. Appl. Geochem., 15: 171- 179.

Burbidge, C.A., C. M. Ford, V. J. Melino, D. C. Jan Wong, Y. Jia, C. L. D. Jenkins, K. L. Soole, S.D. Castellarin, P. Darriet, M. Rienth, C. Bonghi, R. P. Walker, F. Famiani and C. Sweetman, 2021. Biosynthesis and Cellular Functions of Tartaric Acid in Grapevines. Front Plant Sci., 12: 643024.

Cacco, G., E. Attina, A. Gelsomino and M. Sidari, 2000. Effect of nitrate and humic substances of different molecular size on kinetic parameters of nitrate uptake in wheat seedlings. J. Plant Nutr. Soil Sci., 163: 313- 320.

Canellas, L. P., L.R. Teixeira, L.B. Dobbss, C.A. Silva, L.O. Medici, and A.R. Zandonadi, 2008. Humic acids cross interactions with root and organic acids. Ann. Appl. Biol., 153: 157- 166.

Chen, Y., and T. Aviad, 1990. Effects of humic substances on plant growth. In: McCarthy, P, Clapp CE, Malcolm RL, Bloom PR, editors. Humic Substances in Soil and Crop Sciences. Madison, WI, USA: American Society of Agronomy. pp. 161- 186.

Cottenie, A., M. Verloo, L. Kiek, G. Velghe and R. Camerlynek, 1982. "Chemical analysis of plants and soils" Laboratory of Analytical Agrochemistry. State University, Gent, Belgium, Article No. 42, 80-284.

Dursun, A., I, Güvenç and M. Turan, 2002. Effects of different levels of humic acid on seedling growth and macro and micronutrient contents of tomato and eggplant. Acta Agrobot 56: 81- 88.

El- Kamar, F.A., 2020. Evaluation of some Soil Conditioners on some Properties of Salt Affected Soil and Wheat Productivity and Quality. J. of Soil Sciences and Agricultural Engineering, Mansoura Univ., Vol. 11 (7):307-314.

El-Beltagi, H.S. and H. I. Mohamed, 2013. Alleviation of cadmium toxicity Francisco Rocha , Manuel Esteban Lucas-Borja, Paulo Pereira and Miriam Muñoz-Rojas. Cyanobacteria as a Nature-Based Biotechnological Tool for Restoring Salt-Affected Soils. Agronomy. 10: 1321

El-Bordiny, M. M. and C. Y. El-Dewiny, 2008. Effect of some properties on micronutrients availability. J. Appl. Sci. Res. 4 (11): 1569- 1573.

Francisco R., M. Esteban, M. Lucas-Borja; P. Pereira and M. Muñoz-Rojas, 2020. Cyanobacteria as a Nature-Based Biotechnological Tool for Restoring Salt-Affected Soils. Agronomy 10: 1321.

Ghafoor, A., G. Mortaze, B. Ahmed and T. M. Boers, 2008. Evaluation of amelioration treatments and economic aspect of using saline sodic water for rice and wheat under arid land condition. Irrigation, Drain (57): 424 - 434.

Gill, S. S., and N. Tuteja, 2010. Reactive oxygen species and antioxidant machinery in abiotic stress tolerance in crop plants. Plant Physiol. Biochem., 48: 909- 930.

Gümü¸S. and C. ¸Seker, 2015. Influence of humic acid applications on modulus of rupture, aggregate stability, electrical conductivity, carbon, and nitrogen content of a crusting problem soil. Solid Earth 6: 1231- 1236.

Hafez, E.M. and W.H. Abou El –Hassan, 2015. Nitrogen and water utilization efficiency of barley subjected to desiccated conditions in moderately salt -affected soil. Egypt. J. Agron., 37 (2): 231-249.

Hegazi, A.Z., S.S.M. Mostafa and H.M.I. Ahmed, 2010. Influence of different cyanobacterial application methods on growth and seed production of common bean under various levels of mineral nitrogen fertilization. Nat. Sci., 8:183- 194.

Helmy, A.; M. Abdel-Fatah and Kh. A. Shaaban, 2013. Nitrogen efficiency in barley under saline – sodic conditions as affected by urea, compost. J. Soil Sci. and Agric. Eng. Mansoura Univ.,4 (4): 1189- 1198.

Hussain N., G. Hassan, M. Arshadullah and F. Mujeeb, 2001. Evaluation of amendments for the improvement of physical properties of sodic soil. International Journal of Agriculture and Biology. 3 (3): 319- 322.

Khaled, H., and H. A. Fawy, 2011. Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil and Water Res., 6: 21-29.

Kobeasy, M.I., H.S. El- Beltagi, M.A. El- Shazly and E. A. H. Khattab, 2011. Induction of resistance in rachis hypogaea L. against Peanut Mottle Virus by nitric oxide and salicylic acid. Physiological and Molecular Plant Pathology 76 (2): 112- 118.

Kudla, J., D. Becker, E. Grill, R. Hedrich, M. Hippler, U. Kummer, M. Parniske and T. Romeis, K. Schumacher, 2018. Advances and current challenges in calcium signaling. New Phytologist., 414- 431. https://doi.org/10.1111/nph.14966

Liu, P.P., J.H. Bai, Q.Y. Ding, H.B. Shao, H.F. Gao, and R. Xiao, 2012. Effects of water level and salinity on TN and TP contents in marsh soils of the Yellow River Delta, China. Clean - Soil, Air, Water 40: 1118- 1124.

Lv, Y. C., G. Xu, J.N. Sun; M.Brestič, M. Živčák and H.B. Shao, 2015. Phosphorus release from the soils in the Yellow River Delta: dynamic factors and implications for eco-restoration. Plant Soil Environ. 8, 339–343.

Mayhew, L., 2004. Humic Substances in Biological Agriculture. Rev. ACRES 34:1- 2.

Metwally, A., I. Finkemeier, M. Georgi and K. J. Dietz, 2003. Salicylic acid alleviates the cadmium toxicity in barley seedlings. Plant Physiology 132 (1): 272- 281.

Mohsen, A. A. M., A. S. A. Salama and F. M. A. El-Saadony, 2016. The Effect of Foliar Spray with Cyanobacterial Extracts on Growth, Yield and Quality of Lettuce Plants (*Lactuca sativa L.*). Middle East Journal of Agriculture Research, 5 (1): 90- 96.

Monowara, K.1; A. Rahan; S. T. Bin Salam and S. M. Rahman, 2019. In *Pisum sativum* L. seedlings by calcium chloride. Notulae Botanicae Horti Agrobotanici Cluj-Napoca 41(1): 157- 168.

Munns, R. and M. Tester, 2008. Mechanisms of Salinity Tolerance. Annual Review of Plant Biology 59: 651- 681.

Muscolo, A., F. Bovalo, F. Gionfriddo and S. Nardi, 1999. Earthworm humic matter produces auxin-like effects on *Daucus carota* cell growth and nitrate metabolism. Soil Biol. Biochem., 31: 1303-1311.

Nardi, S., D. Pizzeghello, A. Muscolo and A. Vianello, 2002. Physiological effects of humic substances on higher plants. Soil Biol. Biochem., 34: 1527- 1536.

Nisha, R., B. Kiran, and C. B. Kaush, 2017. Bioremedation of salt affected soils using cyanobacteria in terms physical structure, nutrient status and microbial cropping system. Asian J. Agric. and Biol., 6.

Ounia, Y., T. Ghnayaa, F. Montemurrob, Ch. Abdellya and A. Lakhdara, 2014. The role of humic substances in mitigating the harmful effects of soil salinity and improve plant productivity. International Journal of Plant Production 8 (3): 353-374.

Page, A.L., R.H. Miller and D.R. Keeney, 1982. "Methods of soil analysis" mer. Soc. Agron., Madison, Wisconsin, U.S.A.

Paliyath, G., D. P. Murr, A. K. Handa and S. Lurie, 2008. Postharvest Biology and Technology of Fruits, Vegetables, and Flowers. Wiley-Blackwell. ISBN: 978-0-813-80408-8.

Pilbeam, D.J and P.S. Morley, 2007. (Eds.), Handbook of Plant Nutrition, Taylor & Francis, Boca Raton, FL. p., 121- 140.

Quirk, J.P., 2001. The significance of the threshold and turbidity concentrations in relation to sodicity and microstructure. Australian J. Soil Res., 39: 1185- 1217.

Rengasamy P. and G.J. Churchman, 1999. Cation exchange capacity, exchangeable cations and sodicity. In Peverill K.I. Sparrow L.A. and Reuter D.J. Soil Analysis: An Interpretation Manual. CSIRO Publishing, Collingwood.

Sahu, D., I. Priyadarshani and B. Rath, 2012. Cyanobacteria as potential biofertilizer. CIBTech J Microbiol., 1:20- 26.

Seddik, W. M. A., Wagida Z. Hassan and Hanaa A. Zein El-Abdeen, 2016. Influence of Organic Acids on Nutrients Availability from Natural Alternative Fertilizers. Egy. J. Soil Sci., 56: 503- 517.

Selim, E. M., and A. A. Mosa, 2012. Fertigation of humic substances improves yield and quality of broccoli and nutrient retention in a sandy soil. J. Plant Nutr. Soil Sci., 1- 9.

Shabala, S. and R. Munns, 2012. Salinity Stress: Physiological Constraints and Adaptive Mechanisms. In: Shabala, S., Ed., Plant Stress Physiology, CAB International, Oxford, 59-93.

Shafeek, M.R., Y.I. Helmy, W.A. El Tohamy and H.M. El Abagy, 2013. Changes in growth, yield and fruitquality of cucumber (*Cucumis sativus* L.) in response to foliar application of calcium and potassium nitrate under plastic house conditions. Res. J. Agric. Biol. Sci., 9: 114- 118.

Sharma, P., M. Rolle, B. Kocar, S. Fendorf, and A. Kappler, 2011. Influence of natural organic matter on as transport and retention. Environ Sci Technol. 15;45(2):546-53.
doi: 10.1021/es1026008. Epub 2010 Dec 13.

Sibanda, H.M and S.D. Young, 1986. Competitive adsorption of humus acids and phosphate on goethite, gibbsite, and two tropical soils. J. Soil Sci., 37: 197- 204.

Snedecor, G.W. and W.G. Cochran, 1980. "Statistical Methods".7th Edition, Iowa State Univ. Press., Ames., IA., U.S.A.

Soniya, D., N. Rani and A. Sagar, 2021. Bioreclamatory studies on salt affected soil by using cyanobacterial biofertilizers India Plant Archives, 21(2): 416- 422.

Srivastava, M.K. and U. N. Dwivedi, 2000. Delayed ripening of banana fruit by salicylic acid. Plant Sci., 158: 87- 96.

Sumner, M.E., 1993. Sodic soils: New perspectives. Australian J. Soil Res., 31: 683-750.

Türkmen, Ö; A. Dursun; M. Turan and Ç. Erdinç, 2004. Calcium and humic acid affect seed germination, growth, and nutrient content of tomato (*Lycopersicon esculentum* L.) seedlings under saline soil conditions. Acta Agric. Scan., 54: 168- 174.

Valdrighi, M.M., A. Pera, M. Agnolucci, S. Frassinetti, D. Lunardi and G. Vallini, 1996. Effects of compost-derived humic acids on vegetable biomass production and microbial growth within a plant (*Cichorium intybus*)-soil system: a comparative study. Agr. Ecosyst. Environ., 58: 133-144.

Welch, S.A., A.E. Taunton and J. F. Banfield, 2002. Effect of microorganisms and microbial metabolites on apatite dissolution. Geomicrobiol. J., 19: 343- 367.

Yan, J; L.J. Deng and J. Huang, 2005. Effect of conservation tillage on soil physicochemical properties and crop yields. Chinese Agriculture Mechanization 2: 31- 34. (In Chinese).

Yasser, M. A., E.A. Shalaby and N. T. Shanan, 2011. The use of organic and inorganic cultures in improving vegetative growth, yield characters and antioxidant activity of Roselle plants (*Hibiscus sabdariffa L.*) Afr. J. of Biotechnology. 11: 1988- 1996.

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Zaka, M.A., A. Khalil, R. Hafee zullah, S. Muhammed and S. Helge, 2018. Effectiveness of compost and gypsum for amelioration of saline sodic soil in rice wheat cropping system. Asian J. Agri. & Biol., 6 (4): 514- 523.

Zandonadi, D.B., L.P. Canellas and A.R. Façanha, 2007. Indolacetic and humic acids induce lateral root development through a concerted plasmalemma and tonoplast H+ pumps activation. Planta. 225: 1583- 1595.

Zein El-abdeen, H. A., F. A. F. Khalil and Wafaa M.T. El-Etr, 2018. Effect of Calcium Humate, Nitrogen Fertilizer Rates and Irrigation Regime on Soil Chemical Properties and Faba Bean Productivity. J. Soil Sci. and Agric. Eng., Mansoura Univ., Vol. 9 (11): 575- 586.

Zhang, W.Z., X.Q. Chen, J.M. Zhou, D.H. Liu, H.Y Wangand and C.W. Du, 2013. Influence of humic acid on interaction of ammonium and potassium ions on clay minerals. Pedosphere 23: 493- 502.