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ALLEVIATION SOIL SALINITY AND SODICITY HAZARD USING SOME BIO-CHEMICAL AMENDMENTS FOR PRODUCTION OF CANOLA (*Brassica napus L.*) IN NORTH DELTA REGION

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ABSTRACT

A biotic stresses (salinity, drought, improper temperature, flooding, metal toxicity, ozone, UV-radiations, herbicides, etc.) remain the greatest constraint to crop production worldwide. It has been reported that more than 50% of yield reduction is the direct result of a biotic stresses. A field experiment at Sakha Research Station Farm , Kafr El-Sheikh, Egypt was carried out during two successive winter seasons 2012/2013 and 2013/2014 to study the role of some bio-chemical in alleviation of soil salinity hazard and improving oilseed rape production. A split plot design with three replicates was performed. The main plots were occupied by different amendments: control (T_1), humate (T_2), Si (T_3), biotol (T_4), humate + Si (T_5), humate + biotol (T_6), Si + biotol (T_7) and humate + Si + biotol (T_8). Whereas, sub plots were the method of application: foliar, soil and foliar + soil application. The results showed that T_8, treatment (humate + Si + biotol) clearly improved the electric conductivity (EC), sodium adsorption ratio (SAR) and exchangeable sodium percentage (ESP), where their values were decreased by 16.9 %, 13.5% and 9.5%, respectively. However, CEC was increased with different amendments as compared to the control in both growing seasons. The highest increase of CEC value (7.4%) was recorded with T_8. The results also revealed that the rape yield and its attributes affected significant by different treatments. The highest increases of seed, oil and protein yields (229.7 %, 250 % and 374 %, respectively) were achieved with T8 (mean of both seasons). The application methods of the ameliorators are affected significantly on their impacts and the foliar + soil application was the best method. The seed yield, protein and oil content were highly significantly increased with the interaction between the ameliorators and methods of application in saline soils. Silicon alleviate salt stress and increased the yield of rape oilseed, whereas the humate improved physical, chemical and biological properties of soil and the uptake of macro- and micro-nutrients and finally increased the yield. Economic evaluation recorded the highest values 11276.6, 75560, 2.42 and 2.0 for total income (LE $ha.^{-1}$), net income (LE $ha.^{-1}$) , Net income from water unit (LE m^{-3}) and economic efficiency, respectively with T_8. It could be concluded that the alleviation of soil salinity and sodicity stress of salt-affected soils can be achieved by foliar and/or soil application of Si+ +humate + biotol.

Keywords: Oilseed rape, silicon, potassium humate, biofertilizer, soil properties, Nutrient recovery (%) salt-affected soils and economic evaluation.

INTRODUCTION

Soil, as a non-renewable resource, has the central role to all primary production system .The salt affected soils alone have assumed significant global dimension as about one billion hectare areas in more than 100 countries exist mostly under arid and semi-arid climates (Biswas 2014). Currently, at least 20% of the world's irrigated land is salt-affected. Among those affected by salt, about 60% are sodic (Qadir *et al.* 2006). FAO (2005) reported that salt affected soils represent 30 % from the total cultivated area in Egypt. The increasing pressure on soil resources lead to different types of degradation including sodification and/or salinization, which is the process of increasing salt in soil profile. Hence, soil degradation resulting from sodicity, salinity or both; it is a major impediment to optimal utilization of soil resources (Sahin *et al.* 2011). Thus, in order to reach the food security, the sustained productivity from these limited soil resources is further threatened by the multiplicity of resource degradation problems. In Egypt, improving salt affected soils could be considered as an important issue in the agricultural security program (Abdel-Fattah 2012).

Under saline and saline-sodic soils, reduction in crop yield is associated with osmotic and specific ion effect and the degree and extent of the adverse effect is further exacerbated when saline water is used for irrigation (Sharma and Rao 1998). Therefore, under these previous conditions, potassium (K) can play an important role in mitigating the adverse effects of high salt concentrations in these soils (Garg and Gupta 1998) and the stress tolerance of crops can be enhanced by optimizing K nutrition (Roemheld and Kirkby 2010). Whereas, potassium is well known as osmo-regulation and stress mitigation, particularly under saline conditions (Cakmak 2010).

Although Egypt was supposed to be self-sufficient by about 95 % in edible vegetable oils during the early sixties, this self-sufficiency decreased to 31.6% in 2007 (Hassan and Sahfique 2010). Nowadays, Egypt produces roughly 3 to 5 % of total domestic edible oil consumption demand. Imports of palm oil, sunflower oil, and soybeans and soybean oil bridge the 95 to 97 % gap between the domestic consumption and local production (2.06 tons) from cottonseed, soybeans, sunflower and sesame (USDA 2013).

Although oilseed rape (*Brassica napus* L.) is one of the most important oilseed crops in the world, it is not common cultivated in Egypt even its seeds contain about 40 % oil and 23 % protein (Gül and Amar 2006). Furthermore, it is the dominant oilseed crop in northern Europe (Rathke *et al.* 2006) and its oil is high in mono-and poly-unsaturated fatty acids (Oleic and linolenic). This oil could be used as edible oil for human (Chowdhury *et al.* 2007). Production of oil in Egypt can be increased by expanding the area and maximizing the yield of oil seed crops. Hence, the acreage could be increased by cultivating such new oil seed crops in the old and new reclaim soils.

Although , Si is the second most abundant element both on the surface of the Earth’s crust (28 %) and in soils (54 %), it is not among the essential elements for higher plants (Liang *et al.* , 2007 and Kabata-Pendias , 2011) , but its uptake by plants can alleviate both biotic and abiotic stresses. However, the beneficial roles of Si in stimulating the growth and development of many plant species have been generally recognized (Liang *et al.* 2007; Zhu and Gong 2014). The importance of Si for plant fitness, by affording protection from biotic and abiotic stresses, has been increasingly recognized

(Raven 2003; Liang *et al.* 2007). Recently, numerous studies have shown that Si can significantly alleviate aluminum, manganese, salt, drought, chilling, and freezing stresses, and has beneficial effects on plant growth and production (Ma and Yamaji 2008; Fahramand *et al.* 2014). In addition, Si is effective in mitigating salinity in some plant species, such as barley (Liang *et al.* 2003), maize (Moussa 2006), tomato (Romero-Aranda *et al.* 2006), and wheat (Tuna *et al.* 2008; Fahramand *et al.* 2014). In the higher plants, Si can be mediated the alleviation of abiotic stresses through the following mechanisms: (1) stimulation of antioxidant systems in plants, (2) precipitation of toxic metal ions with Si, (3) immobilization of toxic metal ions in growth media, (4) uptake processes, and (5) constraint of metal ions within plants (Liang *et al.* 2007). Also, silicon reduces ion toxicity in plants under salt stress by decreasing toxic ion accumulation and/or improving plant water status (Zhu and Gong 2014).

Enormous publications over more than five decades reported that humic substances (HS) have positive effects on plant growth and productivity (Quilty and Cattle ,2011 and Billingham ,2012) and substantial interest in their potential for improving nutrient-use efficiency and contributing to carbon sequestration in the soil (Billingham 2012 and Rose *et al.* 2014). The stimulatory effects of humic substances were attributed to hormone-like activity and its action similar to auxins, cytokinins and absisic acid (Mayhew 2004). Also, the stimulatory effects of HS have been directly correlated with enhancing the uptake of macronutrients, such as N, P, S (Chen and Aviad, 1990) and micronutrients, i.e. Fe, Zn, Cu and Mn (Chen *et al.* 1999). In addition, humic substances enhance the uptake of minerals through the stimulation of microbiological activity (Day *et al.* 2000 and Mayhew 2004).

In Egypt, soil fertility is diminishing gradually due to loss of nutrients, soil erosion, accumulation of salts and other toxic elements, water logging and unbalanced nutrient compensation. Biofertilizers are considered as an important part of environment friendly sustainable agricultural practices (Yadav *et al.* 2010). The biofertilizers include mainly the nitrogen fixing, phosphate solubilizing and plant growth-promoting microorganisms (Hasaneen *et al.* 2009). Biofertilizers are known to play a number of vital roles in soil fertility, crop productivity and production in agriculture as they are eco-friendly (Yadav *et al.* 2010) by fixing atmospheric nitrogen, with or without association with plant roots, solubilize insoluble soil phosphates and produces plant growth regulators in the soil. They are in fact being promoted to use the natural biological nutrients (Venkatashwarlu, 2008). Also, application of biofertilizers increased mineral and water uptake, root development, vegetative growth and nitrogen fixation (Yadav *et al.* 2010). Poraas *et al.* (2008) stated that maize grain yield, 100 grain weight and stover yield which grown on saline soil (EC dSm^{-1} in soil paste, 10.7) were significantly increased due to organic and bio treatments.

Soil salinity and fertility interaction experiments, which carry out in salt affected soils can be considered as an important issue in soil sciences. A more systematic research is required to observe the responses of crops to this interaction at the field level where extreme variability in salinity, soil texture and soil nutritional status is a norm. Therefore, the present study deals with the effect of silicon, K-humate and biofertilizer on the yield of canola in salt affected soils.

MATERIALS AND METHODS

1. Experimental site and treatments:

Field trials were carried out at Sakha Research Station, Kafr El Sheikh, which lies in 134 km north Cairo. The experiment was conducted during two successive winter seasons (2012/2013 and 2013/2014) to study the effect of some bio-chemical on canola using a split plot design with three replicates .Plot area was 10.5 m^2 (3.5 m length x 3 m width). The main plots were devoted to ameliorators: (1) control (without application), (2) Si as salicylic acid (H_4SiO_4), (3) K-humate, (4) biofertilizer (biotol), (5) Si + K-humate, (6) Si + biotol, (7) biotol + K-humate and (8) Si + K-humate + biotol. The sub-main plots are occupied method of application (Foliar ,Soil and Foliar +Soil application), as shown in Table (1)

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Table 1.Layout of the experiment

Ameliorator treatments (main plots)		**Application methods (sub-main plots)**		
		Foliar (F)	**Soil (S)**	**F+S**
T_1	Control	F	S	F+S
T_2	Si (Salicylic acid)	F	S	F+S
T_3	K-humate	F	S	F+S
T_4	Biotol (biofertilizer)	F	S	F+S
T_5	Si + K-humate	F	S	F+S
T_6	Si + biotol (biofertilizer)	F	S	F+S
T_7	K-humate + biotol.	F	S	F+S
T_8	Si + K-humate + biotol	F	S	F+S

Salicylic acid and K-humate were added at 2.0g L^{-1} twice after 25 and 50 days from sowing *via* a foliar application, while 2.4 kg salicylic acid and 7.2 kg ha^{-1} K-humate were added before sowing *via* a soil application. The biotol, which produced from the Agricultural Research Center (ARC, Giza, Egypt) contains N_2-fixing free living bacterial cultures (*Azotobacter chroococcum* and *Azospirillium lipoferum*) and phosphate dissolving bacterial culture (*Bacillus megaterium*) was added in 3 equal doses at the rate of 9.6 L biotol/ha^{-1} before sowing , 25 and 50 days from sowing *via* soil application.

Canola seeds (*Brassica napus L*. cv. Pactol) obtained from Oil Crop Research Section, ARC, were planted on 25th November , 2012 and 11th November , 2013, whereas, the plants were harvested in April in both seasons.The recommended cultural practices of canola were performed,according to Egyption Ministry of Agriculture.

2. Data recorded at harvest

At harvest, 10 plants were chosen in 3 replications from 3 inner rows in each treatment to determine the following parameter: plant height (cm), number of branches / plant, number of seeds / pod , number of pods /plant, 1000-seed weight (g), seed yield (Mg ha^{-1}), oil yield (oil % * seed yield in Mg ha^{-1}), protein yield (protein % * seed yield in Mg ha^{-1}).

3. Recovery of nutrient (%)

The recovery of nutrient (%) for NPK (as individual nutrient) was calculated for each treatment according to **Crasswell and Godwin (1984)** as follow:

Recovery of nutrient (%) = [(Total nutrients uptaked from treatment - Total nutrient uptaked from control) / applied nutrients with treatment] X 100 %

4. Chemical analyses of soil and plant samples

Before the cultivation , soil samples were taken from each treatment in both growing seasons at two depths (0 - 20 and 20 - 40 cm depth). Soil samples were prepared for physical and chemical analysis according to the standard methods. These soil samples were dried, sieved through a 2 mm mesh and analyzed for texture, exchangeable cations Ca, Mg, K and Na, soluble cations and anions, soil pH and EC as well as available N, P and K according to **Page *et al.* (1982**) as shown in Table (2). Three samples of canola were randomly collected from each treatment, dried at 70 C° in a hot air oven and analyzed for oil content using Soxhlet apparatus and petroleum ether as a solvent. Seed nitrogen content was measured by an automated colorimetric method following Kjeldahl digestion (Page *et al.* 1982).The protein content was calculated using the factor of 6.25 (on a dry weight basis).

Table 2: Soil characterization of the experimental site before cultivation

Growth season	Soil depth (cm)	Soil texture	Soil pH *	Soil EC (dS m^{-1})	Soil CEC ($cmol_c$ kg^{-1})	Soil organic mater (g kg^{-1})	Soil SAR	Soil ESP (%)
1st season	0 – 20	Clayey	8.26	5.61	40.0	12.1	11.68	13.72
	20 – 40	Clayey	8.25	5.97	39.0	12.0	12.05	14.17
2nd season	0 – 20	Clayey	8.20	5.41	43.0	12.0	10.79	12.88
	20 – 40	Clayey	8.14	5.61	42.5	11.8	10.99	13.10

***Soil pH was determined in soil water suspension (1:2.5)** **SAR, sodium adsorption ratio**
Soil EC was determined in saturated soil paste extract **CEC, cation exchange capacity**
ESP,exchangable sodium percentage.

According to Natural Resources Conservation Service (NRCS), Oregon State University, USA, the soil of experiment can be classified as saline soil where (EC > 4 dS m^{-1}, SAR > 13, ESP < 15% and soil pH < 8.5) (Horneck *et al.* 2007)

5- amount of irrigation water applied ($m^3 fed.^{-1}$) was measured by using cut-throat flume (30x90cm) according to Early,(1975).

6. Statistical analysis

The obtained results were subjected to analyses of variance according to the procedure outlined by Gomez and Gomez (1984), and significant differences were weighted by LSD test at 0.05 level of probability.

RESULTS AND DISCUSSION

1. Soil chemical properties:

Treatments had a positive effect on decreasing soil salinity (EC_e) after harvesting of canola (Table 3) during both seasons. Data show that EC_e values (mean of both seasons) were decreased by about 5.7, 5.5, 6.4, 6.9, 8.0, 9.5 and 16.9 % with T_2,T_3,T_4,T_5,T_6, T_7 and T_8 , respectively , compared with the control (T_1).

With respect to the effect of treatments on soil SAR after harvesting of canola , data pointed out that SAR values were decreased with different treatments as compared with the control in both seasons as shown in Table (4). Data also show that the mean values of SAR (mean of both seasons) were decreased by about 6.3, 7.2, 8.4, 9.3, 9.7, 11.0 and 13.5 % with application of T_2,T_3,T_4,T_5,T_6,T_7 and T_8 , respectively as compared with T_1 (control). The same trend was observed also for ESP, where the its mean values were decreased by 2.5, 3.2, 3.4, 0.1, 1.3, 7.4 and 9.5 % with the same previous treatments , respectively. Furthermore, the combined application of foliar and soil was the best application method, its mean values were decreased by -8.6%. This may be due to the dominance of soluble Ca^{+2} on the exchange complex.

With respect to CEC, there is a positive effect due different treatments was observed during both seasons, Table 3. Data in Table 4 show that the mean CEC values of both seasons were increased by 0.6, 1.4, 1.6, 2.9, 4.1, 5.5, and 7.4 % with T_2,T_3,T_4,T_5, T_6, T_7 and T_8 , respectively ,compared with T_1,. The highest values of the CEC can be achieved using T_8.Concerning the impact of the treatments on soil chemical properties, the impacts were in the following order : $T_8 > T_7 > T_6 > T_5 > T_4 > T_3 > T_2 > T_1$ in both growing seasons.

Table 3: Some chemical characteristics of the soil after harvesting of oilseed rape as affected by ameliorators application (both two seasons)

Treatments	1st Season				2nd Season			
	EC	SAR	ESP	CEC	EC	SAR	ESP	CEC
Main treatments (T)								
Control (T_1)	5.61	11.9	13.3	39.1	5.71	11.8	13.3	39.1
Si (T_2)	5.52	11.2	12.9	39.3	5.16	11.0	13.1	39.3
K-humate (T_3)	5.54	11.2	12.9	39.6	5.16	10.8	12.9	39.6
Biotol (T_4)	5.45	11.0	12.9	39.7	5.14	10.7	12.9	39.7
K-humate + Si (T_5)	5.41	10.8	13.3	40.3	5.13	10.7	13.3	40.1
Si + bio.(T_6)	5.31	10.8	13.1	40.7	5.11	10.6	13.1	40.7
K-humate + biotol (T_7)	5.25	10.7	12.3	41.2	5.0	10.4	12.3	41.3
K-humate + Si + biotol (T_8)	5.00	10.5	12.0	42.0	4.41	10.0	12.0	42.0
Sub-main treatments (M)								
Foliar application (F)	5.6	11.8	13.9	39.1	5.65	11.7	13.9	39.2
Soil application (S)	5.4	10.8	12.4	40.7	5.42	10.9	12.4	40.7
F + S	5.4	10.8	12.2	40.8	5.42	10.9	12.3	40.9

Table 4: Relative change (± %) of some soil characteristics after harvesting of canola as affected by different ameliorators (mean of both seasons)

Treatments	EC	SAR	ESP	CEC
Control (T_1)	5.66	11.85	13.3	39.1
Si (T_2)	-5.7	-6.3	-2.5	+0.6
K-humate (T_3)	-5.5	-7.2	-3.2	+1.4
Biotol (T_4)	-6.4	-8.4	-3.4	+1.6
K-humate + Si (T_5)	-6.9	-9.3	-0.1	+2.9
Si + bio.(T_6)	-8.0	-9.7	-1.3	+4.1
K-humate + biotol (T_7)	-9.5	-11.0	-7.4	+5.5
K-humate + Si + biotol (T_8)	-16.9	-13.5	-9.5	+7.4
Foliar application (F)	-0.5	-0.8	+ 4.4	+0.2
Soil application (S)	-4.4	-8.4	-7.5	+4.2
F + S	-4.4	-8.4	-8.6	+4.5

2. Yield and yield components:

It is well known that the combined application of organic and inorganic amendments may play a significant role in improvement of canola yield and its components. Yield of canola and its components were increased with addition of biotol, K-humate as well as silicon as shown in Table (5). Concerning the yield components in both growing seasons, the highest values of plant height (159.8 and 162.2 cm), number of branches/plant (12.0 and 12.2), pods/plant (87.8 and 89.4), seeds/pod (24.9 and 25.3) and 1000-seed weight (5.7 and 5.8 g) were achieved with T_8. Furthermore, the combined application of foliar and soil was the best application method. Concerning the canola yield, the highest values of seed (3.19 and 3.24 Mg ha^{-1}) , oil (1.38 and 1.35 Mg ha^{-1}) and protein (0.775 and 0.785 Mg ha^{-1}) in both growing seasons, respectively, can be gained using T_8 (Table 6). The same trend was observed also for the method of application. The interaction between different amendments and the methods of application was highly significant.

The application of K- humate, Si and biotol individually or together significantly increased the yield and yield components of canola. The ameliorative role of the previous amendments in salt affected soils may be attributed that these materials increase the tolerance of plants to salinity and/or drought at both physiological and biochemical levels.

Data in Table (7) showed that the highest yield increase of seed (229.7 %, oil (250.0 %) and protein (374.2 %,) of canola (mean of both growing seasons) were achieved with T_8. Concerning the methods of application on canola, data pointed out that foliar with soil application achieved the highest increase in seed yield (130.8 %), oil yield (144.0 %) and protein yield (204.9 %).

Table 5. Canola yield , plant height, branch number, pod number and seed number and 1000-seed weight as affected by different treatments

Treatments	Plant height (cm)	Branch no. /plant	Seed no / pod	1000-seed weight (g)	Pod no. /plant
Main treatments (T)	2012/2013 Season				
Control	136.0 h	8.7 e	18.0 f	4.0 e	69.0 g
Si (Salicylic acid)	141.2 g	9.1 de	19.1 e	4.1 d	70.2 f
K-humate	143.7 f	9.3 d	19.7 d	4.2 c	72.2 e
Biotol (biofertilizer)	145.5 e	10.4 c	20.0 d	4.2 c	73.2 d
K-humate + Si	146.7 d	10.7 c	20.7 c	4.4 b	73.3 d
Si + biotol	152.7 c	11.2 b	22.7 b	4.4 b	76.4 c
K-humate + biotol	155.5 b	11.4 b	23.0 b	4.4 b	78.4 b
K-humate + Si + biotol	159.8 a	12.0 a	24.9 a	5.7 a	87.8 a
$LSD_{0.05}$	0.73	0.45	0.33	0.05	0.74
Sub-main treatments (M)					
Foliar application (F)	149.14 c	10.2 b	20.4 c	4.3 c	73.0 c
Soil application (S)	150.29 b	10.3 b	21.0 b	4.4 b	76.3 b
F + S	150.75 a	10.7 a	21.6 a	4.5 a	79.3 a
$LSD_{0.05}$	0.4	0.2	0.15	0.03	0.51
Interaction: T x M	ns	ns	**	**	**
	2013/2014 Season				
Main treatments (T)					
Control	137.5 h	8.1 h	18.2 f	4.0 e	70.0 g
Si (Salicylic acid)	143.5 g	9.1 g	19.4 e	4.1 d	71.2 f
K-humate	146.0 f	9.5 f	20.0 d	4.2 c	73.2 e
Biotol (biofertilizer)	148.0 e	10.5 e	20.3 d	4.3 c	74.2 d
K-humate + Si	149.3 d	10.7 d	21.0 c	4.4 b	74.3 d
Si + biotol	155.4 c	11.2 c	23.1 b	4.5 b	77.4 c
K-humate + biotol	158.2 b	11.5 b	23.4 b	4.5 b	79.8 b
K-humate + Si + biotol	162.2 a	12.2 a	25.3 a	5.8 a	89.4 a
$LSD_{0.05}$	0.37	0.12	0.33	0.05	0.71
Sub-main treatments (M)					
Foliar application (F)	146.9 c	10.1 c	20.7 c	4.3 c	72.0 b
Soil application (S)	147.6 b	10.3 b	21.4 b	4.5 b	75.2 b
F + S	148.5 a	10.7 a	21.9 a	4.6 a	78.0 a
$LSD_{0.05}$	0.18	0.07	0.15	0.03	0.45
Interaction: T x M	**	**	**	**	**

Table 6. Canola seed yield, oil and protein content and yields as affected by different treatments

Treatments	Seed yield (Mg ha^{-1})	Oil content (%)	Oil yield (Mg ha^{-1})	Protein content (%)	Protein yield (Mg ha^{-1})
Main treatments (T)	2012/2013 Season				
Control	0.97h	41.5 g	0.40 h	16.83 g	0.163 h
Si (Salicylic acid)	1.24 g	41.5 f	0.52 g	19.57 f	0.242 g
K-humate	1.64 f	41.5 f	0.68 f	19.63 f	0.319 f
Biotol (biofertilizer)	2.14 e	41.7 e	0.89 e	20.36 e	0.437 e
K-humate + Si	2.19 d	41.9 d	0.92 d	23.50 d	0.514 d
Si + biotol	2.22 c	42.7 c	0.95 c	24.14 c	0.538 c
K-humate + biotol	2.48 b	42.8 b	1.07 b	24.27 b	0.605 b
K-humate + Si + biotol	3.19 a	42.9 a	1.38 a	24.37 a	0.775 a
$LSD_{0.05}$	0.016	0.01	0.007	0.09	0.009
Sub-main treatments (M)					
Foliar application (F)	1.91c	42.1 b	0.798 c	21.37 c	0.415 c
Soil application (S)	1.94 b	42.1 b	0.811 b	21.65 b	0.432 b
F + S	2.26 a	42.2 a	0.946 a	21.73 a	0.502 a
$LSD_{0.05}$	0.012	0.01	0.005	0.04	0.006
Interaction: T x M	**	**	**	**	**
Main treatments (T)	2013/2014 Season				
Control	0.98 g	41.5 g	0.38 h	16.88 h	0.166 h
Si (Salicylic acid)	1.26 f	41.5 f	0.53 g	19.37 g	0.242 g
K-humate	1.65 e	41.5 f	0.65 f	19.48 f	0.322 f
Biotol (biofertilizer)	2.17 d	41.7 e	0.87 e	20.39 e	0.442 e
K-humate + Si	2.22 c	41.9 d	0.93 d	22.71 d	0.504 d
Si + biotol	2.25 c	42.7 c	0.97 c	23.75 c	0.535 c
K-humate + biotol	2.52 b	42.8 b	1.15 b	24.10 b	0.607 b
K-humate + Si + biotol	3.24 a	42.9 a	1.35 a	24.22 a	0.785 a
$LSD_{0.05}$	0.023	0.01	0.01	0.08	0.004
Sub-main treatments (M)					
Foliar application (F)	1.88 b	42.1 b	0.806 c	21.22 c	0.418 c
Soil application (S)	1.92 b	42.1 b	0.818 b	21.36 b	0.432 b
F + S	2.24 a	42.2 a	0.957 a	21.50 a	0.501 a
$LSD_{0.05}$	0.017	0.01	0.01	0.05	0.003
Interaction: T x M	**	**	**	**	**

Table 7. Relative change (±%) of seed yield, oil and protein content and their yields of canola as affected by different treatments (mean of both seasons)

Treatments	Seed yield	Oil content	Oil yield	Protein content	Protein yield
Main treatments (T)					
Control	0.975	41.5	0.39	16.86	0.165
Si (Salicylic acid)	+28.2	0.0	+34.6	+15.5	+47.1
K-humate	+68.7	0.0	+70.5	+16.0	+94.8
Biotol (biofertilizer)	+121.0	+0.5	+125.6	+20.9	+167.2
K-humate + Si	+126.2	+1.0	+137.2	+37.1	+209.4
Si + biotol	+129.2	+2.9	+146.2	+42.1	+226.1
K-humate + biotol	+156.4	+3.1	+184.6	+43.5	+268.4
K-humate + Si + biotol	+229.7	+3.4	+250.0	+44.1	+374.2
Sub-main treatments (M)					
Foliar application (F)	+94.4	+1.4	+105.6	+26.3	+153.2
Soil application (S)	+97.9	+1.4	+108.8	+27.6	+162.6
F + S	+130.8	+1.7	+144.0	+28.2	+204.9

In the present study,the improvement of canola yield may be due to the role of K (from K-humate) in plant nutrition, osmoregulation and mitigating the adverse effects of high salt concentrations in soils, (Munns ,2002, Shabala and Lew ,2002 , Marschner, 2012 and Wang et al., 2013), or humic substances have the potential positive effects on plant growth and productivity (Billingham, 2012 and Rose et al., 2014), Si contribute to osmotic adjustment and increase photosynthetic enzymatic activities and can regulate the levels of endogenous plant hormones under stress conditions (Zhu and Gong 2014) or the biofertilizer is defined as a substance which contains living micro-organisms and give good expansion of the root system and better seed germination (Chen ,2006 ,Yadav *et al.* 2010 , Mahdi *et al.* , 2010 and Singh *et al.* , 2011).

3. Nutrient uptake by plant and its recovery:

The data in Table (8) revealed that the nutrients uptake by canola was significantly affected by different soil ameliorators (T) , methods of application (M) and the interaction T x M . The highest uptake of N (124.1 and 125.5 kg ha^{-1}), P (17.23 and 15.05 kg ha^{-1}) and K (38.11 and 38.57 kg ha^{-1}) in both growing seasons , respectively were recorded with the foliar and soil application of K- humate + Si + biotol (T_8).

Table 8. Effect of different treatments on N, P, K uptake (kg ha.$^{-1}$) by canola

Treatments	Nutrient uptake (kg ha^{-1})					
	N	P	K	N	P	K
Main treatments (T)	2012/2013			2013/2014		
Control	26.1 h	3.07 h	9.48 h	26.4 h	3.36 h	9.55 h
Si (Salicylic acid)	38.8 g	4.46 g	12.38 g	38.8 g	4.44 g	12.50 g
K-humate	50.8 f	5.81 f	16.56 f	51.6 f	5.88 f	16.70 f
Biotol (biofertilizer)	70.0 e	7.85 e	22.01 e	70.9 e	7.92 e	22.25 e
K-humate + Si	82.3 d	8.16 d	22.68 d	80.6 d	8.26 d	22.97 d
Si + biotol	85.9 c	8.59 c	24.67 c	85.4 c	8.71 c	24.94 c
K-humate + biotol	96.9 b	10.56 b	27.67 b	97.2 b	10.66 b	28.01 b
K-humate + Si + biotol	124.1 a	17.23 a	38.11 a	125.5 a	15.05 a	38.57 a
$LSD_{0.05}$	0.67	0.06	0.19	0.59	0.07	0.18
Sub-main treatments (M)						
Foliar application (F)	66.72 c	7.48 c	20.18 c	66.9 c	7.37 c	20.40 c
Soil application (S)	69.12 b	7.70 b	20.54 b	68.8 b	7.63 b	20.76 b
F + S	80.16 a	9.48 a	24.36 a	80.4 a	8.98 a	24.65 a
$LSD_{0.05}$	0.42	0.05	0.13	0.44	0.05	0.13
Interaction: T x M	**	**	**	**	**	**

Concerning the recovery of the previous nutrients, the recovery (%) was in the following order: N (68.1 and 68.8) > K (49.7 and 50.4) > P (16.8 and 19.7) in both growing seasons, respectively as shown in Fig. (1). It could be observed also that the relationship between nutrient recovery and different treatments were high correlation values. The results suggest that the highest recovery of these nutrients by canola was achieved by the combined application of K-humate, Si and biotol (T_8). The R^2 values were 96, 85 and 91 % for N, P and K nutrients, respectively as a mean of both growing seasons. Regarding the application method, the highest values of recovery were recorded with soil and foliar application together as shown in Fig.(2).

These results suggest that K-humate, Si and biotol can enhance the canola plants to uptake these essential nutrients (NPK) from soil solution in saline soils. It means that these the previous ameliorators may induce canola plants to overcome the salinity stress to uptake the essential nutrients from soil to give high yield.

4. Interactions among yield compartments:

The results in Table 9 show that the interactions among yield and yield components of canola are significant except only the relation between the number of seeds per pod and the number of pods per plant .This reflects the importance of yield components of canola and its strong relation with the harvested yield.

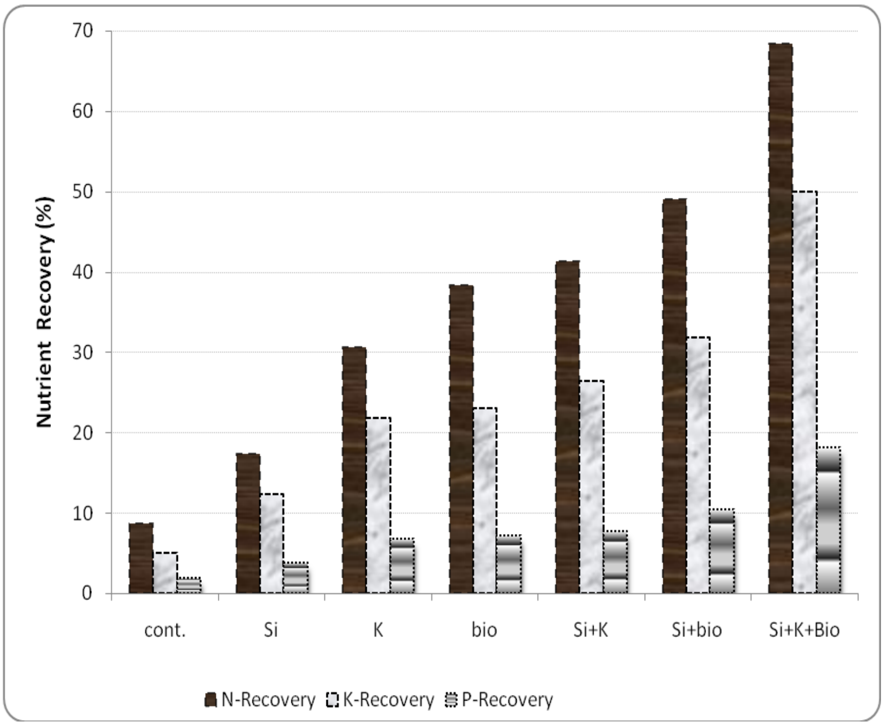

Fig. 1. Nutrient (N, P, and K) recovery (%) of canola for different treatments as a mean of the two growing seasons. Abbreviations: cont. (control), Si (Salicylic acid), K (K-humate), bio (biofertilizer)

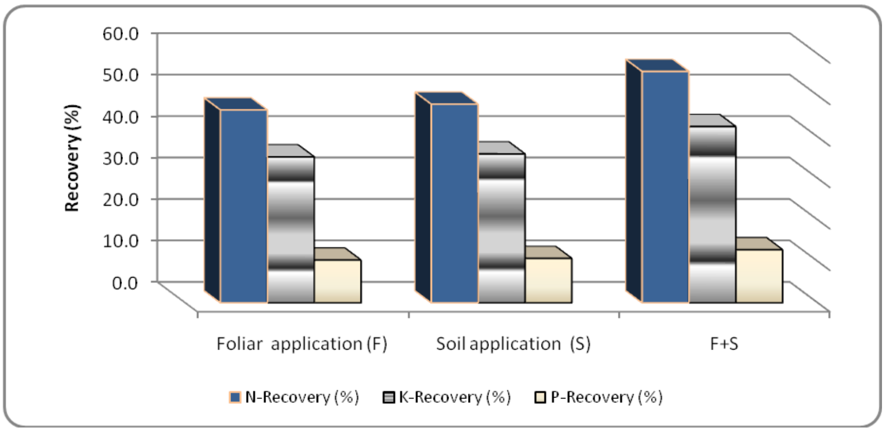

Fig. 2. Nutrient (N, P, and K) recovery (%) of canola for different methods of application as a mean value over the two growing seasons

Table 9. Linear correlation (*r* values) between yield of canol and its components

Parameters	Seed yield (Mg ha^{-1})	1000 seed weight (g)	Seed no. /pod	Pod no. /plant	Branch no. /plant	Plant height	Protein yield	Oil yield
Seed yield	-							
1000-seed weight (g)	0.80 **	-						
Seed no. /pod	0.89 **	0.79 **	-					
Pod no. /plant	0.72 **	0.49 **	0.76**	-				
Branch no. / plant	0.90 **	0.68 **	0.89 **	0.79 **	-			
Plant height (cm)	0.92 **	0.77 **	0.96 **	0.78 **	0.90 **	-		
Protein (Mg ha^{-1})	0.99 **	0.79 **	0.93 **	0.89 **	0.93 **	0.95 **	-	
Oil (Mg ha^{-1})	0.99 **	0.80 **	0.90 **	0.83 **	0.92 **	0.92 **	0.99 **	-

*** Correlation significant at the 0.01 level (2-tailed)**

5. Economic evaluation:

It is well known that any the agricultural system should be evaluated from the economic point of view. Therefore, the total out comes and incomes should be calculated. So, the current soil amendments were evaluated taking in consideration the yield of canola. The economic evaluation of this study includes calculation of the total net income (LE ha.$^{-1}$) , the total costs (LE ha.$^{-1}$), net income from water unit (LE m^{-3}) and economic efficiency. Due to the highest values of yield beside the total net income, net income from water unit (LE m^{-3}) resulting from the application of K-humate + Si + biotol, which ameliorated the saline soil, the economic efficiency for the previous amendments were increased with soil and foliar of application. The highest values were 11276.6, 7556.6, 2.42 and 2.0 for total income (LE ha.$^{-1}$), net income (LE ha.$^{-1}$) , Net income from water unit (LE m^{-3}) and economic efficiency, respectively, (Table 10).

Table 10. The total and net income from water unit and economic efficiency of sugar beet as affected by different treatments

Treatments	Seed (Mg ha^{-1})	Total income (LE ha^{-1})	Total costs (TC)	Net income (NI)	Net IWU	Eco. Eff
Main treatments (T)						
Control	0.981	3433.8	3600.0	-166.2	-0.05	0.0
Si (Salicylic acid)	1.249	4372.3	3712.0	660.3	0.21	0.2
K-humate	1.646	5762.5	3728.0	2034.5	0.65	0.5
Biotol (biofertilizer)	2.157	7548.2	3696.0	3852.2	1.23	1.0
K-humate + Si	2.207	7723.0	3704.0	4019.0	1.29	1.1
Si + biotol	2.240	7840.3	3712.0	4128.3	1.32	1.1
K-humate + biotol	2.505	8768.9	3720.0	5048.9	1.62	1.4
K-humate + Si + biotol	3.222	11276.6	3720.0	7556.6	2.42	2.0
Sub-main treatments (M)						
Foliar application (F)	1.899	6647.5	3649.5	2998.0	0.96	0.8
Soil application (S)	1.928	6748.8	3699.0	3049.8	0.98	0.8
F + S	2.250	7875.8	3748.5	4127.3	1.32	1.1

Economic efficiency= total net income (LE ha.$^{-1}$) /total cost (LE ha.$^{-1}$)
Net income from water unit (LE m^{-3}) = net income (LE ha.$^{-1}$) / applied water (m^{3} ha.$^{-1}$)
Where: the applied water calculated as 3120 m^{3} ha^{-1} in one season
Net IWU = Net income from water unit (LE m^{-3})
Eco. Eff. = Economic efficiency. TC, total costs whereas TI, total income and NI, net income in LE fed.$^{-1}$

CONCLUSIONS

On the basis of aforesaid findings, it could be concluded that the foliar with soil application of K-humate, Si and biotol together (T_8) was the best treatment in salt-affected soils. Thus, application of this treatment in saline soils appeared to be beneficial to the plant growth as well as to the physiological processes of canola plant. The magnitude of amelioration of the adverse effects of sodicity is more pronounced with silicon. Also, it can suggest that biofertilizers, if appropriately used, can lower the chemical fertilizer required to the saline soil and consequently mitigation the pollution. Concerning the benefits of K-humate, it can be energizing the plant ability to chelate soil nutrients, improve nutrient uptake, especially N, P, and K reduce the need for N- fertilization. In general, the benefits of organic ameliorator on improving soil health by enhancing soil quality parameters: physical fertility (soil porosity, aggregation, structure, bulk density, and water holding capacity), chemical fertility (pH, EC, CEC, SAR, ESP and nutrients) and biological fertility (microbial biomass/function and mineralization potential). The implications of this research may be astonishing. The conventional farming are faced with the mandated scarcity of soluble and organic fertilizers , farmers can take advantage of the microbiological release of nutrients from insoluble minerals with humic substances ,while they stabilize and improve the bioavailability of these minerals in soil solution.

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خفض مخاطر ملوحة وصودية التربة باستخدام بعض المحسنات الكيموحيوية لمحصول الكانولا في منطقة شمال الدلتا

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يعتبر الإجهاد غير الحيوى و الذى يتمثل فى الملوحة ، الجفاف ، و غيرها من أهم المعوقات التى تعيق إنتاج المحاصيل المختلفة على مستوى العالم ، و طبقاً للتقارير الدولية فقد وجد أن هناك إنخفاضاً قد يصل لأكثر من 50 % فى الإنتاج أو المحصول نتيجة مباشرة لهذه الإجهادات غير الحيوية. و عليه فقد أجريت تجربة بحثية بمحطة بحوث سخا بكفر الشيخ خلال موسمين شتويين متعاقبين (2012/2013 و 2013/2014) و ذلك بغرض دراسة إستخدام بعض المحسنات الكيموحيوية لخفض مخاطر ملوحة التربة على إنتاجية محصول الكانولا . و قد إجريت التجربة الحقلية بإستخدام تصميم القطع المنشقة فى ثلاث مكررات حيث كانت القطع الرئيسية تتضمن االمخصبات (بدون معاملة) ، السليكون (,Si) ، الدبال البوتاسى (K-humate) ، سماد حيوي (biotol) ، Si + K-humate ، biotol + Si ، Si+ K-humate + biotol و كانت القطع التجريبية المنشقة هى طرق إضافة هذه المحسنات أرضيا (S) أو رشا (F) او كلاهما معا (F + S). أما عن أهم النتائج المتحصل عليها فتتمثل فى تحسن كلا من ملوحة التربة ،نسبة ادمصاص الصوديوم ونسبة الصوديوم المتبادل فقد لوحظ تناقص كلا منهم بنسبة 16.9% ، 13.5% و9.5% بالترتيب نتيجة المعاملة بالدبال البوتاسي+حامض السالسيلك + سماد حيوى لمتوسط قيم موسمى الدراسة ومن ناحية أخرى تأثرت السعة التبادلية الكاتيونية نتيجة الجمع بين اضافة كلا من المعاملات(الدبال البوتاسي+حامض السالسيلك+ سماد حيوى) حيث بلغ معدل التغير النسبي10.6 % لمتوسط قيم موسمى الدراسة. أما بالنسبة للمحصول فقد لوحظ زيادة المحصول و مكوناته زيادة معنوية نتيجة لإضافة هذه المحسنات الثلاث مجتمعة مقارنة بالإضافة الفردية و الكنترول ، حيث زاد محصول البذور والزيت و البروتين بمعدل تغير نسبى لمتوسط الموسمين 229.7 % ، 250.0%،و374.2 % على الترتيب مقارنة بالكنترول عند إضافة هذه المحسنات الثلاث مجتمعة ، و عموماً فإن إضافة هذه المحسنات الثلاث مجتمعة قد أعطى أعلى محصولاً و كذلك مكونات المحصول حيث كانت هناك العلاقة المعنوية بين طريقة إضافة هذه المحسنات و المحسنات نفسها تحت ظروف الأراضي المتأثرة بالأملاح. و قد لوحظ أن السيليكون قد زاد من قدرة النباتات على تحمل ظروف الملوحة ، بينما الدبال البوتاسي قد حسن من خصائص التربة الطبيعية و الكيمياوية و الحيوية و كذلك معدلات إمتصاص هذه النباتات للمغذيات المختلفة صغرى كانت أم كبرى مما إنعكس فى النهاية على زيادة المحصول .

- تبين من التقييم الاقتصادى لمحصول الكانولا الحصول علي أعلى قيم العائد الكلى (11276.6جنيه/هكتار)،وصافى العائد(7556.6 جنية/هكتار)، صافى العائد بالجنيه من استخدام وحده المياه (2.42)،ونسبة العائد من الاستثمار(1:2) نتيجة الجمع بين اضافة كلا من المعاملات (الدبال البوتاسي+حامض السالسيلك + سماد حيوى)

و عليه فإنه يمكن التوصية بأنه تحت ظروف الأراضى الملحية أو المتأثرة بالأملاح يمكن إضافة كلاً من الدبال البوتاسي والسيليكون والأسمدة الحيوية معاً بالمعدلات التى وردت بهذه الدراسة مع إضافتها رشاً و كذلك الإضافة الأرضية معاً لتلافى التأثيرات الضارة الناتجة عن التركيز العالى من الأملاح،وتحسين بعض من خواص التربة.