EVALUATION OF POTASSIUM HUMATE AND *SPIRULINA PLATENSIS* AS A BIO-ORGANIC FERTILIZER FOR SESAME PLANTS GROWN UNDER SALINITY STRESS

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Abstract

A field experiment was conducted at private farm at Gelbana district Sahl El-Tina plane (North Sinai), Egypt during summer season 2006 to examine the effect of foliar spray or soil application methods of K-humate and *S. platensis* alga individually and combined as bio-organic fertilizer on sesame yield and its attributes under saline soil conditions. Soil physico-chemical and biological properties after sesame harvesting were determined. Foliar application of bio-organic fertilizer (k-humate + *Spirulina platensis*) recorded the highest values of plant height, number of capsules/plant, number of branches/plant, seed weight /plant and 1000-seed weight followed by K-humate and alga individually compared to the control (mineral fertilizer only). While, soil application of K-humate combined with *S platensis* gave the highest values of seeds and straw yields followed by K-humate and alga individually compared to the control. The use of bio-organic fertilizer (k-humate + *Spirulina platensis*) gave the highest values of N,P and K contents in sesame seed as well as protein content. Oil percentage was not much influenced by the application methods or fertilization treatments under studied. The soil application of K-humate and *S. platensis* alga individually or in combination generally increased field capacity (FC) and available water (AW), while reduced the wilting point (WP), bulk density (BD) and hydraulic conductivity (HC) better than foliar application. Best results obtained by the combined treatment followed by the individuals. Also, the soil application of bio-organic fertilizer significantly decreased pH and EC, while increased organic matter content (OM) and available NPK in saline soil under studied. Soil biological activity i.e. dehydrogenase, nitrogenase, CO_2 evolution, total bacterial and total cyanobacterial counts, as a result of soil physio-chemical properties improvement, was enhanced by soil application of bio-organic fertilizer better than foliar spray application. Obviously, foliar spray application didn't vary saline soil physical, chemical and biological properties which reflect the lower sesame productivity than that obtained by soil application. Impact of each of the methods added (soil and foliar) varies according to capacity studied in the research under conditions of saline soil.

Key words: Salinity soil, K-humate , *Spirulina Platensis*, Bio-organic fertilizer, Sesame plants.

INTRODUCTION

Arid and semi-arid lands constitute approximately one third of the world's land surface (Arcihold, 1995) and salinity is the most serious problem in these regions. About 9.5 billion ha of the world's soils are salt-affected, except for large areas of secondarily salinized soil in cultivated land (Li *et al.*, 2005). The majority of salt-affected soils in Egypt are located in the northern-central part of the Nile Delta and on its eastern and western sides. However, fifty five percent of the cultivated lands of northern Delta region are salt-affected, twenty percent of the southern Delta and middle Egypt region and twenty five percent of the Upper Egypt region are salt-affected soils (FAO, 1995).

Soil salinity is characterized by high amounts of Na^{+}, Mg^{2+}, Ca^{2+}, Cl^{-}, HCO^{3-}, So_4^{2-} and B ions which have negative effects on plant growth. Generally, NaCl forms salt stress in nature. The general effect of soil salinity on plants is called a physiological drought effect. The high salt content decreases the osmotic potential of soil water and consequently this reduces the availability of soil water and nutrients uptake by plants. Thus, this affects the fertility of the soil negatively (Grattan and Grieve, 1999). Many investigators (Hashem *et al.*, 1997, El-Banna *et al.*, 2004) used different soil conditioners (organic manures, mineral fertilizers, sulfur and gypsum) to avoid the risks of irrigation with drainage water on growing crops. Also the role of these conditioners on amelioration of some chemical and physical properties of different soils was investigated by Abou-Baker and Omar (1996) who found that application of organic compost alone or accompanied with NPK fertilizers caused a decrease in soil salinity when compared with the control treatment.

The humic substances in the soil have multiple effects (Sangeetha *et al.,* 2006). It may have both direct and indirect effects on plant growth (Chen and Avid, 1999). Indirect effects involve improvement of soil properties such as aggregation, aeration, permeability, water holding capacity, micronutrients transport and availability (Tan, 2003). Direct effects are those, which require uptake of humic substances into the plant tissue resulting in various biochemical effects (Chen and Avid, 1999). Kulikova *et al.*, (2005) pointed out that humic substances might show anti-stress effects under abiotic stress conditions (unfavorable temperature, pH, salinity, etc.).

On the other hand, algal biofertilizer is also useful for the reclamation of marginal soils such as saline-alkali and calcareous soils (Hedge *et al.,* 1999).

Spirulina platensis is a photosynthetic blue-green microalga. It is a commercial product with high nutritional value, serving as a source of nutrients for food, feed and biofertilizer (Sánchez , 2003). *Spirulina platensis* has been used as biofertilizer for many crops in different application methods individually or comined with other organic fertilizers (Aly *et al.,* 2008).

El-Dardiry (2007) mentioned that organic matter (OM) plays an important role for decreasing soil salinity to extent improved barley grains germination. Also, biological technique and use of organic matter has long been known to facilitate the reclamation of saline soils.

This study aimed to evaluate the response of sesame productivity grown in saline soil to foliar or soil application methods of individual K-humate as organic source, *Spirulina platensis* as biological source, and their combination as bio-organic fertilizer as well as, the effect of these treatments on physio-chemical and biological properties of soil remained after sesame harvesting.

MATERIALS AND METHODS

Field experiment was carried out in a private farm at Gelbana district Sahl El-Tina plane (North Sinai), Egypt, during summer season 2006. Soil samples were taken at depth of 30 cm for physical and chemical properties (Table 1) as described by Chapaman and Pratt (1978). The experimental unit area was 10.5 m^2 (i.e. 1/400 feddan) consisting of five rows (3.5 m long and 60 cm between rows). A randomized complete block design with three replications was conducted.

Sesame (Giza 32) seeds were sown at a rate amounted 3 kg /fed. Only the control treatment was received the recommended dose of chemical fertilizer.

N,P and K fertilizers (40: 30: 48) were added at a rate of 200 kg/fed ammonium sulfate (20.6 % N) in two equal doses after 15 and 45 days of sowing, while phosphorus and potassium were added at a rate of 200 kg/fed calcium superphosphate (15.5 P_2O_5) and 100 kg/fed potassium sulfate (48 % K_2O), respectively. Potassium humate (K-humate) was used at a level of 30 L/fed as organic-fertilizer and *Spirulina platensis* alga as biofertilizer at a level of 15 L /fed individually or in combination mixture as bio-organic fertilizer. Prepared bio-organic fertilizer from K-humate and *Spirulina platensis* culture suspension was described by Mostafa and Ali (2009). Potassium humate was extracted from rice straw compost with KOH and characterized according to Knonova and Chikova, (1961).

Table 1. Mechanical and chemical analyses of the experimental soil

properties	Level
Practical size distribution	
Sand %	50.20
Silt %	32.05
Clay %	17.75
Soil texture	Sandy loam
B.D. cm^3/g	1.43
H.C Cm /h	3.98
F.C. %	24.11
W.P. %	13.75
A.W. %	14.81
Chemical analyses	
$CaCO_3$ %	8.32
pH (1:2.5)	7.45
EC dS/cm	11.02
Organic matter %	0.34
Available nutrients mg/k soil	
N	4.91
P	1.48
K	7.56

Spirulina platensis was obtained from Microbiology Res. Department, Soils, Water and Environment Research Institute, Agriculture Research Center (ARC), Giza, Egypt. The alga was grown in one liter Erlenmeyer flasks containing 500 ml of standard synthetic medium (Zarrouk, 1966) under continuous illumination (2000 lux). The flasks were incubation at 35°C$\pm$ 2°C. After 30 days of incubation the culture was transferred to glass-reactor (4 litre) and maintained under aerobic conditions using filtered compressed air and incubation at, 37°C for 21 days. *Spirulina platensis* culture concentration of 2.54 nm was measured spectrophotometrically at 560 nm by Leduy and Therien (1977). pH (1.51) and dry weight (2.63 gl^{-1}) were estimated according to Vonshak (1986). Chlorophyll- a (23.5 mgl^{-1}) was determined by the method of Vonshak and Richmond (1988).

Some characteristics for K_humate, *Spirulina platensis* culture and bio-organic fertilizer showed in Table (2).

Two application methods (foliar spray or soil application) were used in three successive additions, with 15 day intervals during the growing period and before flowering stage for sesame plants. First dose was applied after 15 days from sowing, then second and third doses were applied after 30 and 45 days respectively. The treatments of the field experiment were as follows:

- Chemical fert. NPK (control).
- K-humate at a rate of 30 L / fed individually as foliar application.
- K-humate at a rate of 30 L / fed individually as soil application.
- *S. platensis* culture at a rate of 15 L / fed individually as foliar application.
- *S. platensis* culture at a rate of 15 L / fed individually as soil application.
- Bio-organic fertilizer as foliar application at a rate 20 L/ fed.
- Bio-organic fertilizer as soil application at a rate 20 L/ fed.

Random samples of 5 plants from the two central rows in each plot were taken after 120 days from sowing to determine:

- Growth characters and yield attributes: Plant height, number of branches/plant, number of capsules/plant, seed yield/plant and 1000-seeds weight.
- Yield and yield contents: all plants from each plot were harvested and dried to determine seeds and straw yield/fed.
- Chemical traits: seeds content of NPK and seeds oil content were determined according to A.O.A.C. (1980). Seed protein % calculated by multiplying N % x 5.75.

The soil samples were taken after sesame harvesting to determine physical properties (field capacity FC, wilting point WP, available water AW, bulk density BD and hydraulic conductivity HC), chemical properties (EC, pH, organic matter content OM and available N, P and K) according to Black (1982).

Soil biological activities of the post harvested soil were estimated in terms of dehydrogenase activity (DHA) was estimated according to Casida *et al.* (1964), nitrogenase activity (N-ase) was measured by acetylene reduction as described by

Dart *et al.* (1972), CO_2 evolution was determined according to Gaur *et al.* (1971), total bacterial counts in soil samples were performed on nutrient agar medium using the spread plate method (APHA, 1985) and total counts of blue green algae were determined by plating ten-fold serial soil suspension-dilutions in triplicate onto agarized BG_{11} medium (Stanier *et al.,* 1971).

Data were subjected to statistical analyses according to Snedecor and Cochran (1980).

Table 2. Some characteristics of materials used in the experiment

Characteristics	K -Potassium	*S. platensis* Culture	Bio-organic (combined mixture)
Color	Dark brown	Blue-green	Brownish-green
pH	9.83	10.51	8.38
EC ($dScm^{-1}$)	7.05	19.3	3.59
Organic matter (gL^{-1})	5.51	2.72	1.2
Organic carbon (gL^{-1})	3.2	1.60	0.7
Total nitrogen (gL^{-1})	0.87	0.70	10.0
Total phosphorus (gL^{-1})	0.52	0.50	2.25
Total potassium (gL^{-1})	1.29	2.34	4.8

RESULTS AND DISCUSSION

I) Effect of K-humate and *Spirulina platensis* (foliar or soil application) individually and in combination as bio-organic fertilizer on sesame plants grown in saline soil

- **Growth characters and yield attributes**

Data in Table (3) illustrated the plant height, number of capsules/plant, number of branches/plant, seeds weight/plant and 1000-seeds weight as affected by foliar or soil application methods of K-humate and *S. platensis* either individually or in combination mixture. Foliar spray positively affected all the above plant growth parameters {plant height (8.91, 6.23 and 5.6%), number of capsules/plant (9.7, 5.6 and 2.2%), number of branches/plant (36.92, 28.46 and 6.15%), seed weigh/plant (12.86, 6.37 and 3.6%) and 1000-seed weight (43.55, 26.52 and 2.92%)} greater than soil application {plant height (6.02, 5.31 and 0.28%), number of capsules/plant (7.68, 4.89 and 0.86%), number of branches/plant (32.31, 30.77 and 4.61%), seed weigh/plant (9.76, 4.95 and 2.68%) and 1000-seed weight (40.15, 31.39 and 2.68%)}for bio-organic fertilizer (K-humate + *S. platensis*) followed by the individual treatments of K-humate and alga respectively.

Plant foliar nutrients are rapidly absorbed by the plant leaves. Within 8 hours after application of humic substances changes of different metabolic processes are detected. Enhanced carbohydrate production can either result in improved product quality or increased yields (Khan and Mir, 2002). These results could be explained according to the finding of Cheng *et al.* (1998) who stated that spraying humic acid enhanced the water retention, increased the ability rate of wheat leaves for photosynthetic process, increased the grain filling intensity, enhanced the drought resistance of wheat and increased its thousand grain weight. Ordog (1999) documented that the suspension of extract of cyanobacteria and microalgae contain a special set of biologically active compounds including plant growth regulators, which can be used for treatment to decrease senescence, transpiration as well as to increase leaf chlorophyll, protein content and root and shoot development. *Spirulina platensis* secretes plant growth hormones i.e. indole-3-acetic acid and gibberellic (Aly *et al.*, 2008) acid auxin, vitamins, amino acids, polypeptides and polymers especially exopolysaccharides that were reported to enhance growth and productivity of plants (Zaccaro *et al.*, 2006).

Ghosh and Mohiuddin (2000) found that the use of biofertilizer induced significant improvement in sesame plant height and number of branches/plant as well as increasing the yield components (number of capsules/plant, number of seeds/capsule, 1000–seed weight and seed yield).

In addition, *Spirulina platensis* application in presence of the chemical or organic amendments played an important role on growth, yield and yield components of carrot (Mahmoud *et al.,* 2007). The increase in growth characters, yield and its attributes by foliar fertilization may be due to that the sprayed solution of nutrients is readily absorbed by the leaves and not lost through fixation, decomposition or leaching (Abdel-Hadi *et al.,* 1985). Moreover, It is worthy to mention that the efficiency of foliar nutrition does not only depend on the concentrations and combination of nutrients, but also on carriers of the nutrient (Kariem *et al.,* 1991).

Table 3. Effect of K-humate and *S. platensis* (foliar or soil application) individually and in combination on growth and yield of sesame plants grown in saline soil.

Treatments	Plant height (cm)	Number capsules /plant	Number of branches /plant	seed weight /plant (g)	1000-seed weight (g)
Foliar application					
Control	131.81	85.72	6.50	35.16	4.11
K-humate	140.14	90.50	8.35	37.40	5.20
S. platensis	139.13	87.59	6.80	36.40	4.23
Bio-organic fertilizer (combined mixture)	143.56	94.03	8.90	39.68	5.90
L.S.D 0.05	0.02	0.10	0.14	0.18	0.2
Soil application					
Control	131.81	85.72	6.50	35.16	4.11
K-humate	138.81	89.91	8.50	36.90	5.40
S. platensis	132.18	86.46	6.90	34.67	4.22
Bio-organic fertilizer (combined mixture)	139.75	92.30	8.50	38.59	5.76
L.S.D 0.05	0.02	0.10	0.19	0.19	0.2

- **Yield and Yield components**

Data presented in Fig. (1) showed the effect of K-humate and *S. platensis* individually and in combination as bio-organic fertilizer on seeds and straw yields /fed. Significant differences were observed between treatments on the seeds and straw yields by using either foliar or soil application. The obtained data illustrated that soil application was more effective in increasing seed straw yield over the control treatment than foliar application methods. While, opposite trend was found with straw yield. Where, soil application increased seed yield by 39.61, 19.62 and 15.75% however, foliar spray enhanced seed yield by 36.49, 16.63 and 11.08% over the control by bio-organic fertilizer, K-humate and *S. platensis*, respectively. Straw yield of foliar application method (10.64, 11.01 and 6.28%) was relatively higher than that of soil application (9.12, 8.18 and 5.96%) by bio-organic fertilizer, K-humate and *S. platensis*, respectively.

These results are in concert with those obtained by Venkatakrishnan (1998). Fernandez *et al.* (1996) pointed out that under field conditions, foliar application of leonardite extracts stimulated shoot growth and promoted the accumulation of K, B, Mg, Ca and Fe in leaves. However, when leaf content of N and K values were below the sufficiency range, the foliar application of humic substances was ineffective to promote the accumulation of these nutrients in leaves. The results are in accordance with those reported by Govindasmy and Chandrasekaran (1992) they succeeded to increase yield of sugar cane by humic acid as foliar application. Similar results were also reported by Delfine *et al.* (2005) and Kurban *et al.* (1999).

- **Chemical traits**

Table (4) illustrated the effect of K-humate and *Spirulina platensis* individually and in combination mixture on NPK, oil and protein contents of seeds (%). Generally, all treatments in the two application methods significantly increased the N,P and K contents of seeds comparing with control treatment. The use of bio-organic fertilizer (K-humate + *Spirulina platensis*) gave the highest value of N,P and K% in seeds, being 11.1, 19.3 and 30.53 % with foliar application and 13.1, 31.58 and 41.98 % with soil application, respectively. The obtained data also cleared significant increases in oil and protein contents in seeds by all treatments comparing with the control in the two application methods. Best oil and protein contents of seeds under the two application methods were obtained by the bio-organic fertilizer (K-humate + *S. platensis*) followed by the individual treatments of K-humate and alga respectively. NPK, oil and protein increase percentages over the control treatment were superior by using soil application than foliar application method of all treatments.

Nageshwar *et al.* (2001) reported that the oil percentage decreased with increasing of N content, there was greater accumulation of protein that hinders the availability of carbohydrates for polymerization into fatty acids and thus leading to lower oil content into seed. These results are in harmony with those obtained by El-Habbasha *et al* (2007) who found that applying bio-organic fertilizer to sesame (Giza 32) gave the highest values of seed yield/fad, oil yield/fad and seed protein yield/fad.

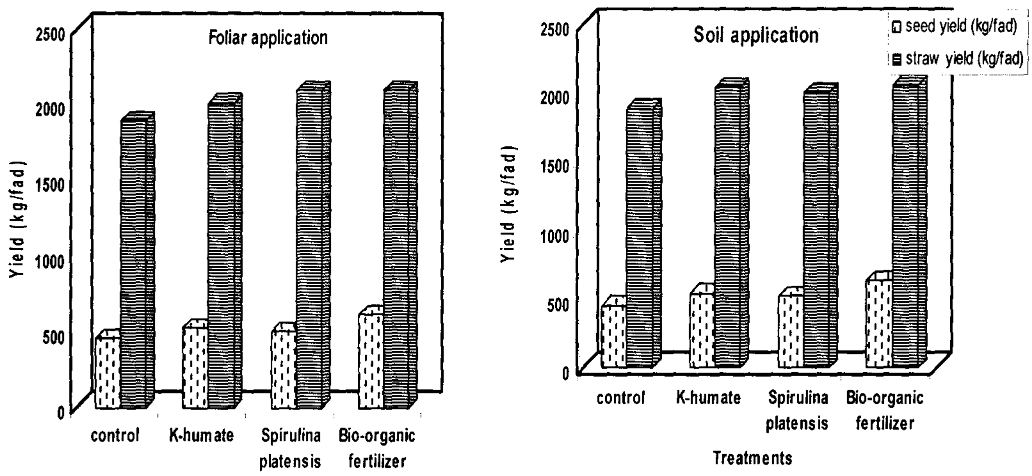

Fig. 1. Effect of K-humate and *S. platensis* (foliar or soil application) individually and/or in combination on sesame seeds and straw yields (kg/fad).

Table 4. Effect of K-humate and *S. platensis* (foliar or soil application) individually and/or in combination on NPK, oil and protein contents (%) in sesame seeds.

Treatments	NPK in seeds (%)			Oil (%)	Seed Protein (%)
	N	P	K		
Foliar application					
Control	3.14	0.57	1.31	49.81	18.05
K-humate	3.46	0.61	1.66	49.89	19.89
Spirulina platensis	3.38	0.62	1.33	49.87	19.43
Bio-organic fertilizer (combined mixture)	3.49	0.68	1.71	49.91	20.06
L.S.D (0.05)	0.018	0.019	0.019	0.021	0.019
Soil application					
Control	3.14	0.57	1.31	49.81	18.05
K-humate	3.53	0.72	1.82	50.63	20.29
Spirulina platensis	3.44	0.72	1.45	50.13	19.78
Bio-organic fertilizer (combined mixture)	3.55	0.75	1.86	50.65	20.41
L.S.D (0.05)	0.019	0.017	0.019	0.019	0.02

Generally, foliar and soil application of K-humate, alga and their mixture (bio-organic fertilizer) induced more increasing of N, P and K content of sesame seeds than the full dose of chemical fertilizer (control). It was interesting to notice the beneficial role of bio-organic fertilizer to increase K^+ uptake, which causing decreasing of Na^+/K^+ ratio in plant roots tissue to overcome deleterious effect of high osmotic pressure in saline soil (Kazem, 1988). Zuccarini (2007) proved that biofertilizer significantly reduced Na and Cl plant uptake and stimulated the absorption of K and P. Also, Bacilio *et al.* (2004) found that under high NaCl concentration, inoculation with *A. lipoferum* reduced the deleterious effects of NaCl. Under salt stress, the first doses of both soil and foliar application of bio-organic fertilizer increased the content of nutrients. These results agreed with those obtained by Asik *et al.* (2009).

II) Effect of K-humate and *Spirulina platensis* (foliar or soil application) individually and/or in combination as bio-organic fertilizer on saline soil properties

The remained soil after sesame harvesting was analyzed to evaluate the changes in soil physical, chemical and biological properties due to foliar or soil application of K-humate and/or *S. platensis* comparing to the chemical fertilized treatment (control).

- **Physical properties**

Data in Table (5) indicated the effect of foliar or soil application K-humate and *S. platensis* culture individually and/or in combination as bio-organic fertilizer on field capacity (FC), wilting point (WP), available water (AW), bulk density (BD) and hydraulic conductivity (HC). Results showed that the soil application of bio-organic fertilizer (K-humate + *S. platensis*) was more effective for increasing field capacity and available water due to the reduction of wilting point, bulk density and hydraulic conductivity followed by K-humate and alga individually compared to the control (mineral fertilizer only) treatment. These increases in FC (2.98, 2.20 and 1.24%, respectively) and AW (18.41, 15.20 and 6.60 %, respectively) were correlated with decreased in WP (-14.10, -5.46 and -4.44 %, respectively), BD (-2.8, -2.1 and -1.4 %, respectively) and HC (-13.38, -7.8 and -4.54%, respectively) due to soil application of bio-organic fertilizer, potassium humate and alga, respectively as compared to the control. While, foliar application of K-humate, *S. platensis* culture and bio-organic fertilization have no clear effect on soil physical properties. High salt content decreases the osmotic potential of soil water and consequently, reduces the availability of soil water for plants. Briefly, the uptake of water by plant roots is limited by increasing amounts of Na^+ and Cl^- (Asik *et al.*, 2009). Eventually, high salt concentrations in the soil reduce the absorption of nutrients by plants, causing negative effect on soil fertility. In addition, Increasing soil solution salinity would be decrease available water and consequently, negative effect on crop yield could be observed, if salinity levels are high enough (11.20 dS/cm). Any increase in humic substances by a unit causes a relatively large increase in the percentage of water retained in soil at the field capacity than at wilting point in coarse textured soils and the opposite was true in case of fine textured ones where showed increasing in both EC and wilting point with increasing organic matter by a unit (Bauer and Black, 1992).

Table 5. Effect of K-humate and *S. platensis* (foliar or soil application) individually and/or in combination on some soil physical properties.

Treatments	*Physical properties				
	FC	WP	AW	BD	HC
Foliar application					
control	24.13	16.66	10.68	1.43	3.96
K-humate	24.45	15.87	12.10	1.41	3.85
Spirulina platensis	24.23	16.35	11.19	1.42	3.94
Bio-organic fertilizer (combined mixture)	24.6 1	15.75	12.52	1.40	3.80
L.S.D 0.05	0.24	1.01	2.0	0.04	0.2
Soil application					
control	24.13	16.66	10.68	1.43	3.96
K-humate	24.66	15.75	12.31	1.40	3.65
Spirulina platensis	24.43	15.92	11.39	1.41	3.78
Bio-organic fertilizer (combined mixture)	24.85	14.31	12.65	1.39	3.43
L.S.D 0.05	0.2	0.02	0.02	0.02	0.019

*(FC): field capacity (WP): wilting point (AW): available water (BD): bulk density (HC): hydraulic conductivity

Bauer and Black (1992) stated that increasing organic matter decrease bulk density and consequently increase soil total porosity. They also added that soil organic matter affects on water movement in soil because of its hydrophilic character and its effect on soil structure and bulk density.

The humic substances in the soil have multiple effects. It may have both direct and indirect effects on plant growth. Indirect effects involve improvements of soil properties such as aggregation, aeration, permeability, water holding capacity, micronutrient transport and availability, Tan, (2003). Generally the effect of the studied treatments on soil physical properties still needed to be established by more than one season and duplicating replicates. On the other hand, cyanobacteria that exert a mechanical effect on soil particles as they form a gluing mesh and bind soil particles on the surface of their polysaccharidic sheath material (Malam Issa *et al.,* 1999, 2001). Cyanobacteria also excrete extracellular polymeric secretions (EPS) mainly composed of polysaccharides (Hu *et al.,* 2003). Extracellular polymeric secretions ensure the role of binding agent of soil particles (Lynch and Bragg, 1985).

Microbiotic crusts thus lead to the formation of tough and entangled superficial structures that improve the stability of soil surface and protect it from erosion (Malam Issa *et al.* 1999, 2001). Cyanobacterial sheaths and EPS also play a significant role in water storage due to the hygroscopic properties of polysaccharides (Decho, 1990). Cyanobacteria contribute to increased water retention capacity of soil (Défarge *et al.*, 1999) and have been used as inoculants in attempts to improve soil structure, increase soil fertility or recover damaged soil crusts (Zulpa de Caire *et al.*, 1997).

- **Chemical properties and available nutrient content in saline soil**

Data in Table (6) showed the response of saline soil pH, EC and organic matter (OM) content to foliar or soil application of K-humate as organic fertilizer, alga as biofertilizer individually and/or in combination as bio-organic fertilizer. Foliar application of bio-organic fertilizer was slower effect on chemical properties (pH, EC and OM) in saline soil compared to soil application technique. Soil application of bio-organic fertilizer succeeded to decrease pH (7.32) and EC (7.31 dS/cm). However, it increased organic matter content in soil (0.58 %) compared to the control. This increase could be attributed to the improvement of saline soil water properties (Table 5), aeration and aggregates, thus increasing available nutrients in soil solution. Biological treatments and use of organic matter has long been known to facilitate the reclamation of saline soils (Vereeken *et al.*, 1995).

The beneficial effect of organic materials incorporation followed by leaching is preferred to decompose organic matter resulting in the evolution of carbon dioxide and organic acids, lowering soil pH and release of Ca^{2+} by solubilization of $CaCO_3$ and other soil minerals, thereby increasing the electrical conductivity and replacement of exchangeable sodium by cations like calcium and magnesium and thus lowering the ESP (Alam and Khan, 2006).

Table 6. pH, EC, organic matter content and available nutrients (N,Pand K) affected by foliar and soil application of bio-organic fertilizer

Treatment	pH	EC (dS/cm)	OM (%)	Available macro nutrients mg/k soil		
				N	P	K
Foliar application						
control	7.42	10.75	0.34	4.97	1.52	7.75
K-humate	7.40	9.78	0.36	5.12	1.55	8.80
Spirulina platensis	7.41	10.12	0.33	5.06	1.54	8.76
Bio-organic fertilizer (combined mixture)	7.40	9.45	0.36	5.70	1.63	9.12
L.S.D 0.05	0.03	1.16	0.06	0.18	0.02	0.04
Soil application						
control	7.42	10.75	0.34	4.97	1.52	7.75
K-humate	7.36	8.13	0.44	6.45	1.75	9.11
Spirulina platensis	7.38	8.45	0.42	5.78	1.61	8.95
Bio-organic fertilizer (combined mixture)	7.32	7.31	0.58	7.49	1.84	9.76
L.S.D 0.05	0.04	1.23	0.05	0.25	0.04	0..41

Available N,P and K in soil were significantly increased due to soil application of bio-organic fertilizer followed by K-humate and alga individually.

These increases being 50.70, 29.78 and 16.30% for N, 21.05, 15.13 and 5.92% for P and 25.94, 17.55 and 15.48% for K, respectively. In addition, the increases being 14.68, 3.01, 1.81% for N, 7.2, 1.97 and 1.32 % for P and 17.68, 13.55 and 13.03 % for K were due to the foliar application and recorded by biofertilizer, K-humate and alga individually, respectively.

Also the role of these conditioners on amelioration of some chemical and physical properties of different soils was investigated by Abou-Baker and Omar (1996) where they found that application of organic compost alone or accompanied with NPK fertilizers caused a decrease in soil sanity when compared with the control treatment. Cyanobacterial applied in rice or oil-seed rape cultivation supplied soil with nutrient and significantly increased productivity (Fernandez Valiente *et al.*, 2000). cyanobacteria, as C and N fixers, can improve the nutrient content of soil in arid environments (Mayland and McIntosh, 1966). As photosynthetic organisms they are the main primary producers, enriching the soil with organic matter and representing a potential source of nitrogen, which may be beneficial for crop production (Zaady *et al,*. 1998).

- **Soil biological activity**

K-humate and *Spirulina platensis* individually or in combination as a bio-organic fertilizer affected significantly on soil biological activity (Table 7) comparing to the chemical fertilized treatment (control) in the soil remained after sesame harvesting.

Salinity causes a detrimental effect on soil microorganisms and, in general, results in a decrease productivity of crop plants (Yamaguchi and Blumwald, 2005). But, the obtained data revealed that foliar or soil application method of bio-organic fertilizer (K-humate + *Spirulina platensis* culture suspension) resulted in maximum values of soil biological parameters followed by the individual treatments of K-humate and *S. platensis,* respectively. The enhancement of dehydrogenase, nitrogenase, CO_2 evolution, total bacterial and total cyanobacterial counts over the control was relatively higher in all treatments by using soil application than that by foliar application method.

These results are in coincidence with those obtained by Mahmoud *et al.* (2007) who reported that, *Spirulina platensis* combined with organic amendments significantly enhanced the soil biological activity in terms of increasing the total bacterial and cyanobacterial counts, CO_2 evolution, dehydrogenase, nitrogenase and phosphatase activities.

Table 7. The biological activity of the remained soil after sesame harvesting

Treatments	DHA activity (µg TPFg^{-1} dry soil Day^{-1})	N-ase activity (ml mole C_2H_4 g $soil^{-1}hr.^{-1}$)	CO_2 evolution (mg100g $soil^{-1}$ day^{-1})	Total bacterial count (10^5cfu g $soil^{-1}$)	Total cyanobact. count (10^2cfu g $soil^{-1}$)
Foliar application					
Control	2.06	42.29	20.89	36.46	32.00
K-humate	12.47	45.95	23.70	48.50	122.00
S. platenssis	10.22	43.91	22.57	45.00	121.50
Bio-organic (combined mixture)	17.67	99.81	24.38	61.00	220.00
L.S.D. 0.05	2.2	1.89	1.89	1.6	0.18
Soil application					
Control	2.06	42.29	20.89	36.46	32.00
K-humate	13.61	106.06	24.37	51.50	130.00
S. platenssis	11.24	46.70	23.07	46.50	125.00
Bio-organic (combined mixture)	28.09	134.08	30.83	71.50	250.00
L.S.D. (0.05	1.7	2.0	1.90	1.89	1.7

Organisms that thrive in hypersaline environments possess specific mechanisms to adjust their internal osmotic pressure (Laloknam *et al.*, 2006). One such mechanism of *Spirulina* is the ability to accumulate compatible low-molecular-weight organic solutes such as glycine betaine (Kempf and Bremer, 1998).

Cyanobacteria can be incorporated into soil as organic matter and also as a source of enzymes as they produce extracellular acid and alkaline phosphatases that are active in solution or located in the periplasmatic space of the cell wall. Both biomass and exopolysaccharides incorporated into soil, induced a growth promotion of other microorganisms and increased the activity of soil enzymes that participate in the liberation of nutrients required by plants (Caire *et al.,* 2000).

The influence of humic acid as organic fertilizer on microbial population and rhizosphere enzymes in sugarcane rhizosphere was studied by (Sellamuthu and Govindaswamy, 2003). They reported that bacterial population, fungi and actinomycetes population were increased by 100% NPK with 20 kg ha^{-1} humic acid application. They also added that humic acid application at 30 kg ha^{-1} significantly influenced the dehydrogenase activity. The increase in population might be due to the presence of humic acid in the root zone, which favours the microbial growth in the rhizosphere. Hopkins and Stark (2003) showed that The beneficial effects of HS on living organisms have been numerously reported. They can be provided by either indirect or direct impact of HS. The indirect effects are mostly provided by the HS-driven changes in environmental conditions such as bioavailability of some nutrients salts balance, physical and physico-chemical soil properties (soil structure, aeration, drainage, water retaining capacity, soil temperature, and others). On the other hand, HS are supposed to influence biota directly. The principal direct effects exhibited by HS onto living organisms include an increase in biomass accumulation, nutrient uptake, biosynthesis, antiviral activity, and others (Cacco et al., 2000).

CONCLUSION

Generally, it could be concluded that using the bio-organic fertilizer (K-humate + *S. platensis*) in growing sesame in saline soil either by foliar spray or soil application is preferable than the costly polluted chemical fertilizers. All the treatments under this study affected significantly on sesame growth and its productivity as well as saline soil improvement than the full dose of chemical fertilizer (control). Foliar application of the bio-organic fertilizer affected plant growth (plant height, number of capsules/plant, number of branches/plant, seed weigh/plant and 1000-seed weight) and straw yield better than soil application. While soil application was better in seed yield, NPK of seeds, oil and protein contents of seeds than foliar application.

However, it could be observed that using soil application technique of the combined treatment (K-humate + *S. platensis*) as bio-organic fertilizer was better for saline soil physical, chemical and biological properties than foliar technique.

It is worthy to mention that the use of chemical fertilizers has been doubled during the last two decades. Thus the coincident application of bio-organic fertilizers is frequently recommended for improving biological, physical and chemical properties of saline soil and to get agricultural products with good quality and free pollutants.

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تقييم هيومات البوتاسيوم وطحلب *Spirulina platensis* كسماد عضوي-حيوي لنبات السمسم النامى فى أرض ملحية

ليلى قرنى محمد على ، سها سيد محمد مصطفى

معهد بحوث الأراضي والمياه والبيئة-مركز البحوث الزراعية-الجيزة

أقيمت تجربة حقلية في مزرعة خاصة فى منطقة سهل الطينة ، محافظة العريش ، مصر ، خلال موسم الصيف عام ٢٠٠٦ لدراسة تأثير طرق اضافة هيومات البوتاسيوم و طحلب *Spirulina platensis* اما منفردا او مجتمعة معا كسماد عضوي-حيوي على الصفات المورفولوجية وإنتاجية محصول السمسم النامي في أرض ملحية وكذلك الخواص الفيزيائية والكيميائية والبيولوجية للتربة الملحية بعد الحصاد.

أوضحت النتائج المتحصل عليها الى وجود اختلافات كبيرة بين المعاملات على الخصائص التي شملتها الدراسة.

أظهرت النتائج أن إضافة المعاملة المجمعة في صورة سماد عضوي حيوي Bio-organic رشاً على النبات سجلت أعلى القيم من حيث طول النبات ، وعدد القرون/النبات وعدد الفروع/نبات ، ووزن البذور/النبات ووزن ١٠٠٠ بذرة ، تليها معاملة هيومات البوتاسيوم ثم الطحلب كل بمفرده مقارنة بمعاملة الكنترول (الأسمدة المعدنية فقط). بينما أعطت الإضافة الأرضية لمعاملة هيومات البوتاسيوم وطحلب *Spirulina platensis* معا أعلى القيم لكل من محصول البذور والقش ، تليها هيومات البوتاسيوم ثم الطحالب كل بمفرده. وبصفة عامة كانت هناك زيادة معنوية في محتوى البذور من النيتروجين والفوسفور والبوتاسيوم و كذلك محتوى البذور ن البروتين نتيجة للإضافة الأرضية لسمادBio-organic بينما لم تتأثر النسبة المئوية للزيت تأثراً كبيراً نتيجة لإضافة أى من المعاملات تحت الدراسة.

كما أوضحت الدراسة أن الإضافة الأرضية لهيومات البوتاسيوم وطحلب *Spirulina platensis* اما منفردا او مجتمعة معا كسماد bio-organic أدى بصفة عامة إلى تحسين السعة الحقلية (FC) والماء الميسر (AW) ، في حين انخفض كل من محتوى الرطوبة عند نقطة الذبول (WP) والكثافة الظاهرية (BD) والتوصيل الهيدروليكى (HC). وكان لإستخدام معاملة سماد الـ Bio-organic الأثر الأكبر تليها المعاملات المنفردة لكل من هيومات البوتاسيوم و طحلب *Spirulina platensis*.

أيضا أدت الإضافة الأرضية لسماد Bio-organic بشكل ملحوظ لانخفاض درجة الحموضة pH ونسبة الأملاح فى التربة ، في حين زاد كلا من محتوى التربة من المادة العضوية (OM) وزاد تيسر كل من النيتروجين والفوسفور والبوتاسيوم فى محلول التربة.

وأدت هذه النتائج إلى تحسين الخواص البيولوجية للتربة (إنزيم الديهيدروجينيز و النيتروجينيز وثاني أكسيد الكربون المتصاعد من التربة، و العدد الكلي لكل من البكتريا والسيانوبكتريا) والتي تفوقت فيها المعاملة الأرضية عن معاملة الرش الورقي. ومن الملاحظ أن المعاملة الورقية لم تؤثر على الصفات الطبيعية والكيميائية والحيوية للتربة الملحية مما يعكس قلة إنتاجية محصول السمسم نسبياً عن المعاملة الأرضية. وأن تأثير كل من طرق الإضافة (الأرضية اوالورقية) يختلف حسب الصفة المدروسة في البحث تحت ظروف الأرض الملحية.