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Research Article

Improving Seed and Oil Yield of Sunflower Grown in Calcareous Soil Under Saline Stress Conditions

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Abstract

Background and Objectives: Salinity adversely affects plant growth via many ways like low water potential of soil solution, imbalance of nutritional status and ions toxicity, so, alleviating the adverse effect of salinity has become a main concern of many researchers. The aim of the present study was to produce sunflower grown in a calcareous soil under saline stress conditions. **Methodology:** Two field experiments in a Randomized Complete Block Design (RCBD) were conducted in two summer seasons of 2015 and 2016 in a private farm, Oraby Village, Mariut sector, Alexandria, Egypt to study the effect of foliar spraying with micronutrients alone and combined with potassium humate, cytokinin and algae extract on growth, seed and oil yield and nutrients content of sunflower plants grown in calcareous soil under saline stress conditions. Results were statistically analyzed and then by using SAS software version 9.3. **Results:** A combined analysis was conducted and the results revealed that foliar spraying with micronutrients either alone or combined with potassium humate, cytokinin or algae extract resulted in a significant increase in growth parameters (plant height, stem diameter, number of leaves, chlorophyll index, weight of 100 seeds and head diameter). Increases ranged from 11-111% compared with control and the highest ones was for the stem diameter. Also, a significant increase was observed due to the application of the treatments in seed yield, oil percentage and oil yield and the percent increases were ranged from 9% for oil percentage and 61% for oil yield comparing with control. Moreover, the nutrients content of sunflower plants (N, K, Ca, Mg, Na and Fe, Mn and Zn) was significantly increased due to all treatments of the foliar sprays. The combined treatment of algae extract and micronutrients was the best treatment where it recorded the highest values of all the studied parameters. In which 1630 kg seed per fed was achieved with percent increase of 36% and also 437 kg oil per fed with percent increase of 61% comparing with control. **Conclusion:** It could be concluded that foliar spraying with both algae extract and micronutrients may help sunflower plants to cope with salinity and produce an improved seed and oil yield under salinity stress conditions in calcareous soil.

Key words: Sunflower, foliar spraying, micronutrients, potassium humate, cytokinin, algae extract, drainage water

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Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Recently, sunflower has become an important source of healthiest edible oil and is considered as one of the promising oil crops in everywhere in the world due to its high contents of unsaturated fatty acids which can play an important role in lowering cholesterol levels in the blood¹. Sunflower oil is also a good source of linoleic acid which is an essential fatty acid needed to the body human health². The productivity of sunflower is affected by many factors such as soil fertility and both soil and irrigation water salinity. Salinity causes many adverse effects on plant developmental stages due to many factors such as low water potential of soil solution, nutritional and hormonal imbalance and ions toxicity which induced salt stress³. Salinity causes osmotic stress and ionic toxicity due to the accumulation of sodium ion which enhanced the formation of Reactive Oxygen Species (ROS), such as, superoxide (O_2^-), hydrogen peroxide (H_2O_2), hydroxyl radical (OH^-) and singlet oxygen ($1O_2$), which damage mitochondria, chloroplasts and cellular structure of the cell^{4,5}. Irrigation water of a good quality is expected to decrease in the future, thus, irrigated agriculture faces the challenge of using less water, in many cases of poorer quality, to provide food and fiber for an expanding population. Some of these future water needs can be met by using available water supplies more efficiently, but in many cases it will prove necessary to make increased use of municipal wastewaters, irrigation drainage waters and sea water^{6,7}. The necessity to use saline water in irrigation compensating the shortage in the fresh water, the bio fertilizers that originated from seaweed are better and more economical than other fertilizers in that cases⁸. Effect of seaweed bio fertilizers have been studied on different crops⁹ and improving their yield. For instance, the yield of canola (*Brassica napus*) was improved with foliar application of seaweed extract¹⁰. Exogenous application of micronutrients¹¹ and antioxidants¹² such as potassium humate and cytokinin to plants grown under salt stress conditions have been known to have stimulatory effect on crop yield and their resistance to salt stress. The current study was carried out to examine the effect of foliar spraying with micronutrients and its combination with potassium humate, cytokinin and algae extract on seed and oil yield and chemical composition of sunflower plants grown in a calcareous soil under saline stress conditions of both soil and drainage water irrigation. This study will help in using algae extract and other growth enhancers to improve sunflower productivity in marginal lands and irrigation water salinity.

MATERIALS AND METHODS

Two field experiments were carried out in Oraby Village at Mariut sector, Alexandria governorate, Egypt (located between latitude $30^{\circ}58'47''$ N and longitude $29^{\circ}48'38''$ E) during two summer growing seasons 2015 and 2016. The soil of the experimental site has a clay loam texture, pH 8.5, EC 3.9 dS m^{-1} , total CaCO_3 27.2% and organic matter 2.0%. While N, P, K, Ca, Na, Fe, Mn and Zn contents were: 700, 23, 280, 474, 800, 6.71, 1.23 and 1.00 ppm, respectively, which determined according to Estefan *et al.*¹³. The drainage water source used for irrigation has pH 8.4 and EC 6.9 dS m^{-1} . twenty experimental plots (84 m^2) $30 \times 2.8\text{ m}$ (5 treatments with 4 replicates) were arranged in a Randomized Complete Block Design (RCBD). Seeds of sunflower (Sakha 53) were sown at the rate of 5 kg per feddan in the second week of May in both seasons at 20 cm between hills and 60 cm between ridges. An integrated fertilizer program (60 kg N, 30 kg P_2O_5 and 25 kg K_2O per fed) and other all practices for growing sunflower were applied as recommended by Ministry of Agriculture. Foliar spray of micronutrients (3% Fe, 3% Mn, 3% Zn and 0.2% B), potassium humate (12% K_2O), cytokinin (0.1%) and algae extract (5% N, 7% OM, 2.5% P_2O_5 , 2.5% K_2O , 0.4% S, 1% Mg, 140 ppm Fe, 100 ppm Mn, 100 ppm Zn, 125 ppm Cu, 25 ppm B, 10% amino acids, 2.5% carbohydrates, traces of cytokinin and gibberellin and auxin) were applied twice (30 and 50 days after sowing) at concentration of 1 mL or g L^{-1} . Gross five guarded plants samples from each plot were randomly taken after 90 days of sowing for the following measurements: Plant height (cm), stem diameter (cm), leaf number and chlorophyll index. At the end of the experiments, all plants heads of each plot were collected, head diameter (cm) were recorded then seeds were isolated from their heads, air-dried and weighed to record seed yield per feddan and 100-seed weight. Seed oil percent was determined using soxhlet extraction unit as reported by Estefan *et al.*¹³ and seed oil yield was calculated in kg per feddan. The nutrients contents of leaves of Sunflower plants were determined according to the methods described by Estefan *et al.*¹³.

Statistical analysis: All results were statistically analyzed according to Snedecor and Cochran¹⁴. Bartlett's test revealed homogeneity of error and the combined analysis was conducted for all data of the two seasons using SAS software version 9.3¹⁵. The Significant Least Differences (L.S.D) were used to compare the means (LSD at 5%).

Table 1: Effect of micronutrients and its combination with potassium humate, cytokinin and algae extract on sunflower growth parameters (combined analysis of two successive seasons)

Treatments	Plant height (cm)	Stem diameter (cm)	No. of leaves	Chlorophyll index	100- seeds weight (g)	Head diameter (cm)
Control	130.0	1.9	16.3	35.3	9.9	15.9
Micronutrients	159.6	3.0	22.7	36.8	11.5	20.1
Micronutrients+Potassium humate	168.7	3.7	25.7	37.6	12.3	21.9
Micronutrients+Cytokinin	176.3	3.9	27.3	38.4	13.1	23.0
Micronutrients+Algae extract	182.0	4.0	28.7	39.3	13.7	24.7
LSD at 5%	9.95	0.16	1.74	2.35	0.34	0.58

Table 2: Effect of micronutrients and its combination with potassium humate, cytokinin and algae extract on sunflower seed yield, oil percentage and oil yield (combined analysis of two successive seasons)

Treatments	Seed yield		Oil		Oil yield	
	kg per fed	Increase (%)	%	Increase (%)	kg per fed	Increase (%)
Control	1199.0	100.0	22.6	100.0	271.0	100.0
Micronutrients	1429.4	119.2	24.7	109.3	353.1	130.3
Micronutrients+Potassium humate	1493.7	124.6	25.3	111.9	377.9	139.4
Micronutrients+Cytokinin	1525.1	127.2	25.5	112.8	388.9	143.5
Micronutrients+Algae extract	1630.2	136.0	26.8	118.6	436.9	161.2
LSD at 5%	6.83		0.14		2.51	

Table 3: Effect of micronutrients and its combination with potassium humate, cytokinin and algae extract on sunflower chemical composition (combined analysis of two successive seasons)

Treatments	N	K	Ca	Mg	Na	Fe	Mn	Zn
	%					ppm		
Control	2.17	3.03	2.33	0.97	2.60	285.3	45.3	24.0
Micronutrients	3.13	4.07	2.43	1.02	2.63	403.0	77.3	41.7
Micronutrients+Potassium humate	2.97	5.03	2.53	0.87	2.10	412.6	83.0	52.3
Micronutrients+Cytokinin	2.73	4.13	2.63	1.09	2.30	422.7	90.3	47.0
Micronutrients+Algae extract	3.9	4.67	3.23	1.28	2.83	450.3	96.7	57.0
LSD at 5%	0.07	0.28	0.08	0.11	0.12	10.50	4.6	2.4

RESULTS

Plant height, stem diameter, number of leaves, chlorophyll index, weight of 100 seeds and head diameter of sunflower plants tended to gradually increase as a result of both spraying micronutrients alone or combined with potassium humate, cytokinin and algae extract. All the applied treatments resulted in a significant increase in all the studied characters as compared to the control treatment (Table 1). The combined treatment of algae extract and micronutrients was the best treatment where it gave the highest values of all the studied parameters. It exceeds the control treatment by 40% in plant height, 111% in stem diameter, 76% in number of leaves, 11% in chlorophyll index, 38% in weight of 100 seeds and 55% in head diameter.

Foliar sprays with micronutrients and its combination with potassium humate, cytokinin and algae extract resulted in a significant and gradual increase in seed yield, oil % and oil yield as illustrated in Table 2. The combined treatment of algae extract and micronutrients gave the highest values of seed yield (1630.2 kg per fed), oil% (26.8%) and oil yield

(436.9 kg per fed). As compared to the control treatment the increasing percentage were 36% for seed yield, 18.6% for oil percentage and 61.2% for oil yield. The enhancement effect of the treatments on the growth of sunflower plants may be attributed to the effect of these substances as growth promoters. These results are coincided with those obtained by Osman and Salem¹⁶.

As illustrated in Table 3 the applied treatments had a significant effect on the chemical composition of sunflower plants. Regarding the nitrogen content, the combined treatment of algae extract and micronutrients gave the highest percent of nitrogen (3.9%) with almost 80% increase as compared to the control treatment. While the combined treatment of potassium humate and micronutrients gave the highest percent of K with 66% increase over the control treatment. Back to the combined treatment of algae extract and micronutrients which recorded the highest value of Ca with 38.6% increase, 31.9% increase in Mg, 8.8% in Na, 58% in Fe, 113% in Mn, 137% in Zn as compared to the control treatment.

DISCUSSION

The results from the present study indicated that foliar application of micronutrients alone or combined with potassium humate, cytokinin, or algae extract resulted in an increase in growth parameters, seed yield and oil yield where the foliar treatments provided the sunflower plants with micronutrients and growth promoters that compensate its lack due to the effect of salinity and consequently enhances the growth of sunflower plants under salinity stress and produce an acceptable seed and oil yield from marginal soil. These findings were similar to what reported by several workers where in growth parameters, Karthikeyan and Shanmugam¹⁷ recorded an increase of 10% in plant height, 31% in head diameter when they applied bio-stimulant AQUASAP manufactured from seaweed *Kappaphycus alvarezii* (Rhodophyta) as foliar spray where they. Also, Nagesh and Shanwad¹¹ stated a significant increase in plant height, number of leaves, stem diameter, head diameter, 100 seeds weight when they applied micronutrients as foliar spray. Osman and Salem¹⁶ reported significant increase in many parameters of sunflower plants when sprayed with seaweed extracts such as plant height, head diameter, chlorophyll and seed index.

Concerning seed and oil yield, Karthikeyan and Shanmugam¹⁷ recorded an increase of 51% in seed yield, 15% in oil percentage and 15% in oil yield when they applied bio-stimulant AQUASAP manufactured from seaweed *Kappaphycus alvarezii* (Rhodophyta) as foliar spray. Algae extract contain all the trace elements and plant growth hormones required by plant to enhance yield attributes¹⁸. Nagesh and Shanwad¹¹ stated a significant increase in seed yield (kg ha^{-1}) when they applied micronutrients as foliar spray. Osman and Salem¹⁶ reported significant increase in seed yield, oil percentage and oil yield of sunflower plants when sprayed with seaweed extracts. Arabhanvi *et al.*¹⁹ concluded that foliar spray of micronutrients play a major role in translocation of photosynthates, increasing seed setting percentage, essential for translocation of sugar, germination of pollen grains, stigma receptivity, amino acid and protein synthesis which ultimately increase the productivity of oil seed crops. Patil *et al.*²⁰ observed that potassium humate treated plant showed significant increase on growth and yield characters of soybean and blackgram than control plant. Al-Jobori²¹ revealed that spraying with 200 ppm kinetin gave higher number of total seeds, number of filled seeds and percentage of filled seed in all the three portions and improved mean of seed weight as compared to their respective control of sunflower plant.

Similar results about mineral composition of sunflower plants have been reported by Osman and Salem¹⁶ where they stated a significant increase in K and Na of sunflower plants when sprayed with seaweed extracts. Mancuso *et al.*²² observed increases in uptake of N, P, K and Mg in cucumber and grapevines treated with seaweed extract. On the other hand, Ravi *et al.*²³ reported that foliar spray of iron at 0.5% + zinc at 0.5% sprayed at 30 and 65 DAS has recorded significantly higher nutrient uptake of major and micronutrients as compared to control. This was mainly due to synergetic effect of combined application of micronutrients.

CONCLUSION

It could be summarized that foliar spraying with micronutrients alone and combined with potassium humate, cytokinin, or algae extract may consider a new approach to improve growth and increase sunflower seed yield and oil content. The combined effect of foliar spraying with micronutrients plus algae extract was the most effective combination in enhancing growth parameters, seed yield, oil content and chemical composition as compared to the other treatments under stress of salinity conditions in calcareous soil.

SIGNIFICANCE STATEMENT

This study will help the researcher to uncover the critical areas of the ameliorative effect of algae extract as foliar application in alleviating the adverse effect of salinity on sunflower productivity when applied in combination with micronutrients. Thus a new theory on the production of sunflower under saline conditions may be arrived.

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