

Impact of Ascorbic Acid Foliar Spray and Seed Treatment with Cyanobacteria on Growth and Yield Component of Sunflower Plants under Saline Soil Conditions

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Keywords: Blue-green algae; antioxidant system; nutritional status, Osmoprotectants; growth and productivity; soil salinity

Abstract. A field experiments were conducted during the two summer seasons of 2015 and 2016 in saline soil ($EC_e = 9.0 \text{ dSm}^{-1}$), at Fayoum province, Egypt to study the effect of ascorbic (AsA), as foliar application alone or combined with cyanobacteria (CB) on growth, yield, its components and nutritional status of sunflower plants variety Sakha 54. Treatments comprised 2 ascorbic acid (AsA) levels with or without seed inoculation with cyanobacteria (CB). They were 1 mM AsA, 2 mM AsA, 1 mM AsA + CB and 2 mM AsA + CB in addition to the control treatment in which seeds were not received CB and their plants were sprayed with distilled water. Results could be summarized as follows: increasing the addition of ascorbic acid concentration up to 1Mm with combination of CB increased significantly values of growth attributes (e.i., plant height, of leaves no./plant, shoot dry weight and leaf area), photosynthetic pigments (chlorophyll a, b and carotenoids), physiological responses (total soluble sugars, proline and soluble phenols) as well as the head diameter, seed yield/ plant, 100 seed weight and seed yield (t ha^{-1}). Also, N, P, K, Fe, Mn, Zn and oil percentage of sunflower seeds with compared to control treatment in both years. Generally, the results in most cases, demonstrate that the all parameters increased significantly by using the concentration of ascorbic acid 1Mm combined with CB in both seasons

1. Introduction

Salinization is one of the most important stress factors which decrease the growth and crop productivity of plants in various climatic regions, especially under arid and semi-arid conditions, [1]. It was found that, 6% of the world's earth area and 20% of agricultural lands are already affected by salinity problem [2]. Salinity confused some biochemical and physiological parameters in crops as it caused formation of reactive oxygen species (e.i. superoxide anion (O_2^-), hydrogen peroxide (H_2O_2) and OH radicals) that caused chlorophyll degradation, proteins injury, and lipids of the membrane and nucleic acids which cause toxicity. Therefore, plants possess some strategies which scavenge ROS [3]. The deleterious impacts of salinity on growth of plants were documented by [4, 5, 6, and 7]. Ascorbic acid (AsA) is one of the most important metabolites serve as antioxidant, it interact not with H_2O_2 but also with O_3 , OH and lipid hydroxyl peroxidase and it has been also linked with various types of biological activities in plant, as a donor/ acceptor in electron transport and as enzyme co-factor [8]. AsA acts directly to neutralize superoxide radicals, singlet oxygen or superoxide and as a secondary antioxidant during reductive recycling of the oxidized form tocopherol, [9]. Sunflower is an important oil seed crop which ranks fourth after palm oil, soybean and canola along with other oil seed crops such as (peanut and cotton seeds) which contributes as edible oils in the world [10]. Blue-green algae (cyanobacteria, CB) are able to survive and thrive different environments as high pH and salinity and it can be used to reclaim alkaline soil ($\text{pH} > 8.5$) and enhancing soil fertility for cultivation of plants, [11]. CB usage results to the soil enrichment with fixed nitrogen, improvement of soil structure, reduction of pH, electrical conductivity and Na^+ . These changes improved the crop productivity and yield in salt – affected soil

[12]. This work aimed to study the combined impact of AsA as foliar spray and seed treatment with cyanobacteria on growth, seed and oil yields of sunflower.

2. Materials and Methods

Two field trials were performed during the two successive of 2015 and 2016 at Demo village (reclaimed soil with $EC_e = 9.03 \text{ dSm}^{-1}$), Fayoum province, Egypt. The trials were aimed to examine the combined effect of AsA (foliar spray) and seed treatment with cyanobacteria on growth, seeds and oil yield of sunflower (*Helianthus annuus* L.) cultivated in a reclaimed saline soil. Samples of soil to 0.25m from the experimental location before sowing were collected and analyzed according to [13]. Analysis results of the soil samples are shown in Table 1.

Table 1. Properties of the tested soil (physical and chemical) before sowing of two 2015 and 2016 seasons

Properties	2015	2016
Physical:		
Clay %	28.50	27.50
Silt %	21.00	22.50
Sand %	50.50	50.00
Soil texture	Sandy clay loam	Sandy clay loam
Chemical:		
pH (1: 2.5)	7.90	7.84
EC_e (dSm^{-1})	9.03	8.91
Organic matter %	0.85	0.88
CaCO_3 %	8.05	8.32
Total N %	0.07	0.07
Available nutrients (mg kg^{-1} soil):		
K	69.00	64.32
P	17.52	18.20
Fe	7.37	7.59
Mn	5.98	5.72
Zn	2.96	2.92

Sunflower seeds (cv. Sakha 53) were obtained from Agricultural Research Center, Giza, Egypt. They were sown on April 25, 2015 and 2016. Every year total of 476, 476 and 120 kg ha^{-1} , calcium superphosphate (15.5% P_2O_5), ammonium nitrate (33.5% N) and potassium sulphate (48% K_2O), respectively were added. Treatments include 2 of AsA concentrations with or without seed inoculation with cyanobacteria (CB). They were : 1 mM of AsA, 2 mM of AsA, 1 mM AsA + CB and 2 mM AsA + CB in addition to the control treatment in which seeds were not received CB and their plants were sprayed with distilled water. Before sowing seeds of sunflower were inoculated with cyanobacteria, and AsA, at mentioned levels, was sprayed on the foliage of plants to run off, two times; 30 and 40 days after sowing. Little drops of tween-20 were added to the spraying solution as a wetting agent. The design of experiment was a randomized complete blocks with 3 replications. Each experimental unit consisted of 5 rows 3 m long and 70 cm width, within row spacing averaged 20-25 cm apart.

2.1. Vegetative growth traits:

Fifty days after planting, 3 plants were chosen randomly from each plot and cut off at ground level and submitted to the following determinations: plant height (cm), No. of leaves per plant, leaf area/ leaf (cm^2), total leaves area plant $^{-1}$ (dm^2) and weights of leaves and shoot (stem +leaves) as dry plant $^{-1}$ (g & % for each).

2.2. Seed and oil yields and their components:

Ninety five days after sowing (at harvest stage), heads were picked from 3 randomly selected plants in each experimental unit and air-dried for 3 days then, seeds were manually extracted. Heads and their seeds were subjected to the following estimations: head diameter (cm), seed weight head⁻¹ (g) and 100-seed weight (g). Seed yield ha⁻¹ (ton) was calculated by using all heads of plants remained in all experimental units. Oil yield (t ha⁻¹) was calculated by multiplying seed yield ha⁻¹ (ton) × oil% of seeds. The latter was determined in the air-dried seeds according to the method described by [14] using Soxhlet apparatus and petroleum ether (60-80 °C) as solvent.

2.3 Chemical constituents:

Seven weeks after planting, leaves of 3 randomly chosen plants were collected from each plot for determinations of some chemical attributes (e.i. Photosynthetic pigments; chlorophylls (a, b, and total) and carotenoids concentrations) were determined using colorimetric method as described by [15]. Soluble phenols were, determined the method of [16]. The following parameters were determined using dry matter of leaves. TSS were determined according to [17]. Free proline was determined colorimetrically as outlined by [18]. AsA was determined according to the method of [19]. Nitrogen concentration was colorimetrically determined according to the method of [20]. For P, K, Fe, Mn and Zn determinations, were done as mentioned by [21]. Phosphorus and Potassium concentrations were estimated as described by [13 and 22]. Iron, manganese, and zinc concentrations were determined according to [23]. The protein content was estimated according to method of [24]. Superoxide dismutase, catalase and Guaiacol peroxidase activities were determined according to the methods of [25, 26, and 27].

2.4. Statistical analysis:

The obtained data were statistically analyzed, and comparisons between means of various treatments were done using the Least Significant Differences procedure (LSD) at $p=0.05$ level as illustrated by [28].

3. Results and Discussion

3.1. Effect of ascorbic acid and cyanobacteria of sunflower growth

Plant height, leaves number/plant, leaf area/ plant (cm²), and shoot dry weight/ plant were analyzed statistically as show in Table 2. All traits were significant influenced by AsA concentrations alone or combined with cyanobacteria (CB) in both season. The increasing percentage means (2015 and 2016) of dry weight of shoot plant⁻¹ than the control were 33.5 %, 86.2 %, 145.3 % and 142,5 % for the treatments 1mM AsA, 2mM AsA, 1mM AsA + CB and 2mM AsA + CB, respectively. The highest values of all attributes, had been noted when sunflower seeds were inoculation sunflower with cyanobacteria and plants were subjected to 1Mm of AsA in 2015 and 2016 seasons. AsA had clear effect on growth of sunflower plants and production of biomass. The improved in growth attributes of sunflower produced as a result of increased application rate of AsA could be attributed to Ascorbic acid application (vitamin-c) to plants stimulates their growth, thus, apart from their main role as coenzymes, it is not unlikely that vitamins may also play other independent roles in the processes of biochemical for plants, repairing the harmful impacts of unfavorable conditions.

Table 2. Combined effect of ascorbic acid (AsA) and cyanobacteria (CB) on vegetative growth traits of sunflower plants grown under reclaimed saline soil conditions in both 2015 and 2016 seasons

Treatments	Plant height (cm)	No. of leaves plant ⁻¹	Leaf area leaf ⁻¹ (cm ²)	Dry weight of shoot plant ⁻¹ (g)
2015 season				
Control	74.1d	18.6c	41.8d	25.0d
1mM AsA	99.4c	23.1b	57.1c	34.5c
2mM AsA	121.8b	24.5b	64.3b	49.3b
1mM AsA + CB	134.6a	26.9a	71.5a	63.2a
2mM AsA + CB	131.9a	26.3a	69.9a	62.3a
2016 season				
Control	77.5d	18.3c	41.1e	25.7d
1mM AsA	115.7c	22.7b	53.3d	33.3c
2mM AsA	129.8b	23.3b	60.9c	45.2b
1mM AsA + CB	139.4a	26.0a	69.3a	61.4a
2mM AsA + CB	138.7a	26.0a	65.6b	60.9a

Mean values in each column followed by a different lower-case letter are significantly different at $p \leq 0.05$.

AsA can scavenge the reactive oxygen species which are very damaging to the growth of plant. It is a product of D-glucose metabolism which influence on some activities of nutritional cycle in higher plants and plays a vital role in the electron transport system [29]. Several experiments have confirmed that AsA has a great role in improving plant tolerance to salt stress. [30]. suggested that AsA could increase cell division and cell enlargement of treated plants. Foliar application of ascorbic acid was more effective in increasing growth attributes of the treated plants. Moreover, [31] stated that the promoting effect of AsA on total carbohydrates may be due to their vital role of biosynthesis of chlorophyll molecules which in turn impacted on content of total carbohydrates. Regarding the interaction effect between CB (seeds treated with cyanobacteria) and concentration of ascorbic acid as a foliar spray on such parameters, results in most cases, demonstrate that the all parameters increased significantly when seed inculcation with cyanobacteria (CB) and by using the 1mM concentration of ascorbic acid with in both seasons. Conversely, the lowest ones were obtained without CB and without foliar application of ascorbic acid in both seasons. The positive impacts of the incorporation of CB+1MmAsA or CB+2MmAsA can be clarified based on the useful influence of Blue-green algae bio-fertilizer on amelioration of soil physio-chemical and biological properties. Moreover, the useful impacts of the low molecular weight of ascorbic acid (AsA) that form an significant part of the abiotic stress reaction in plant cells [32, 33].

3.2. Photosynthetic pigments of sunflower leaves

Table 3 showed the reduction concentration of chlorophyll [(a) and (b)] and total carotenoids in leaves of sunflower as a result of salt stress in both seasons. However, application of (AsA), alone or combined with cyanobacteria (CB) enhances the content of leaf photosynthetic pigment. 1 mM AsA, 2 mM AsA, 1 mM AsA + CB and 2 mM AsA + CB treatments significantly increased the content of leaf photosynthetic pigments compared to control treatment, The 1 mM AsA + CB recorded the highest rate of the sunflower leaf photosynthetic pigments at the content of which plants can cope with salt stress. Inhibition of photosynthesis in sunflower plants caused by salt stress in our study could be due to the decreased content of chlorophylls and carotenoids (Table 3). The reduction in chlorophyll content due to osmotic stress has been ascribed to the strong damage and loss of chloroplast membranes, [33]. The decrease in photosynthetic performance under salt stress has also been observed by [34, [34, 33, and 35]. Sunflower plants treated with integrative CB + AsA recorded the highest concentration of photosynthetic pigments compared with control

(Table 3). [33]. illustrated that cyanobacteria can encourage a plant growth substance that ameliorate the leaf chlorophyll content. In the same way, a lot of reactions of chlorophyll content to abiotic stress (salt stress) were found in some cyanobacteria. In our study, AsA with CB integration had improved the contents of total chlorophyll and carotenoid for both growing seasons.

Table 3. Combined effect of ascorbic acid (AsA) and cyanobacteria (CB) on leaf photosynthetic pigments of sunflower plants grown under reclaimed saline soil conditions in both 2015 and 2016 seasons

Treatments	Chlorophylls (mg g ⁻¹ fresh weight)			Carotenoids (mg g ⁻¹ fresh weight)
	a	b	total	
2015 season				
Control	0.87d	0.42d	1.39d	0.26c
1mM AsA	1.05c	0.51c	1.67c	0.30b
2mM AsA	1.16b	0.57b	1.85b	0.33ab
1mM AsA + CB	1.24a	0.65a	2.03a	0.36a
2mM AsA + CB	1.20a	0.64a	1.97a	0.36a
2016 season				
Control	0.78c	0.44c	1.31c	0.27c
1mM AsA	1.11b	0.55b	1.77b	0.31b
2mM AsA	1.14b	0.59b	1.86b	0.35ab
1mM AsA + CB	1.26a	0.64a	2.00a	0.38a
2mM AsA + CB	1.20a	0.63a	1.96a	0.37a

Mean values in each column followed by a different lower-case letter are significantly different at $p \leq 0.05$.

3.3. AsA, total soluble sugars, free proline and soluble phenols concentration

Data presented in Table 4 reveal that the content of AsA, TSS, free proline and soluble phenols decreased in leaves of sunflower as a result of salt stress (control treatment). These osmolyte were significantly increased with the increase of AsA for both seasons.

Table 4. Combined effect of ascorbic acid (AsA) and cyanobacteria (CB) on the concentrations of AsA, sugars, proline and phenols of sunflower plants grown under reclaimed saline soil conditions in both 2015 and 2016 seasons

Treatments	AsA (mmol ascorbate g ⁻¹ DW)	Total soluble sugars (mg g ⁻¹ DW)	Free proline (μg g ⁻¹ DW)	Soluble phenols (μg g ⁻¹ DW)
2015 season				
Control	1.12d	19.2d	120e	498c
1mM AsA	1.54c	24.1c	154d	679b
2mM AsA	1.75b	26.8b	196c	686b
1mM AsA + CB	1.95a	30.2a	244a	754a
2mM AsA + CB	1.88ab	29.8a	220b	740a
2016 season				
Control	1.08d	20.5d	108d	402d
1mM AsA	1.48c	23.9c	132c	467c
2mM AsA	1.66b	27.5b	185b	524b
1mM AsA + CB	1.85a	29.8a	229a	612a
2mM AsA + CB	1.83a	28.9ab	228a	609a

Mean values in each column followed by a different lower-case letter are significantly different at $p \leq 0.05$.

However, incubations sunflower with cyanobacteria have been shown to increase, AsA, TSS, free proline and further soluble phenols concentrations. The CB + AsA1Mm treatment produced sunflower plants with the highest content of AsA, total soluble sugars, free proline and soluble

phenols at the concentrations of which plants can overcome salt stress. Thus, it was concluded that the combined CB + AsA1Mm treatment enhancement content of TSS might contribute as a solute for the osmotic regulation and/or a substrate for the protein and polysaccharide syntheses in roots, and thereby for growth of whole plants [36]. AsA prompted the several parameters in leaves and then in shoots. These changes can be demonstrate as the result of CB + AsA increased growth or biomass of shoots. These results revealed that CB + AsA may be efficient for growth and related characteristics under salt stress, and hence promoting growth and leaf function in shoots [37, 38].

3.3. Nutrients status of the sunflower plants

The concentrations of macro elements (N, P and K; mg g⁻¹ DW) and micro elements (Fe, Mn, and Zn; ppm) are shown in Table 5. Statistically significant ($p < 0.05$) differences between the AsA levels were noted for N, P, K, Fe, Mn, and Zn concentrations. The highest N, P, K, Fe, Mn, and Zn concentrations were observed in plants treated with 2Mm. While, the lowest content of the macro and micro elements were observed from untreated plants (control). Increasing concentration of AsA up to 2Mm produced a significant increase in N, P, K, Fe, Mn and Zn of sunflower compared to unsprayed plants in both years. Also, data reveal that the foliar spray of AsA at 1Mm combined with CB gave the highest significant values of N, P, K, Fe, Mn and Zn concentrations of sunflower in both seasons. According to [39, 40] (CB) play a vital role in conservation and increase the soil fertility. The acts of these CB include: (a) excretion of growth – improving material such as vitamins, hormones, and organic matter (b) enhancement in soil biota after their death and decomposition. Also, under saline environment, application of CB to the soil lead to improve the soil organic matter, which is consequently, increased the soil biological activity by enhancing the soil CO₂ evolution leading to increase the soil fertility [41]. The blue-green algae (CB) are capable of fixing the nitrogen from atmospheric and transform it into an available form of ammonium required for plant growth. Foliar application of antioxidants like AsA has gained considerable attention as a probable approach to improve the unfavorable impacts of salt stress on plants for improving sunflower plant growth, development and yield quantity (seed yield) and quality (N, P, K) of sunflower seeds. The positive influence of AsA on N content could be clarified by the finding of [42] who concluded that the accumulation of nitrate by foliar application of ascorbic acid may be due to the positive effect of AsA on root growth which accordingly increased nitrate absorption.

Table 5. Combined effect of ascorbic acid (AsA) and cyanobacteria (CB) on the concentrations of macro- and micro-nutrients of sunflower plants grown under reclaimed saline soil conditions in both 2015 and 2016 seasons

Treatments	N (mg g ⁻¹ DW)	P (mg g ⁻¹ DW)	K (mg g ⁻¹ DW)	Fe (ppm)	Mn (ppm)	Zn (ppm)
2015 season						
Control	17.7d	0.13d	15.4d	560d	320d	211d
1mM AsA	19.7c	0.16c	16.4c	613c	351c	229c
2mM AsA	21.8b	0.19b	18.2b	652b	382b	255b
1mM AsA + CB	23.9a	0.22a	19.9a	689a	419a	273a
2mM AsA + CB	23.5a	0.22a	19.8a	684a	410a	270a
2016season						
Control	18.4d	0.14d	15.1d	601d	331d	214d
1mM AsA	20.3c	0.17c	17.3c	644c	353c	230c
2mM AsA	21.9b	0.20b	19.4b	686b	382b	248b
1mM AsA + CB	24.1a	0.23a	21.0a	726a	404a	269a
2mM AsA + CB	23.8a	0.22a	20.9a	721a	399a	262a

Mean values in each column followed by a different lower-case letter are significantly different at $p \leq 0.05$.

These results agreed with those obtained by [43] who found that using AsA as foliar application remarkably increased P and K content in wheat grains up to 400 mg L⁻¹ comparable to their untreated controls. Also, AsA significantly ($p < 0.05$) improved N, P, and K content in leaves and seeds of sunflower plants compared with their controls [44].

3.4. Enzymes activities and protein concentration

Results in Table 6 show that, activates of some enzymes (e.i. Superoxide dismutase, catalase and guaiacol peroxidase) and the protein content were significantly improved with using (CB+1Mm AsA) combination as compared with control treatment. Our results reveal that the foliar spray of AsA at 1Mm combined with CB gave the highest significant values of superoxide dismutase, catalase and guaiacol peroxidase and the of protein of sunflower in both seasons.

The highest values in the enzymes activities was registered in the plants exposed to integrative CB+AsA treatment. With these treatments, superoxide dismutase and guaiacol peroxidase, activities improved by 120% and 214%, respectively, compared to the control plants. On the other hand catalase enzyme decreased by 35% as compared to untreated plants. Under saline condition, the accumulation of protein may supply a storage form of N that is reutilized when the stress is over and may play a role in osmotic adjustments [45]. Protein content of sunflower plants significantly increased when treated with CB or in integration with AsA. [46] Noted that the cultures CB were susceptible of increasing plant growth and that they increasing the existence of extracellular proteins in the range of 32–82 μgml^{-1} and an array of amino acids. According to [47, 48] salt stress caused an oxidative destruction in plants by inducing the production of reactive oxygen species (ROS).

Table 6. Combined effect of ascorbic acid (AsA) and cyanobacteria (CB) on the activities of some enzymes and protein concentration of sunflower plants grown under reclaimed saline soil conditions in both 2015 and 2016 seasons

Treatments	Protein (mg g ⁻¹ FW)	Superoxide dismutase ($\mu\text{mol U mg}^{-1}$ protein)	Catalase ($\mu\text{mol min}^{-1}$ mg ⁻¹ protein)	Guaiacol peroxidase ($\mu\text{mol min}^{-1}$ mg ⁻¹ protein)
2015 season				
Control	54.3c	1.42d	1.14a	0.74d
1mM AsA	61.2b	1.85c	0.72b	1.35c
2mM AsA	62.3b	1.92c	0.75b	1.46c
1mM AsA + CB	69.8a	3.14a	0.41c	2.32a
2mM AsA + CB	69.2a	2.56b	0.44c	1.89b
2016 season				
Control	60.4c	1.27d	0.97a	1.04c
1mM AsA	66.3b	1.90c	0.68b	1.84b
2mM AsA	66.9b	2.44b	0.69b	1.80b
1mM AsA + CB	73.7a	2.98a	0.34c	2.78a
2mM AsA + CB	72.6a	2.96a	0.36c	2.69a

Mean values in each column followed by a different lower-case letter are significantly different at $p \leq 0.05$.

3.4. Head diameter, seed yield/ plant, 100 seed weight seed yield and Oil yield

The available data in Table (7) showed that, the head diameter, seed yield/ plant, 100 seed weight, seed yield (t ha⁻¹) and oil yield of sunflower were markedly improved with using CB+1Mm AsA compared with control in both seasons, reached by 31.3, 40.7, 15.2, 39.5 and 109.1% for SI season and 32.5, 42.4, 31.7, 42.8 and 129.0 % for SII season, respectively. This increment in sunflower seed yield may be due to the increases in head diameter, seed yield/ plant and as well as 100-seed weight. It seems that, seed treatment with cyanobacteria encouraged the accumulation of dry matter during the seed filling period of the sunflower. As CB of fact, it is used to improve soil properties, water retention capacity, draining, pH and better availability of soil microorganism. Results in Table (7) showed that the treatment (1mM AsA + CB) increased head diameter, seed weight head⁻¹, 100-seed weight and oil yield feddan⁻¹, the increasing percentages than the control calculated as mean of two seasons were 31.3 %, 41.5 %, 22.90 %, 48.4 % and 114.3 %, respectively. It could be concluded from the results that combined treatment of ascorbic acid with cyanobacteria minimize salinity stress and increase growth characters, yield of sunflower compared with, control. These results are agreement with those found by [33] who revealed that inculcation of

common bean with Blue-green algae significantly increased photosynthetic efficiency, antioxidative activity, dry matter, and seed yields, macro elements (N, P, and K). Results in Table (7) show that increasing the concentration of ascorbic acid from 0 to 2Mm significant increased by head diameter, seed weight/head, 100 seed weight, seed yield (t ha^{-1}) and as well as oil content of sunflower plant in first year by 15.3, 23.2, 4.8, 24.2 and 66.7% and by 20.3, 24.5, 17.6, 26.2 and 67.7% in the second season, respectively, as compared with untreated plants. Ascorbic acid has synergistic impacts on growth, yield and yield quality of sunflower plant species. These compounds have favorable effects on catching the free radicals or the active oxygen that produced during photosynthesis and respiration processes.. AsA is one of the most important water soluble antioxidants in plants, acting as a modulator of plant development through hormone signaling and as coenzyme in reactions by which carbohydrates, fats and proteins are metabolized [49]. Regarding the interaction effect of AsA and CB factors under our study effect on yield and yield quality, the obtained data showed that the highest values of all parameters were recorded with foliar spray of AsA at the 1 Mm concentration and inculcation seeds with blue-green algae in both seasons.

Table 7. Combined effect of ascorbic acid (AsA) and cyanobacteria (CB) on yields and their components of sunflower plants grown under reclaimed saline soil conditions in both 2015 and 2016 seasons

Treatments	Head diameter (cm)	Seed weight head ⁻¹ (g)	100-seed weight (g)	Seed yield (t ha^{-1})	Oil yield (t ha^{-1})
2015 season					
Control	13.1c	26.3c	4.75b	1.57d	0.33d
1mM AsA	14.7b	31.7b	4.85b	1.79c	0.45c
2mM AsA	15.1b	32.4b	4.98b	1.95b	0.55b
1mM AsA + CB	17.2a	37.0a	5.47a	2.19a	0.69a
2mM AsA + CB	17.1a	35.8a	5.38a	2.12a	0.67a
2016 season					
Control	12.8c	25.7c	4.32c	1.45d	0.31d
1mM AsA	15.5b	29.9b	4.90b	1.69c	0.43c
2mM AsA	15.4b	32.0b	5.08b	1.83b	0.52b
1mM AsA + CB	16.8a	36.6a	5.69a	2.07a	0.71a
2mM AsA + CB	16.6a	35.8a	5.60a	2.02a	0.69a

Mean values in each column followed by a different lower-case letter are significantly different at $p \leq 0.05$.

Similar results were obtained by [50, 51]. In addition, AsA plays an important role in preserving the activity of enzymes. In general, priming with 2 mM AsA was more effective than the other concentrations. Nitrogen, phosphorus, potassium and oil percentage of sunflower seeds.

Conclusion

Under salt affected soil the application of cyanobacteria inoculation combined with AsA as foliar application of significantly increased sunflower physiological responses (chlorophylls, carotenoids, total soluble, free proline and soluble phenols), contents of macro- and micro-nutrients of sunflower plants (N, P, K, Fe, Mn and Zn), and activities of some enzymes (superoxide dismutase, catalase and protein concentration). Also, the cyanobacteria inoculation combined with ascorbic acid significantly increased sunflower growth (Plant height, No of leaves plant⁻¹, leaf area plant⁻¹ and shoot dry weight plant⁻¹), yield head diameter, seed yield/ plant, 100 seed weight, seed yield (t ha^{-1}) and oil yield of sunflower grown under saline condition. Cyanobacteria inoculation combined foliar application of ascorbic acid are very effective method to provide the plants with their nutritional requirements.

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