Enhance sunflower productivity by foliar application of some plant growth bio-stimulants under salinity conditions

Sona Salem El-Nwehy, Adel Badr El-Nasharty* and AbdElHalim Ibrahim Rezk

Department of Fertilization Technology, National Research Centre, 33 El Bohouth St., P.O. Box 12622, Dokki, Giza, Egypt.

*Correspondence: elnashartynrc@gmail.com  Accepted: 09 Jun 2018 Published online: 05 Aug. 2018

Two field trials were conducted during 2015 and 2016 to determine the stimulant effects of foliar spraying with some growth stimulating including algae extract, potassium humate and cytokinin on sunflower growth and production of var. *Helianthus annuus* L. plants cultivated in saline and calcareous soil and irrigated by saline water. The results showed that foliar spraying by all used growth stimulating affected significantly on growth measurements, nutrients content, seed yield, head characteristics and oil content of sunflower. The foliar application with algae extract resulted in the highest increase in all measurements especially seed yield (1469.7 kg seed /fed. with relative increase of 23 %) and oil yield (369.9 kg oil/fed with relative increase of 37%) in comparison to control. Algae extract treatment gave also the highest value of the net return (6927 LE fed⁻¹) as well as, the economic efficiency (net return / total cost = 1.7). It could be concluded that foliar application of Algae extract under saline conditions decreased the effect of salinity on sunflower growth and increase nutrient content, yield, and oil yield in comparison to the others by using growth stimulating.

Keywords: Sunflower, foliar spraying, bio-stimulants, potassium humate, cytokinin, algae extract, salinity.

INTRODUCTION

Sunflower var. *Helianthus annuus* L. is a major crop for oil production worldwide, where its seeds contain a high concentration of polyunsaturated fatty acids. The production of vegetable oils in Egypt is so limited and fails to meet the increasing consumption of vegetable oil produced mainly from cotton seeds. However, the expansion of area devoted to cotton cultivation seemed to be hard due to limited cultivated area, intensive crop rotation and others. Thus, increasing production of vegetable oils must depend on the alternative oil crops such as sunflower which can be cultivated in the newly reclaimed soils in Egypt (Taha, 2016). Production of sunflower oil increases by 15% compared to other oil crops, in addition the sunflower cake is a high source of protein (40-44%) and amino acids for animals feeding Karthikeyan and Shanmugam (2015). There are many factors affecting on sunflower seed setting and filling such as bad agronomic management, varieties, physiological factors (e.g. plant hormones) and environmental factors (e.g. water stress and salinity) causing poor seed setting and filling and low production of sunflower. There are several ways to increase seed yield of sunflower and its quality under salinity stress especially saline water. Some of these ways are foliar spray with humic substances (e.g. potassium humate), growth regulators (e.g. cytokinins) and algae extract. The humic substances are more affected on plant growth because it's important role in nutrient uptake, enzyme activity, biosynthesis of nucleic acid,
membranes permeability (Yang et al., 2004). In addition, it decrease using of mineral fertilizers, strengthening plant stem and increase plant resistance to stress conditions such as salinity, heat and drought, accordingly plant production is improved (Zaghloul et al., 2009). Algae extract use in agriculture on a large scale to optimize using of mineral fertilizers and to enhance nutrients absorption under salinity conditions. Otherwise and unlike mineral fertilizers, algae extracts are safe for humans, animals and birds because it is not toxic and polluted and biodegradable (Dhargalkar and Pereira, 2005). It has also high content of potassium with other macro and micro nutrients, and growth hormones such as cytokinin, auxin and gibberellins (Prasad et al., 2010). Growth regulators have also the ability to effect on growth from plantation to maturity stage. It is involved in grain setting and filling (Yang et al., 2002b, and 2003b). Cytokinins are essential for seed formation and increase sink strength (Kamil and Jobori, 2012). The aim of this study is to investigate the effects of foliar spraying with some growth bio stimulants on some growth parameters of sunflower and its seed and oil yield under soil and water saline conditions.

MATERIALS AND METHODS
Two field experiments have been conducted in two summer seasons 2015 and 2016 in Oraby Village at Mariut sector, Alexandria, Egypt (located between latitude 30°58'47"N and longitude 29°48'38"E). The main physical and chemical characteristics of experiment soil determined according to Chapman & Pratt (1978) are shown in table (1). Irrigation water used in experiment was from drainage water and it has high salinity (EC 6.9 dS/m). Experiment design was Completely Randomized Block (CRBD) with 16 plots (four treatments with four replicates) and the plot area was 384 m². The experiment started in the same time in two seasons (May). Recommended doses which achieved by Ministry of Agriculture from Nitrogen (60 kg N/fed), Phosphorus (30 Kg P₂O₅/ fed) and potassium (25 Kg K₂O/ fed⁻¹) were applied during sunflower growth stage and used as control. Treatments with different bio-stimulant (cytokinin, algae extract and potassium humate) were foliar applied (1 gm/ litter) two times after sowing (Thirty and Fifty days - old). Plant samples (5 plants) were taken at 90 days – old from all plots randomly and used for different growth measurements such as stem diameter (cm), plant height (cm) and number of leaves.

At harvest heads of plants from all plots were taken to evaluate yield parameters such as head diameter (cm), weight of 100 seeds, seed yield/ fed, oil percent in seeds as described by A.O.A.C. (2005) and oil yield (kg/fed). Also at harvest samples from leaves were taken for nutrients determination by methods of Cottenue, et al., (1982). Economic return was calculated by calculate each of cultivation cost, gross return, net return and benefit: cost ratios. Statistically analysis were done (Snedecor and Cochran, 1990). Bartlett’s test revealed homogeneity of error and the combined analysis was conducted for all data of the two seasons according to Steel and Torrie (1980). The significant least differences (L.S.D) were used to compare the means.

RESULTS AND DISCUSSION

Effect of potassium humate foliar application on improving growth, yield and nutrients content:

Growth and yield parameters were significantly increased as a result of potassium humate foliar application compared with control (Table 2, 3). Relative increase were 33.0 % in stem diameter, 17.9% in plant height, 14.3 % in number of leaves, 11.3% in head diameter and 4.6% in weight of 100 seeds. Significant increase in seed yield, oil percent, and oil yield as foliar sprays with potassium humate were shown in Figure 1. The relative increases were 10%, 4% and 14%, respectively.

Data in (Table 4) revealed that application of potassium humate produced significant increase on sunflower leaves nutrients content such as N, K, Fe, Mn, and Zn content and significant decrease in Mg and Na content. Relative increase were 63.9% for K, 43% for Mn, 38.7% for Zn, 27.7% for Fe and 21.5% for N, and relative decrease were 22.3% for Mg and 28% for Na.

<table>
<thead>
<tr>
<th>Texture</th>
<th>pH</th>
<th>EC</th>
<th>Total CaCO₃ (%)</th>
<th>Organic Matter (%)</th>
<th>ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay Loam</td>
<td>8.5</td>
<td>3.9</td>
<td>27.2</td>
<td>2.0</td>
<td>700</td>
</tr>
</tbody>
</table>

Table (1): The main physical and chemical characteristics of experiment soil.
Table (2): Effect of potassium humate, cytokinin, and algae extract on sunflower growth parameters (combined analysis of two successive seasons).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Plant height (cm)</th>
<th>Stem diameter (cm)</th>
<th>Leaf number</th>
<th>100 seeds weight (g)</th>
<th>Head diameter (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>128.67</td>
<td>1.91</td>
<td>16.33</td>
<td>10.00</td>
<td>15.73</td>
</tr>
<tr>
<td>Potassium Humate</td>
<td>151.67</td>
<td>2.54</td>
<td>18.67</td>
<td>10.46</td>
<td>17.50</td>
</tr>
<tr>
<td>Cytokinin</td>
<td>153.33</td>
<td>2.79</td>
<td>20.67</td>
<td>10.82</td>
<td>18.97</td>
</tr>
<tr>
<td>Algae extract</td>
<td>162.67</td>
<td>3.17</td>
<td>24.33</td>
<td>11.88</td>
<td>20.77</td>
</tr>
<tr>
<td>LSD at 5 %</td>
<td>13.76</td>
<td>0.12</td>
<td>1.85</td>
<td>0.22</td>
<td>0.73</td>
</tr>
</tbody>
</table>

Table (3): Effect of potassium humate, cytokinin, and algae extract on sunflower seed yield, percent oil content, and oil yield (combined analysis of two successive seasons).

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Yield kg fed.(^1)</th>
<th>% increase</th>
<th>Percent Oil content %</th>
<th>% increase</th>
<th>Oil Yield kg fed.(^1)</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>1193.7</td>
<td>100</td>
<td>22.6</td>
<td>100</td>
<td>269.8</td>
<td>100</td>
</tr>
<tr>
<td>Potassium Humate</td>
<td>1312.8</td>
<td>110</td>
<td>23.4</td>
<td>110</td>
<td>307.2</td>
<td>114</td>
</tr>
<tr>
<td>Cytokinin</td>
<td>1379.1</td>
<td>116</td>
<td>23.5</td>
<td>116</td>
<td>324.0</td>
<td>120</td>
</tr>
<tr>
<td>Algae extract</td>
<td>1469.7</td>
<td>123</td>
<td>25.2</td>
<td>123</td>
<td>370.4</td>
<td>137</td>
</tr>
<tr>
<td>LSD at 5 %</td>
<td>8.2</td>
<td>-</td>
<td>0.3</td>
<td>-</td>
<td>5.2</td>
<td>-</td>
</tr>
</tbody>
</table>

Figure. 1: Effect of potassium humate, cytokinin, and algae extract on sunflower seed yield, percent oil content, and oil yield.
Zaghloul et al.,(2009) revealed that potassium humate caused an increase of nitrogen, phosphorus and potassium in the plant due to improvement metabolism through its effects on absorption and transfer of nutrients in plants. Also, Kao and Govindaraju (2010) found that, Humic acids improved soil physical and chemical properties and absorption of nutrients has increased and it enhanced root growth and fresh and dry yield of plants. It also decreases uses of mineral fertilizers. However, Patil (2011) found that plants treated with potassium humate appeared significant increase on growth and yield parameters of blackgram and soybean compared with control. The obtained results of Khan et al.,(2012) reported that application of humic substances on soil or by spraying on plants positively affected all plant growth and yield parameters of pea plants.

Effect of cytokinin foliar application on improving growth, yield and chemical composition:

Growth parameters increased significantly as compared to the control as a result of cytokinin foliar spray as shown in (Table 2, 3). Relative increases were 46.1% in stem diameter, 26.6% in number of leaves, 20.6% in head diameter, 19.2% in plant height and 8.2% in weight of 100 seeds. Figure 1 showed that foliar spray with cytokinin affected significantly in increasing oil yield, oil percent and seed yield. Relative increases were 20% for oil yield, 16% for seed yield and 4% for oil%. Data in (Table 4) showed that foliar spray of cytokinin significantly increased sunflower leaves nutrient content such as N, K, Ca, Fe, Mn, and Zn and in contrast significantly decreased Mg and Na content. The relative increases were 33.6% for Mn, 24% for Zn, 21.4% for Fe, 17.3% for K, 12.3% for Ca and 10% for N and relative decrease were 16% for Na and 8.7% for Mg.

Kamil and Jobori (2012) revealed that the role of cytokinins is essential for seed formation and decrease the abortion. Growth regulators have the ability to effect on plant from seed germination to maturity. They are affecting on seed formation and grain filling (Yang et al., 2002b and 2003b). Cytokinins are very necessary in starting of seed formation (Hess et al., 2002).

**Effects of algae extract foliar application on improving growth, yield and chemical composition:**

Growth parameters significantly increased as a result of foliar application of algae extract comparing with control (Table 2).The relative increases were 66.0 % in stem diameter, 49.0 % in number of leaves, 32.0% in head diameter 26.4% in plant height and 18.8% in weight of 100 seeds. Figure 1 showed significant increases in seed yield, oil percent, and oil yield as foliar sprays with algae extract. Relative increases were 37% for oil yield, 23% for seed yield and 12% for oil%. Data in (Table 4) showed that application of Algae extract has a significant increase effect on sunflower leaves nutrient content such as N, K, Ca, Mg, Na, Fe, Mn, and Zn content. Relative increase were 56.0% for Zn, 50.3% for Mn, 43.5% for N, 39.5% for Ca, 38.3% for K, 31.5% for Fe,
16.5% for Mg and 10.8% for Na. These results are in agreement with those obtained by Karthikeyan and Shanmugam (2015) who reported that applied algae extract as foliar spray showed relative increase 51% in seed yield, 15% in both oil percent and oil yield. Osman and Salem (2011) reported that sunflower plants which foliar sprayed with sea weed extracts significantly increased seed yield, oil percent, oil yield and its contents of K and Na. Mancuso et al., (2006) reported that the uptake of cucumber and grapevines plants from nitrogen, phosphorus, potassium and magnesium were increased as a result of seaweed extract application. In addition, the promoting effects of algae extract on growth and yield parameters resulted from its contain of all the nutrients and plant growth hormones which are essential for plants to improve yield (Prasad et al., 2010 and Latique et al., 2013).

The economic return:

The effect of the plant growth bio stimulant under salinity conditions on total cultivation cost, gross return, net return and benefit: cost ratios of sunflower production are presented in (Table 5). The economic return was calculated considering the price of one kg of sunflower seeds was 7.5 LE as an average of the two seasons (2015 and 2016) in local market. Data showed that the additional cost of cultivation of LE 157, 339 and 190 gave additional net return of L.E 893, 1390 and 2070 for potassium humate, cytokinin and algae extract treatments, respectively. With incremental benefit: cost ratio of 5.7, 4.1 and 10.9. Algae extract treatment gave the highest value of the net return (6927 LE fed⁻¹) as well as, the economic efficiency (net return / total cost = 1.7). This is due to the highest seeds productivity under algae extract treatment (1469.7 kg seeds fed⁻¹) comparing with the other treatments.

CONCLUSION

It can be concluded that foliar application with some bio stimulant such as algae extract, potassium humane, cytokine were a new methods to enhance growth and increase both seed yield and oil content of sunflower. Algae extract foliar application was the highest bio stimulant effect on growth parameters, seed yield and oil content, in addition to nutrients content as compared with the other bio stimulant. These positive effects of algae extract on growth and yield were due to it's contain of all the macro and micro nutrients and plant growth hormone which are necessary for plant to improve yield. In addition, from the economical point of view, the additional cost of cultivation of LE 190 gave the highest additional net return of L.E 2070 for algae extract treatment. Accordingly, the best treatment compared with the others was foliar spray of sunflower plants with algae extract. It increased seed and oil yield and achieved the highest net return and economic efficiency.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

All authors significantly contributed in all parts and aspects of paper.

REFERENCES


