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# Response of maize productivity to nitrogen fertilizer and spraying with blue green algae extract

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**Key words:** Maize, Nitrogen fertilizer, Blue green algae extract, Growth, Yield, Grains quality.

**Abstract**

The main purpose of this investigation was to evaluate the impact of nitrogen fertilizer and spraying with blue green algae extract levels on the productivity of maize. Two field experiments were conducted at private farm at Algraydh Village, Bialla district, Kafrelshiekh Governorate, Egypt during 2017 and 2018 seasons. The treatments were allocated in a strip-plot design with four replications. The vertical-plots were devoted to nitrogen fertilizer levels (60, 80, 100 and 120kgN fed$^{-1}$). While, the horizontal-plots were assigned to spraying with blue green algae levels (without as control, 1.5, 3.0, 4.5 and 6.0g L$^{-1}$). Increasing fertilizer levels up to 120kg N fed$^{-1}$ significantly exceeded other levels of nitrogen fertilizer and produced the highest averages of growth characters, yield and grain quality, followed by using 100kg N fed$^{-1}$ and there is no significant differences between them in most studied growth characters and yields in both seasons. Foliar spraying with 6.0g L$^{-1}$ significantly surpassed other treatments and recorded the maximum averages of growth, yield and its components and grains quality of maize, followed by spraying plants with 4.5g L$^{-1}$ and without significant differences between them in all studied characters in both seasons. Generally, mineral fertilizing maize with 100kgN fed$^{-1}$ (saved 20kgN fed$^{-1}$) beside spraying with algae extract at 4.5g L$^{-1}$ were recommended for enhancing productivity and seed quality of maize moreover, reducing the pollution resulted from high levels of mineral nitrogen fertilizer under the environmental conditions of Kafrelshiekh Governorate Egypt.

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## Introduction

Maize (*Zea mays* L) is consider one of the major cereal worldwide crops, it is use mainly as human consumption, livestock feed, for industrial purposes as a source of oil, starch extraction and production as well as ethanol production. Its grains contain about 10% protein, 4.8% oil, 8.5% fiber, 66.7% starch, and 7% ash (Khan *et al.,* 2008 and Pavão and Filho, 2011). The allocated area harvested in Egypt reached about 1.08 million hectare with total production 8.00 million tons. But, in the world the total harvested area reached about 187.95 million hectare, with total production 1.06 milliard tons according to (FAO, 2018).

Increasing maize production became one of the most important goals of the world to face human and animal demands. Undoubtedly, mineral nitrogen composites *i.e.* $NH_4^+$ and $NO_3^-$ range about 5% of the total nitrogen in soil, although they are consider the useful form of the nutrient absorbed by plants, also mineral nitrogen fertilizer is applied in large quantities to maintain the nutritional condition of different cereal crops life systems (Brady and Weil, 2008). Mineral nitrogen fertilizer is an important factor of agrotechnical practices and essential for increasing growth, production and quality of plants. Nitrogen availability plays a vital role during plant growth stages, due to it is a major component of many composites necessary for plant growth processes such as the component of protoplasm, chlorophyll formation, increase the activity of meristematic, cell division, increases cell size, increase internodes length, proteins content, nucleic acids content such as DNA and component of ATP as energy-transfer composites (Haque *et al.,* 2001 and Iqbal *et al.,* 2006), organize the availability utilization of phosphorus, potassium and other nutrients in plants (Brady and Weil, 2002), increase the accumulation of dry matter due to increase in leaf area and thus absorb more solar radiation (Purcell *et al.,* 2002 and Shanahan *et al.,* 2008). Many researchers noticed that apply of nitrogen at an adequate quantity is always vital for produce well growth and development of maize plants. In this connection, nitrogen fertilizer significantly influenced plant height, leaf area, stalk diameter, ear height, weight of ear plant$^{-1}$, 100-grain weight, grains and straw yield ha$^{-1}$ as well as grain quality (Almodares *et al.,* 2009 and Gruzska *et al.,* 2016). Raising nitrogen fertilizer levels from 90 to 126kgN fed$^{-1}$ produced the highest grains and straw yields per unit area (Karasu, 2012; Seadh *et al.,* 2013; Gruzska *et al.,* 2016; Abebe and Feyisa, 2017 and Abera *et al.,* 2017). While, application of 150 or 180kg N ha$^{-1}$ produced the maximum averages of plant height, leaf area, number of seed row$^{-1}$, grains and straw yield ha$^{-1}$, protein, oil and carbohydrate contents in maize plants (Cheema *et al.,* 2010; Aghdam *et al.,* 2014; Ali and Anjum, 2017 and Zeleke *et al.,* 2018).

Nowadays, a foliar fertilizers becomes directly available in the plant because it makes them perfect for correcting nutrient deficiencies and they are 100% water soluble. In addition, the prices of agrochemicals became more expensive especially mineral nitrogen, these make farmers with low income from the production of field crops. Foliar spraying is considering one of important technique of fertilization, which may help plants partially compensate the deficient of nutrients uptake by the roots (Ling and Moshe, 2002). So, the use of blue green algae extracts as a source of nitrogen save and moderately the requires of mineral nitrogen in most crop production. In recent times, there is a great consideration of creating novel relationship between agronomically vital plants, such as wheat, maize and $N_2$ -fixing microorganisms including cyanobacteria (Chen, 2006). Blue green algae extract can use for sustainable agriculture, which, it contains macro and micro elements, natural enzymes, auxins and cytokinins in numerous amounts, also plays vital role in stimulate root establishment, root elongation and enhance vegetative growth of plants (Shaaban, 2001; Zhang and Ervin, 2004 and Raupp and Oltmanns, 2006). Foliar application of algae extract has been noticed to increase photosynthetic pigments, crop growth, total biomass, yield and yield components as well as quality, increase nutrient uptake, resistance to stress conditions and growth promoting hormones (Ghalab and Salem, 2001). It can use as bio-fertilizers which enhanced the vegetative growth of main cereal crops *i.e.* wheat, rice and maize (Aziz and Hashem, 2004 and Arora *et al.,* 2010).

In addition, it increases the functional activity of photosynthetic apparatus through raised chlorophyll content, total carbohydrates content, starch, amino acids and protein (Yassen *et al.,* 2007). Algae extracts also, are important source of potassium and contains considerable amounts of P, Cu, Ca, Fe, Mg, Zn and Mn (Abd El-Mawgoud *et al.,* 2010 and Marrez *et al.,* 2014). Moreover, spraying algae extracts at the rate of 3.5 or 4.5g $L^{-1}$ caused an increase in productivity and quality of sugar beet plants (Enan *et al.,* 2016).

Thus, the present study has been undertaken to assess the role of mineral nitrogen fertilizer, blue green algae extract levels and its combination on the productivity of maize plants under the ecological studies of the experiments site.

## Materials and methods

Two field experiments were laid out at private farm at the Algraydh Village, Bialla district, Kafrelshiekh Governorate, Egypt, (31°7' latitude and 30° 93' longitude) during 2017 and 2018 summer seasons to determine the effect of four nitrogen fertilizer levels and five foliar spraying with blue green algae extract levels on growth, yield and its components and grains quality of maize hybrid single cross 2036 (SC 2036). The cultivar under study was obtained from the Company of Misr Hytech, Seed International.

A strip-plot design with four replications for each experiment was used. The vertical plots were allocated with four levels of nitrogen fertilizer (60, 80, 100 and 120kgN $fed^{-1}$). Ammonium nitrate (33.5% N) was added as a source of nitrogen fertilizer at the previously mentioned levels in two equal rations with the first and second irrigations.

Five levels of spraying with blue green alga *i.e.* without (control treatment), 1.5, 3.0, 4.5 and 6.0g $L^{-1}$ were distributed on the horizontal plots. The treatments of spraying were applied at two times after 30 and 40 days from sowing (DFS), the solution was sprayed by using manual hand sprayer (200 liter $fed^{-1}$) after adding wetting agents to spray solution (tween 20 a surfactant 0.05%) and at each sprayer all plots were received equal volume of solutions.

The early isolated blue green algae (*Spirulina platensis*) from Wadi El-Natrun, El-Buhira Governorate was called up to massive scale at Algal biotechnology Unit, National Research Centre within three open ponds (75$m^3$ of a final capacity). Algal slurry was stressed by hyperactive nutritional doses to meet essential nutrient accumulation within algal cells, algal bulk was harvesting by continuous centrifugation using (Westifalia Separator), which have about 75-80% moisture, after that freeze for about 48 hrs. Consequently, at the room temperature the frozen bulk was then re-melted, homogenized and an aerobically fermented for about 72 hr. The fermented biomass was then homogenized and filtered till it used as described by Vonshak and Richmond (1988). Algae extract chemicals analysis were contain macro nutrients (N 8.0%, P 2.45% and K 0.68%) and micro nutrients (Mg 20ppm, Ca 93ppm, Fe 1986ppm, Zn 31ppm, Mn 58ppm and Cu 88ppm), as an average over both seasons.

Samples of soil were collected randomly from the field experimental unit at 0-30cm depth in both seasons to estimate physical and chemical properties of the soil. The soil under study was classified as a clayey soil contained (organic matter 1.72%, electrical conductivity (EC) 1.88 $dSm^{-1}$, calcium carbonate 3.65 and pH 7.75) as an average over two growing seasons.

The field experimental units were prepared through ploughing, leveling, ridging and divided into the experimental units. The experimental basic unit area involved $5^{th}$ ridges, each of 60cm width and 3.5m length, which was 10.5$m^2$ (1/400 feddan, one feddan = 4200 m2). The previous winter crop was sugar beet (*Beta vulgaris* L.) in both growing seasons. During soil preparation calcium superphosphate (15.5% $P_2O_5$) at the rate of 150kg $fed^{-1}$ was applied. In addition, 50kg potassium sulphate $fed^{-1}$ (48% $K_2O$) was applied with the first irrigation.

Grains of maize at the rate of 1-2 grains $hill^{-1}$ were hand sown in hills 25cm apart using the method of Afir dry sowing on one side of the ridge during the first week of May in 2017 and 2018 growing seasons.

The plants were thinned to one plant hill$^{-1}$ before the first irrigation. After three weeks from sowing the 1$^{st}$ irrigation was applied and the next irrigations were applied every 15 days intervals in both seasons. According to the recommendations of Ministry of Agriculture and Land Reclamation, all optimal agricultural practices were applied in maize fields, except the studied factors.

*Studied characters*

*A- Growth characters*

At 90 days from sowing, sample of five plants were randomly taken from the two outer ridges to studied the following characters: 1-Plant height (cm), 2-Ear height (cm), 3- Stalk diameter (mm), 4- Ear leaf area (cm$^2$), was calculated according to Gardner *et al.* (1985).

Ear leaf area (cm$^2$) = ear leaf lengthear leaf width × 0.75×

*B- Yield and yield components*

At maturity after (120 DFS), five plants randomly collected from the three inner ridges to estimate, 1-Ear length (cm), 2- Ear diameter (cm), 3- Ear weight plant$^{-1}$ (g), 4-Number of rows ear$^{-1}$, 5-Number of grains row$^{-1}$, 6-Grains number ear$^{-1}$, 7-Grains weight ear$^{-1}$ (g), 8- 100-grain weight (g), 9-Shelling%. 10-Grain yield (ardab fed$^{-1}$), grains kilograms$^{-1}$ resulted from the plants in the three inner ridges of each plot adjusted to 15.5% moisture and changed to ardab fed$^{-1}$ (one ardab equal 140kg grains). 11-Straw yield (ton fed$^{-1}$), straw yield resulted from all plants in the three inner ridges of each plot without grains were weighted inkg plot$^{-1}$ and then converted to ton fed$^{-1}$.

*C- Grains quality*

1- Crude protein percentage (%), according to AOAC (2007) it was determined by the improved Kjeldahl – method.

2- Oil percentage (%), determined in dried grains as described by AOAC (2007) using Soxhelt apparatus.

3-Total carbohydrates percentage (%), determined using the method of anthrone as described by Sadasivam and Manickam (1996).

*Statistical analysis*

Analysis of variance (ANOVA) for a strip– plot design as described by Gomez and Gomez (1984) using "MSTAT-C" computer software package was used to statistical analyzed the obtained data. Means differences between treatments at 5% level of probability were compared using least significant of difference (LSD) as defined by Snedecor and Cochran (1980).

**Results and discussion**

*I- Effect of nitrogen fertilizer levels*

The results indicated that nitrogen fertilizer levels had a significant effect on all studied traits in both growing seasons except number of rows ear$^{-1}$ in the second season was insignificant (Tables 1, 2 and 3).

Concerning the effect of nitrogen fertilizer levels on plant height, ear height, stalk diameter and ear leaf area. Data indicated that there were significant effects due to nitrogen fertilizer levels on all growth characteristics in both seasons (Table 1). Increasing nitrogen fertilizer levels from 60 to 120kgN fed$^{-1}$ caused significant increases in all studied characters. The highest averages of maize growth characteristics were obtained when applied the highest amount of 120kgN fed$^{-1}$ in both growing seasons, followed by application of 100kgN fed$^{-1}$ and without significant differences between them in all studied traits, except (plant height and stalk diameter) were significant in both seasons. On contrary, the minimum averages of growth characteristics were recorded with the lower level of nitrogen fertilizer (60N fed$^{-1}$) in both growing seasons. The increases of growth characteristics due to the increase in nitrogen fertilizer levels may be ascribed to that nitrogen is plays an important role during the growth stages of maize crop life, where it effect on plant growth processes such as protoplasm, chlorophyll formation, proteins content, nucleic acids content such as DNA and component of ATP as energy-transfer and increase the activity of meristematic, cell division, cell size and internodes length, (Iqbal *et al.,* 2006 and Shanahan *et al.,* 2008), organize the availability utilization of phosphorus, potassium and other nutrients in plants (Brady and Weil, 2002). These results are in good line with those reported by (Seadh *et al.,* 2013; Gruzska *et al.,* 2016; Abebe and Feyisa, 2017; Ali and Anjum, 2017 and Zeleke *et al.,* 2018).

**Table 1.** Means of plant height (cm), ear height (cm), stalk diameter (mm) and ear leaf area (cm²) as affected by nitrogen fertilizer and spraying with blue green algae extract levels and their interaction during 2017 and 2018 seasons.

| Characters | Plant height (cm) | | Ear height (cm) | | Stalk diameter (mm) | | Ear leaf area (cm²) | |
|---|---|---|---|---|---|---|---|---|
| Treatments Seasons | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| *A- Nitrogen fertilizer levels (kgN fed⁻¹)* | | | | | | | | |
| 60 | 237.00 | 241.06 | 129.66 | 132.66 | 25.40 | 25.73 | 780.66 | 812.40 |
| 80 | 245.86 | 249.53 | 130.00 | 132.80 | 25.46 | 25.93 | 820.66 | 834.06 |
| 100 | 256.00 | 259.73 | 138.33 | 141.20 | 26.00 | 26.53 | 838.33 | 882.06 |
| 120 | 273.33 | 276.66 | 151.00 | 154.46 | 27.93 | 28.93 | 891.73 | 924.40 |
| LSD at 5% | * | * | * | * | * | * | * | * |
| *B- Spraying with blue green algae extract levels (g L⁻¹)* | | | | | | | | |
| Without (control) | 242.75 | 246.08 | 132.91 | 136.08 | 25.25 | 25.58 | 756.00 | 813.33 |
| 1.5 | 246.25 | 250.00 | 136.66 | 139.83 | 26.08 | 26.50 | 806.25 | 840.25 |
| 3.0 | 253.33 | 256.75 | 136.66 | 139.75 | 26.08 | 26.66 | 842.00 | 856.58 |
| 4.5 | 259.16 | 263.33 | 139.58 | 142.58 | 26.75 | 27.16 | 872.75 | 898.50 |
| 6.0 | 263.75 | 267.58 | 140.41 | 143.16 | 26.83 | 28.00 | 887.25 | 907.50 |
| LSD at 5% | * | * | NS | NS | NS | * | * | * |
| *C- Interaction (F. test)* | * | * | * | * | NS | NS | NS | NS |

*; significant at 0.05 level of probability and NS; non-significant at 0.05 level of probability.

Concerning the influence of nitrogen fertilizer levels on yield and yield components (ear length, ear diameter, ear weight plant⁻¹, number of rows ear⁻¹, number of grains row⁻¹, grains number ear⁻¹, grain weight ear⁻¹, 100-grain weight, shelling percentage, grains and straw yields fed⁻¹), data indicated that there were a significant effect in both seasons, except number of rows ear⁻¹ was insignificant in the second season as show in (Tables 2 and 3). The obtained results clearly indicated that yield and yield components were significantly increased due to the increases of nitrogen fertilizer levels from 60 to 120kgN fed⁻¹. The highest averages of yield and yield components were obtained from applied the highest level of nitrogen fertilizer (120kgN fed⁻¹), followed by 100kgN fed⁻¹ in all yield and yield components and without significant difference with the previously mentioned treatment in both seasons. While, using the lowest level of nitrogen fertilizer (60kgN fed⁻¹) resulted in the minimum averages of yield and yield components and the maximum value of shelling percentage in two growing seasons. It can be concluded that, increasing nitrogen fertilizer from 60, 80, 100 and 120kgN fed⁻¹ caused increase in grains yield fed⁻¹ by (5.50, 8.59 and 14.25%) and in straw yield fed⁻¹ by (2.13, 3.96 and 6.10%), respectively as an average over both growing seasons. This raises in yield and its components recorded from using the highest level of nitrogen fertilizer levels may be attributed to the significantly influenced of nitrogen in stimulating growth characters of plants, increase the accumulation of dry matter due to increase in leaf area (Purcell *et al.,* 2002 and Shanahan *et al.,* 2008), then accordingly increasing grain and straw yield fed⁻¹. These results are in compatible with those reported by (Seadh *et al.,* 2013; Gruzska *et al.,* 2016; Ali and Anjum, 2017 and Abera *et al.,* 2017).

Grains quality characters, *i.e.* the percentages of protein, oil and total carbohydrates in both growing seasons significantly affected due to nitrogen fertilizer levels (Table 3). The maximum percentages of these characters were resulted from using 120kgN fed⁻¹ in two growing seasons. While, the minimum percentages of grains quality were obtained with the lower fertilizer level 60kgN fed⁻¹ in both growing seasons. The increases in grains quality due to the increasing in nitrogen fertilizer levels may be ascribed to the role of nitrogen in improving growth and dry matter accumulation and the increase of plant metabolism, the availability utilization of phosphorus, potassium, which leading to increase synthesis process of amino acids and their assimilation into grain protein. These results are in harmony with those noticed by (Almodares *et al.,* 2009; Gruzska *et al.,* 2016; Ali and Anjum, 2017 and Zeleke *et al.,* 2018).

**Table 2.** Means of ear length (cm), ear diameter (mm), ear weight plant$^{-1}$ (g), number of rows ear$^{-1}$, number of grains row$^{-1}$, grains number ear$^{-1}$, grain weight ear$^{-1}$ (g) and 100-grain weight (g) as affected by nitrogen fertilizer and spraying with blue green algae extract levels and their interaction during 2017 and 2018 seasons.

| Characters Treatments | Ear length (cm) | | Ear diameter (mm) | | Ear weight plant$^{-1}$ (g) | | Number of rows ear$^{-1}$ | | Number of grains row$^{-1}$ | | Grains number ear$^{-1}$ | | Grain weight ear$^{-1}$ (g) | | 100-grain weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seasons | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| *A- Nitrogen fertilizer levels (kgN fed$^{-1}$):* | | | | | | | | | | | | | | | | |
| 60 | 20.26 | 20.33 | 47.13 | 47.93 | 263.46 | 261.60 | 12.13 | 13.06 | 44.20 | 44.33 | 538.40 | 542.73 | 211.00 | 211.66 | 39.86 | 40.13 |
| 80 | 21.26 | 21.53 | 47.60 | 49.80 | 291.80 | 292.20 | 13.20 | 13.46 | 44.93 | 45.13 | 593.73 | 599.40 | 222.00 | 223.00 | 41.00 | 41.06 |
| 100 | 22.66 | 22.73 | 49.93 | 50.66 | 337.86 | 340.00 | 13.33 | 13.46 | 47.00 | 47.60 | 624.53 | 626.46 | 228.73 | 229.80 | 43.40 | 43.60 |
| 120 | 24.13 | 24.20 | 51.86 | 52.40 | 345.53 | 347.33 | 14.00 | 14.26 | 48.26 | 49.13 | 660.40 | 680.06 | 239.53 | 238.66 | 43.66 | 43.73 |
| LSD at 5% | * | * | * | * | * | * | * | NS | * | * | * | * | * | * | * | * |
| *B- Spraying with blue green algae extract levels (g L$^{-1}$)* | | | | | | | | | | | | | | | | |
| Without (control) | 20.75 | 20.91 | 44.50 | 47.00 | 285.66 | 286.66 | 12.00 | 12.33 | 43.33 | 43.66 | 523.00 | 525.66 | 188.16 | 186.91 | 37.58 | 37.83 |
| 1.5 | 21.08 | 21.16 | 49.83 | 50.33 | 304.58 | 305.66 | 13.00 | 13.33 | 45.91 | 46.25 | 596.66 | 604.25 | 210.66 | 210.91 | 38.91 | 39.08 |
| 3.0 | 22.33 | 22.50 | 50.33 | 51.00 | 312.41 | 313.16 | 13.33 | 13.83 | 46.33 | 46.75 | 600.66 | 620.41 | 228.75 | 229.91 | 41.25 | 41.00 |
| 4.5 | 22.75 | 22.83 | 50.50 | 51.16 | 313.16 | 320.66 | 13.66 | 4.16 | 46.08 | 46.58 | 636.50 | 638.66 | 239.41 | 240.50 | 44.75 | 45.16 |
| 6.0 | 23.50 | 23.58 | 50.50 | 51.50 | 332.50 | 325.25 | 13.83 | 4.16 | 48.83 | 49.50 | 664.50 | 671.83 | 259.58 | 260.66 | 47.41 | 47.58 |
| LSD at 5% | * | * | * | * | * | * | NS | NS | NS | NS | NS | * | * | * | * | * |
| *C- Interaction (F. test):* | * | * | * | * | * | * | NS | NS | NS | NS | NS | NS | NS | NS | * | * |

*; significant at 0.05 level of probability and NS; non-significant at 0.05 level of probability.

**Table 3.** Means of shelling%, grain yield (ardab fed$^{-1}$), straw yield (ton fed$^{-1}$), protein%, oil% and total carbohydrate as affected by nitrogen fertilizer and spraying with blue green algae extract levels and their interaction during 2017 and 2018 seasons.

| Characters Treatments | Shelling% | | Grain yield (ardab fed$^{-1}$) | | Straw yield (ton fed$^{-1}$) | | Protein% | | Oil% | | Carbohydrate% | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seasons | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 | 2017 | 2018 |
| *A- Nitrogen fertilizer levels (kgN fed$^{-1}$)* | | | | | | | | | | | | |
| 60 | 80.18 | 80.97 | 24.20 | 27.66 | 6.365 | 6.381 | 9.18 | 9.04 | 4.36 | 4.58 | 69.90 | 69.54 |
| 80 | 76.22 | 76.69 | 25.66 | 29.20 | 6.471 | 6.547 | 9.23 | 9.36 | 4.78 | 4.99 | 70.84 | 71.22 |
| 100 | 67.66 | 67.55 | 26.26 | 30.06 | 6.571 | 6.681 | 9.39 | 9.71 | 5.10 | 5.28 | 72.30 | 72.66 |
| 120 | 69.51 | 68.87 | 28.00 | 31.20 | 6.653 | 6.872 | 9.55 | 9.90 | 5.18 | 5.41 | 72.54 | 73.25 |
| LSD at 5% | * | * | * | * | * | * | * | * | * | * | * | * |
| *B- Spraying with blue green algae extract levels (g L$^{-1}$)* | | | | | | | | | | | | |
| Without (control) | 66.92 | 66.47 | 22.33 | 24.33 | 6.307 | 6.379 | 9.18 | 9.08 | 4.68 | 4.82 | 70.44 | 70.79 |
| 1.5 | 70.24 | 70.08 | 24.25 | 27.75 | 6.424 | 6.487 | 9.24 | 9.41 | 4.79 | 4.96 | 70.81 | 70.86 |
| 3.0 | 74.04 | 74.28 | 26.08 | 30.00 | 6.517 | 6.650 | 9.29 | 9.52 | 4.87 | 5.00 | 71.45 | 71.67 |
| 4.5 | 77.12 | 75.33 | 27.50 | 31.41 | 6.646 | 6.758 | 9.48 | 9.75 | 4.94 | 5.22 | 71.98 | 72.30 |
| 6.0 | 78.65 | 81.44 | 30.00 | 34.16 | 6.679 | 6.826 | 9.50 | 9.75 | 5.01 | 5.33 | 72.30 | 72.71 |
| LSD at 5% | * | * | * | * | * | * | * | * | * | * | * | * |
| *C- Interaction (F. test):* | NS | NS | * | * | * | * | NS | NS | * | * | NS | NS |

*; significant at 0.05 level of probability and NS; non-significant at 0.05 level of probability.

*II- Effect of spraying with blue green algae extract levels*

The results indicated that foliar spraying with blue green algae extract levels had a significant effect on all studied traits in both seasons, except ear height, number of rows ear$^{-1}$ and number of grains row$^{-1}$ in both seasons and stalk diameter and grains number ear$^{-1}$ were insignificant in the first season (Tables 1, 2 and 3).

Results clearly showed that spraying with blue green algae extract at the levels (0, 1.5, 3.0, 4.5 and 6.0g L$^{-1}$) were significantly affected the growth characters i.e. plant height and leaf area plant$^{-1}$ of maize plant in both seasons, except ear height and stalk diameter were insignificant in both seasons and in the first season, respectively (Table 1). The highest averages of these characters were recorded with the high level of algae extract (6.0g $L^{-1}$), which surpassed other rates of algae extract in both seasons. While, foliar application with 4.5g $L^{-1}$ of algae extract produced the best averages of all studied characters after above-mentioned treatment and without significant differences between them in both seasons. On contrary, control treatment (without using algae extract) produced the minimum averages of growth characters in two seasons. The increases in growth characters due to spraying with algae extract at the levels of 6.0 or 4.5g $L^{-1}$ may be ascribed to the method of foliar application may helping partially compensate for deficient nutrients uptake by the roots (Ling and Moshe, 2002), the positive effects of blue green algae extract as a vital role as a source of nitrogen fixing cyanobacteria ensures saving and moderately the mineral nitrogen required in plant. Also, it contains macro and micro elements, natural enzymes, auxins and cytokinins in numerous amounts, which, stimulate cell division, leaves size, nutrients uptake, resistance to stress conditions photosynthesis, root establishment, root elongation and consequently, enhance vegetative growth of plants (Ghalab and Salem, 2001; Shaaban, 2001 and Zhang and Ervin, 2004). These results are in good line with those noticed by (Yassen *et al.,* 2007; Abd El-Mawgoud *et al.,* 2010 and Marrez *et al.,* 2014).

There was a significant effect on yield and yield components (ear length, ear diameter, ear weight plant$^{-1}$, grains weight ear$^{-1}$, 100-grain weight and grains and straw yields fed$^{-1}$ in both seasons) and (grains number ear$^{-1}$ in the second season only) due to spraying with algae extract levels (Tables 2 and 3). Highest averages of ear length (23.54cm), ear diameter (51.0mm), ear weight plant$^{-1}$ (328.87g), grains weight ear$^{-1}$ (260.12g), 100-grain weight (47.49), shelling percentage (80.04%), grains yield fed$^{-1}$ (32.08 ardab) and straw yield fed$^{-1}$ (6.75ton) were recorded with the highest rate of algae extract 6.0g $L^{-1}$ as an average over both growing seasons, followed by spraying with 4.5g $L^{-1}$ and without significant differences between the previously mentioned treatment. On the other side, plants of maize grown without foliar spraying recorded the minimum averages of yield component as well as grains and straw yields fed$^{-1}$ in both seasons. It could be noticed that increasing the levels of blue green algae extract from (control treatment), 1.5, 3.0, 4.5 and 6.0g $L^{-1}$ caused increases in grains yield fed$^{-1}$ by (11.32, 20.04, 26.12 and 37.37%) and in straw yield fed$^{-1}$ by (1.77, 3.78, 5.65 and 6.45%), respectively as an average over both growing seasons. The increases in yields and yield components due to foliar spraying maize plants with the highest levels of blue green algae extract as a new technique in maize fertilization might have been due to its vital effect on increasing the process of cell membrane permeability, encouraging plant efficiency in the absorption of nutrients such as nitrogen, phosphorous, potassium which has a direct relation with leaf chlorophyll concentration and regulation the balance between the processes of photosynthesis and respiration in plants. Also, it plays an important role in delaying the aging of leaves by decreasing the degradation of chlorophyll due to it is a source of auxins, natural enzymes and cytokinins (Raupp and Oltmanns 2006 and Yassen *et al.,* 2007).

With respect to grains quality (protein%, oil% and carbohydrates%), the results clearly indicated that grain quality characters significantly affected due to spraying with algae extract in both seasons (Tables 3). Foliar spraying with 6.0g $L^{-1}$ of algae extract recorded the maximum percentages of these characters, followed by spraying with 4.5g $L^{-1}$ and without significant differences between them in growing seasons. On contrary, minimum percentages of grains quality were achieved from control treatment of foliar spraying in both seasons. The beneficial role of algae extract on grains quality may be attributed to its improving vegetative growth characters and accumulation of additional assimilates that translocated to maize grains, consequently increased in grains quality. These results are in agreement with those noticed by (Ghalab and Salem, 2001; Zhang and Ervin, 2004 and Yassen *et al.,* 2007).

*III- Effect of interaction*

Concerning the interaction influence, there are significant effects between minerals nitrogen fertilizer and spraying with various green algae extract levels of on growth characters (plant height and ear height) and yield and yield components (ear length, ear diameter, ear weight plant$^{-1}$, 100-grain weight, grains and straw yields fed$^{-1}$) as well as grains quality (oil%) during both seasons (Tables 1, 2 and 3). Highest averages of plant height (Fig. 1), ear height (Fig. 2), ear length (Fig. 3), ear diameter (Fig. 4), ear weight plant$^{-1}$ (Fig. 5), 100-grain weight (Fig.6), grains yield fed$^{-1}$ (Fig. 7), straw yield fed$^{-1}$ (Fig. 8) and oil% (Fig. 9 ) were resulted from adding 120kgN fed$^{-1}$ plus spraying with blue green algae extract at 6.0g L$^{-1}$.

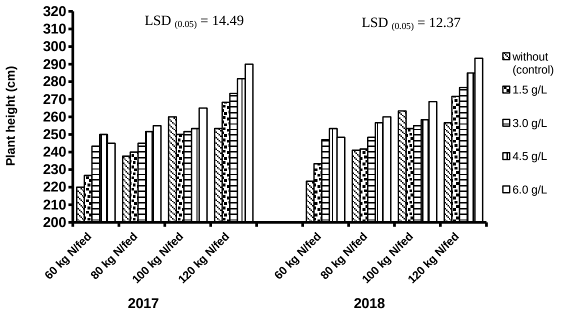


**Fig. 1.** Plant height (cm) as affected by the interaction between nitrogen fertilizer and spraying with blue green algae extract levels during 2017 and 2018 growing seasons.

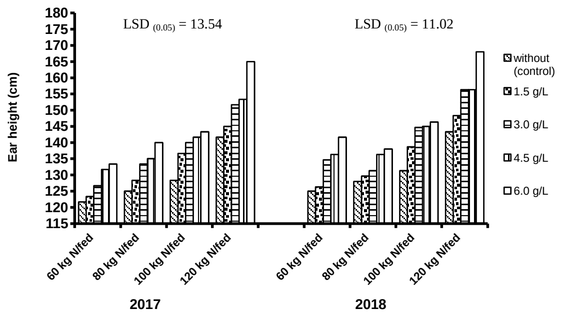


**Fig. 2.** Ear height (cm) as affected by the interaction between nitrogen fertilizer and spraying with blue green algae extract levels during 2017 and 2018 growing seasons.

The second best interaction treatment that improved the growth, yield and its components and grains quality of maize in the same time decreases the agriculture inputs as well as environmental pollution was adding 100kgN fed$^{-1}$ besides spraying with blue green algae extract at the levels of 4.5g L$^{-1}$ and without significant differences with the previously mentioned treatment in both seasons. These results might be ascribed to combine the favourable effect of both nitrogen fertilizer and spraying with blue green algae extract as discussed before. On the other hand, application mineral nitrogen fertilizer at 60kgN fed$^{-1}$ besides control treatment of blue green algae extract gave the minimum averages of all studied characters in both growing seasons.

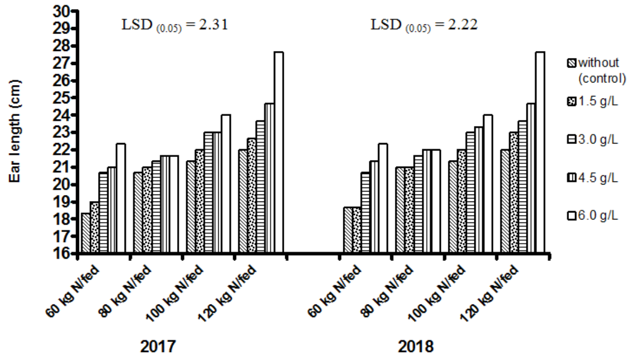


**Fig. 3.** Ear length (cm) as affected by the interaction between nitrogen fertilizer levels and foliar application of spraying with blue green algae extract during 2017 and 2018 growing seasons.

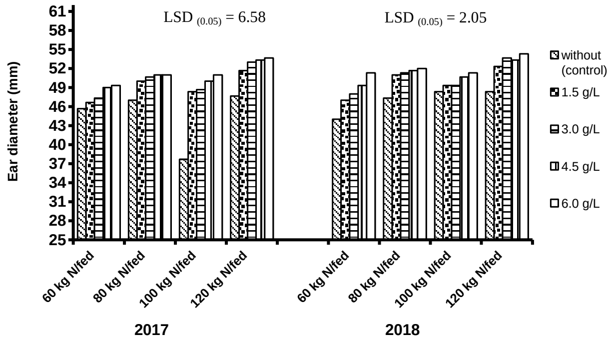


**Fig. 4.** Ear diameter (mm) as affected by the interaction between nitrogen fertilizer and spraying with blue green algae extract levels during 2017 and 2018 growing seasons.

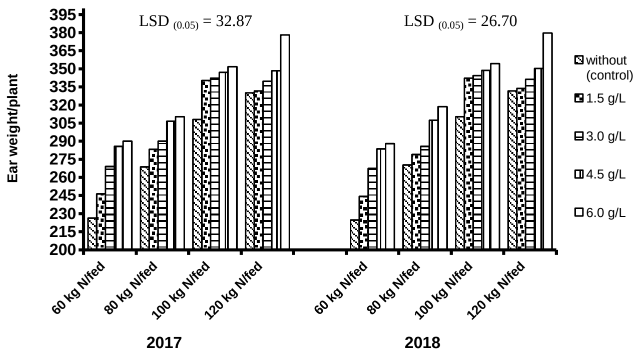


**Fig. 5.** Ear weight/plant (g) as affected by the interaction between nitrogen fertilizer and spraying with blue green algae extract levels during 2017 and 2018 growing seasons.

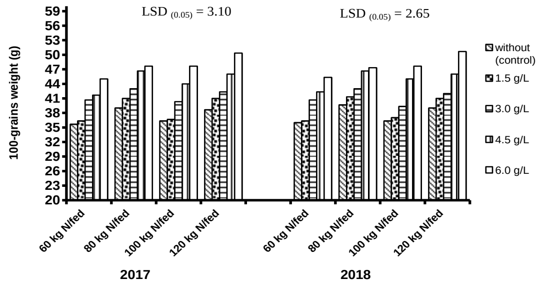


**Fig. 6.** 100-grains weight (g) as affected by the interaction between nitrogen fertilizer and spraying with blue green algae extract levels during 2017 and 2018 growing seasons.

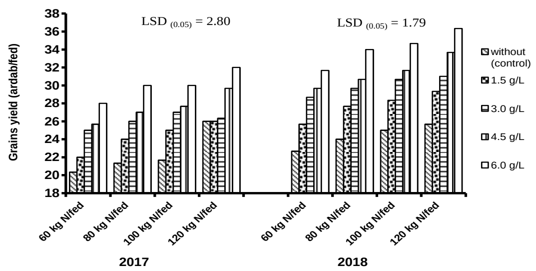


**Fig. 7.** Grains yield (ardab/fed) as affected by the interaction between nitrogen fertilizer and spraying with blue green algae extract levels during 2017 and 2018 growing seasons.

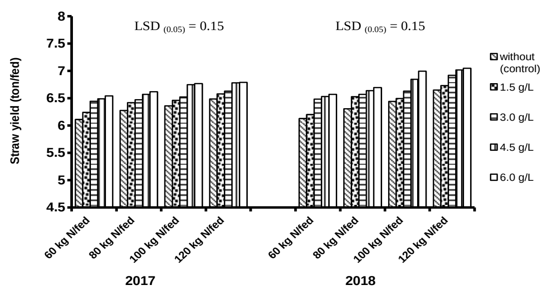


**Fig. 8.** Straw yield (ton/fed) as affected by the interaction between nitrogen fertilizer and spraying with blue green algae extract levels during 2017 and 2018 growing seasons.

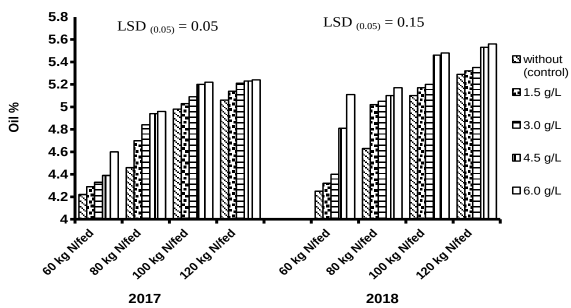


**Fig. 9.** Oil% as affected by the interaction between nitrogen fertilizer and spraying with blue green algae extract levels during 2017 and 2018 growing seasons.

## Conclusion

It could be noticed that, increasing nitrogen fertilizer levels up to 120N fed$^{-1}$ increased all growth and yield characters as well as grains quality, followed by using 100N fed$^{-1}$ and without significant differences between them in most studied characters and yields in both seasons. In addition, spraying with the highest levels of algae extract (6.0g L$^{-1}$) increased the productivity and grains quality of maize plants, followed by spraying with 4.5g L$^{-1}$ and without significant differences between them in all studied characters in both seasons. In general, mineral fertilizing maize plants with 100kgN fed$^{-1}$ (saved 20kgN fed$^{-1}$) beside spraying with algae extract at 4.5g L$^{-1}$ were recommended for increasing grains yield and its quality besides reducing production costs (saved 20kgN fed$^{-1}$) and nitrogen environmental pollution under the ecological studies of the experiments site.

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