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# Amelioration Of Snap Bean Growth, Yield, Quantity And Nutritional Status Under Salinity Stress By Using Spirulina Algae Extract And Amino Acids

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**Abstract:**

Salinity stress is a major abiotic stress that limits agricultural production and threatens global food security due to rapid climate change. Salt stress negatively affects the growth, yield and quality of crops. Amino Acids and Spirulina Algae Extract are well-known biostimulants that have positive effects on plant growth and productivity and significantly reduce damage caused by abiotic stress. Therefore, this study investigated the effect of several treatments with spirulina extract and amino acids on snap bean plant growing under saline soil stress. Field experiment was carried out during the two successive summer seasons of 2021 and 2022 under saline soil at private farm in Faqus - Sharkia Governorate, to study the effect of spirulina algae and amino acid concentrations as foliar spray on growth, yield quantity and quality and nutritional status of snap bean cv, Bronco. The experiment was executed in split plot design, three rates of spirulina algae extracts (0, 1 and 2 $cm^3$ $L^{-1}$) were distributed on main plot and another three level of amino acids (0, 500 and 1000 mg $L^{-1}$) were arranged on subplot. Finally, main and subplot were replicated three times. The results can be summarized as follows: Under saline soil condition, spraying snap bean plants with different concentrations of spirulina extract and amino acids three times led to an improvement in plant growth, crop quantity and quality as well as nutritional status, compared to the experimental treatment in which both were not used. The highest values of growth, yield and content of nitrogen, phosphorus and potassium were obtained by spraying 2 $cm^3$ $L^{-1}$ of spirulina extract with 1000 mg $L^{-1}$ of amino acids under two consecutive seasons. Thus, it can be said that Therefore, the spirulina algae extract and amino acids are considered one of the safe solutions to get rid of the effect of soil salinity on the snap bean plant, and then obtain a high yield and also high quality.



***Keywords: Snap bean, Saline soil, Spirulina algae, Amino acids, Growth, Yield, quality, Nutrients content.***

## Introduction:

Abiotic stress is one of the major environmental constraints leading to significant reductions and losses in global agricultural production **(Noreen et al., 2018)**, salinity stress is one of this abiotic stresses, and 7% of the world's total area (1000 million hectares) is vulnerable to salinity **(Amanturdiev et al. 2020).** Soil salinity has had a negative impact on the growth and development of plants around the world. About 45 million hectares of land in the world are depleted by salinity, which directly affects crop production **(Machado and Serralheiro 2017)**.

Spirulina platensis is a free-floating blue-green algae found in warm waters and alkaline volcanic lakes. It can also be grown in remote, unsuitable and infertile soils. Wild spirulina keeps starving herds from roaming the alkaline lakes of East Africa. Spirulina biomass is approximately 62% amino acids. It also contains a full range of natural carotenoid pigments and mixed xanthophylls, the richest natural source of vitamin $B_{12}$ **(Gershwin and Belay, 2008).** Moreover**,** foliar application of algae extracts has many positive effects, spraying plants improves yield and crop quality, increases nutrient uptake, especially in plants growing in semi-arid and desert conditions and frost and resistance to stress conditions **(Yassen *et al*., 2019)**. **EL-Sharnoby *et al*., (2021)** reported that spraying spirulina extract on sugar beet plants maximized productivity and increased the plants content of nutrients and total sugar percentage. Besides**,** spirulina platensis is a rich of essential nutrients for plants, including amino acids, proteins, and essential fatty acids **(Godlewska *et al*., 2019**). It has also been found to enhance the growth, photosynthetic capacity, and yield of crops like yellow lupine and red spinach (**Shedeed *et al*., 2022).** Spirulina platensis extract contains phytohormones like cytokinins, gibberellins, and auxins, which support plant growth and production **(Rady *et al*., 2023).**

Amino acids are one potential technology for increasing crop yields. These are organic nitrogen polymers used as building blocks of proteins and enzyme **(Shokunbi et al., 2012)** and are known as stronger plant growth bio-regulators **(Pessarakli et al., 2015). Shekari and Javanmardi (2017)** indicated that foliar feeding with adequate amounts of amino acids gave good results on the physical and chemical properties of the Broccoli transplants. These effects reinforced the role of the applied amino acids in broccoli plant metabolism. Amino acids as biostimulants substances that promote plant growth, improve nutrient availability, and enhance plant quality **(Rouphael et al., 2018)**. Besides, foliar application of amino acids can have a positive effect on the growth and yield of snap bean plants **(Noroozlo *et al*., 2019)**.

Snap bean (*Phaseolus vulgaris* L.) is an important vegetable crop in Egypt for both domestic consumption and export. In addition, it is an important food crop in Egypt, it is eaten as a cooked vegetable, as a dry seed or as green beans. As an inexpensive source of protein, carbohydrates, vitamins and minerals, it plays an important role in human nutrition. Furthermore, snap beans are also known as green beans, and they are a popular crop for export in some countries (**Mosquera and Gutiérrez, 2015**). Snap beans are also an important source of food security. They are a rich world resource of biodiversity and are considered a vital component of sustainable agriculture **(Uebersax *et al*., 2023)**.

The purpose of the study was to investigate the effect of spraying different concentrations of spirulina extract and amino acids and their effects on snap bean plant growth, yield quantity and quality and nutritional status under saline soil condition during two consecutive growing seasons.

## Material and Methods

### Site Description and Plant Material

Two field experiments were conducted during two successive growth summer seasons of 2021 and 2022 at private farm in Faqus - Sharkia Governorate, Egypt (latitude 30° 43' 48.22" N, longitude 31° 48' 6.55" E). The physical and chemical properties of farm soil were determined for each growing season; the particle size distributions and soil moisture were determined as described by **Blackmore (1972)**. Soil pH, EC, cations and anions, organic matter and available N, P&K were run according to **Black *et al.,* (1982).** Physical and chemical analysis of the saline soil is described in (Table, 1).

### Experimental Treatments

This experiment included nine treatments, which were the combination between three rates of spirulina algae extracts (0, 1 and 2 $cm^3$ $L^{-1}$) and three concentrations of amino acids (0, 500 and 1000 mg $l^{-1}$). The plants were sprayed with spirulina extract and amino acids three times at 15, 30 and 45 days after sowing in both growing seasons.

**Table (1): Some physical and chemical properties of the saline soil at the beginning of the experiment.**

| **Soil properties** | | **Values** | |
|---|---|---|---|
| | | **First season** | **Second season** |
| **Particle size distribution (%)** | Sand | 93.32 | 94.0 |
| | Silt | 4.68 | 3.56 |
| | Clay | 2.00 | 2.44 |
| | Texture | Sandy soil | Sandy soil |
| **pH$_{(1:2.5 \text{ soil suspension})}$** | | 8.11 | 8.15 |
| **EC (dS m$^{-1}$)** | | 4.13 | 4.11 |
| **Soluble caions (mmol L$^{-1}$)** | $Ca^{++}$ | 8.02 | 7.96 |
| | $Mg^{++}$ | 2.88 | 3.16 |
| | $Na^{+}$ | 28.1 | 27.2 |
| | $K^{+}$ | 2.32 | 2.78 |
| **Soluble anions (mmol L$^{-1}$)** | $CO_3^{--}$ | - | - |
| | $HCO_3^{-}$ | 3.10 | 3.10 |
| | $Cl^{-}$ | 28.8 | 28.8 |
| | $SO_4^{--}$ | 9.40 | 9.20 |
| **Available nutrients mg kg$^{-1}$** | N | 18.2 | 16.5 |
| | P | 2.05 | 2.00 |
| | K | 41.6 | 39.5 |

**Spirulina algae extract source**

Spirulina extract was produced at the Algae Production Station of the National Research Centre (NRC, Giza, Egypt). Major components of algae extract is shown in (Table, 2).

**Table (2): Chemical analysis of spirulina algae extract.**

| | Macronutrients (%) | | | Micronutrients (ppm) | | |
|---|---|---|---|---|---|---|
| Spirulia algae extract | N | P | K | Fe | Zn | Mn |
| | 5.90 | 2.35 | 1.35 | 10.9 | 6.50 | 8.50 |
| | Plant growth regulators (ppm) | | | | | |
| | Indol acetic acid | Abscisic acid | Cytokinin | Gibrilic acid | | |
| | 205.1 | 57.11 | 171.1 | 45.49 | | |

**Amino acid composition**

Amino acids contain eleven amino acids, as shown in Table 3

**Table (3): Amino acids analysis.**

| **Amino acid** | **Value (%)** |
|---|---|
| Arginine | 2.00 |
| Histidine | 2.62 |
| Isoleucine | 2.25 |
| Methionine | 0.70 |
| Proline | 1.51 |
| Lysine | 2.88 |
| Threonine | 2.10 |
| Valine | 2.20 |
| Tryptophan | 0.50 |
| Glutamic acid | 2.00 |
| Leucine | 3.05 |
| Total | 21.8 |

**Experimental Design**

These treatments were arranged in a split plot design with three replications. Spirulina extract rates were randomly assigned in the main plots, while, amino acids were devoted in sub plots. Seeds of snap bean (cv, Bronco.) were obtained from the Hort. Res. Instit., Agric. Res. Center, Egypt. Seeds were sown on 2 and 6

March in the 1st and 2nd seasons, respectively. The experimental unit area was 10 $m^2$ (three drippers lines with 6m length for each and 60 cm width), the distance between drippers was 25 cm.

**Experimental Site Preparation and Cultivation**

The recommended fertilizer rates were added for each of the nitrogen, phosphate and potassium fertilizers, where nitrogen fertilizer was added in the form of ammonium sulphate (20.5 % N) at 80 kg N, phosphorus fertilizer was added in the form calcium superphosphate (15.5% $P_2O_5$) at 37 kg $P_2O_5$ and potassium fertilizer was added in the form potassium sulphate (48% $K_2O$) at the rate 50 kg $K_2O$. Cultural practices and disease and pest control management were in accordance with the recommendations of the Egyptian Ministry of Agriculture.

**Measurements of Crop Parameters**

**Vegetative Growth**

Random sample of ten plants from every plot was taken after 60 days from sowing and plant height (cm), number of leaves/plants, and number of branches/plants was recorded.

**Leaf Pigment Contents**

Photosynthetic pigments, that is, chlorophyll a, b and carotenoid contents, were determined in fresh leaves sampled at 60 days after planting date based on **Moran (1982).** Fresh leaf disks (500mg) were immersed overnight in 10mL of N, N-dimethyl formamide. The obtained extracts were measured at 470, 647, and 663nm using a ultraviolet-visible (UV-Vis) spectrophotometer (T-60, PG instrument, Wibtoft Leicestershire, UK) for carotenoids, chlorophyll b, and chlorophyll a, respectively, N, N-dimethyl formamide was used as blank.

**Snap bean yield and yield components**

Green pods of each plot were harvested at the proper maturity stage, counted and weighted in each harvest and number of pods/ plant , yield / plant and total pod yield (ton /fed.) were determined. Ten plants were randomly marked from each plot for determining the number of pods/plant. Twenty pods were randomly chosen from each treatment to determine pod length (cm).

**Yield quality**

Total carbohydrate was determined in pods dry matter according to the method described by **Dubois *et al.* (1956).** Total crude fibers were determined as percentage according to **Maynard (1970).** Pod protein percentage was determined as percentage according to **(Kelly and Bliss, 1975).**

**Nutritional status**

Plant samples were dried at 65C° for 48 hrs, ground and wet digested using $H_2SO_4$: $H_2O_2$ method (**Cotteine, 1980).** The digests samples were then subjected to measurement of N using Micro-Kjeldahle method; P was assayed using molybdenum blue method and determined by spectrophotometer and K was determined by Flame Photometer (**Chapman and Pratt, 1961).**

**Statistical Analysis**

Data of the two seasons were arranged and statistically analyzed using Mstatic (M.S.) software. The comparison among means of the different treatments was determined, as illustrated by **Snedecor and Cochran (1982).**

**Results and Discussion:**

**Plant Vegetative Growth Parameters**

Table 4 shows the effect of spraying different concentrations of spirulina extract and amino acids on the vegetative growth characteristics of snap bean plants grown in saline soil during the two successive growing seasons. Increasing the spraying concentration of spirulina extract from 0 to 2 $cm^3$ $L^{-1}$ led to a significant increase in the growth characteristics (plant height, Number of leaves/plant and Number of branches/plant) with increasing the spraying concentration of amino acids from 0 to 1000 mg $L^{-1}$. Maximum plant height, number of leaves per plant and number of branches per plant (41.2 cm, 33.5 and 7.25 respectively at first season and 42.0 cm, 34.3 and 7.33 respectively at second season) were recorded when spraying of the spirulina extract and amino acids at highest concentration, compared to other treatments in both studied seasons.

Amino acids can directly or indirectly affect bioactivities in plant growth and development, such as exogenous application of amino acids that have been reported to regulate growth **(Hildebrandt et al., 2015)**. Amino acids play a key role in the stimulating effects of all measurable growth parameters and are important for improving plant metabolism, protecting plants, maintaining plant health and promoting plant growth in saline soils **(Zaky *et al*., 2021)**. Amino acid represents an important source for nitrogen, thus they greatly affecting the plant growth **(Persson and Näsholm, 2002)**. The improving effect of algae extract on the growth characteristics of pea plants can be explained by the auxin content in the algae extract, which plays an important role in cell division and proliferation, this leads to an increase in plant growth **(Gollan and Wright, 2006)**. **Shehata *et al*., (2011)** studied the effects of amino acids and seaweed extracts on celery plants and the results showed that spraying plants with amino acids and seaweed at a high rate resulted in a significant increase in plant height compared to the control treatment. Spirulina platensis liquid extract has been shown to have a protective role against salinity stress effects on plants like wheat. Which it can help mitigate the negative impact of salinity stress on plant growth and development. Overall, Spirulina platensis plays a significant role in plant nutrition by providing essential nutrients, improving growth and yield, enhancing plant defenses, and protecting plants against stress conditions **(Hamouda et al., 2022)**.

**Table (4): Effect of different concentrations of spirulina extract and amino acid on growth parameters of snap bean during two seasons**.

| Spirulina extract $cm^3\ L^{-1}$ | Amino acids $mg\ L^{-1}$ | Plant height cm | Number of leaves/plant | Number of branches/plant |
|---|---|---|---|---|
| Season (1) | | | | |
| 0 | 0 | 29.0 | 19.7 | 5.11 |
| | 500 | 33.2 | 23.5 | 6.33 |
| | 1000 | 35.7 | 25.6 | 7.03 |
| 1 | 0 | 32.3 | 20.0 | 6.33 |
| | 500 | 36.4 | 26.0 | 7.00 |
| | 1000 | 39.2 | 27.3 | 7.15 |
| 2 | 0 | 36.3 | 23.4 | 6.60 |
| | 500 | 38.4 | 30.1 | 7.15 |
| | 1000 | 41.2 | 33.5 | 7.25 |
| **LSD $_{0.05}$** | | **1.77** | **1.38** | **0.55** |
| Season (2) | | | | |
| 0 | 0 | 28.2 | 20.1 | 5.11 |
| | 500 | 34.5 | 25.6 | 6.33 |
| | 1000 | 36.0 | 27.3 | 7.11 |
| 1 | 0 | 33.1 | 22.3 | 6.11 |
| | 500 | 36.5 | 26.2 | 7.00 |
| | 1000 | 39.1 | 28.4 | 7.15 |
| 2 | 0 | 35.8 | 24.2 | 6.61 |
| | 500 | 39.8 | 32.1 | 7.20 |
| | 1000 | 42.0 | 34.3 | 7.33 |
| **LSD $_{0.05}$** | | **1.80** | **1.44** | **0.60** |

LSD least significant difference

**Snap bean yield and yield components**

Data presented in Table 5 indicated that, under saline stress, the highest values of all determined parameters of snap bean yield and yield components were recorded when snap bean plants were treated with spirulina extract and amino acids at the highest concentrations (2 $cm^3\ L^{-1}$ spirulina extract + 1000 $mg\ L^{-1}$ amino acids). The same trends were observed in both seasons of the study. On the contrary, the snap bean plants that did not receive any treatments showed significantly ($p \leq 0.05$) low values of total yield and yield components in both seasons. Therefore, the parameters of vegetative growth shown in Table 4 were highly related to the total snap bean yield and yield components shown in Table 5, which ultimately increased the total yield. The total yield (ton/fed) and yield per plant were increased by up to 39.3–43.4% and 37.8–42.8% between the first and second seasons, respectively, when snap bean plants received foliar application at the highest level of spirulina extract and amino acids.

**Table (5): Effect of different concentrations of spirulina extract and amino acid on yield and yield components of snap bean during two seasons**.

| Spirulina extract $cm^3 L^{-1}$ | Amino acids $mg L^{-1}$ | Pod length cm | Number of pods /plant | Yield/plant g | Total yield ton $fed^{-1}$ |
|---|---|---|---|---|---|
| Season (1) | | | | | |
| 0 | 0 | 7.20 | 9.88 | 50.7 | 2.32 |
| | 500 | 8.42 | 10.8 | 57.6 | 2.68 |
| | 1000 | 9.55 | 11.0 | 66.4 | 3.53 |
| 1 | 0 | 8.77 | 10.7 | 59.2 | 2.81 |
| | 500 | 9.66 | 11.5 | 67.2 | 3.37 |
| | 1000 | 10.8 | 11.6 | 72.1 | 3.70 |
| 2 | 0 | 10.0 | 11.0 | 67.2 | 3.10 |
| | 500 | 10.3 | 11.8 | 79.1 | 3.71 |
| | 1000 | 11.1 | 11.9 | 81.6 | 3.82 |
| **$LSD_{0.05}$** | | **0.69** | **1.10** | **4.15** | **0.18** |
| Season (2) | | | | | |
| 0 | 0 | 7.50 | 9.75 | 52.3 | 2.44 |
| | 500 | 8.44 | 11.0 | 61.2 | 2.84 |
| | 1000 | 9.60 | 11.5 | 70.4 | 3.56 |
| 1 | 0 | 8.81 | 10.6 | 61.5 | 3.21 |
| | 500 | 9.75 | 11.5 | 75.6 | 3.78 |
| | 1000 | 10.9 | 11.6 | 79.8 | 4.00 |
| 2 | 0 | 10.1 | 11.1 | 75.1 | 3.46 |
| | 500 | 10.5 | 12.1 | 85.6 | 4.15 |
| | 1000 | 11.6 | 12.3 | 91.4 | 4.31 |
| **$LSD_{0.05}$** | | **0.71** | **1.14** | **4.79** | **0.21** |

LSD least significant difference

Spirulina extract contains a lot of organic substances, trace elements, vitamins, amino acids, and is also rich in vitamins and growth regulators such as auxins, cytokinins and gibberellins, so use spirulina extract for various crops is very important **(Shehata *et al*., 2011)**. Foliar spraying of arginine has a significant impact on seed yield and yield components of soy bean plant, which growing under salinity stress, because the positive role of putrescine (the final product of arginine) in regulating growth, development and seed yield **(Liu et al., 2007). Zewail (2014)** indicated that using seaweed at 2 ml $l^{-1}$ with amino acids at 4 ml $l^{-1}$ led to increase in yield components of snap bean. Amino acids can improve yield productivity by the improvement of the biosynthesis of proteins and nutrients uptake **(Santi et al. 2017)**. Spirulina platensis showed a high potential to increase the growth and productivity of Vicia faba grown under salt stress **(Selem, 2019)**.

**Leaf Pigment Contents**

Under saline soil condition, the highest significant ($p \leq 0.05$) values of bean leaf pigment contents (chlorophyll a, b, and carotenoids) in both seasons caused by 2 $cm^3 L^{-1}$ spirulina extract was combined with 1000 mg $L^{-1}$ amino acid, whereas 0 $cm^3 L^{-1}$ spirulina extract + 0 mg $L^{-1}$ amino acid treatment obtained the lowest values (Table 6).

The improvement in chlorophyll content with amino acid addition may be due to increased excretion of α-ketoglutarate **(Farshid *et al*., 2013). Abdelkader et al. (2020)** reported that the use of dahlia plants by spraying with amino acids had a significant effect on pigment content, giving maximum values of chlorophyll a, b. However, untreated plants showed minimum chlorophyll a, b values. **(Awad et al., 2007)** indicated that spraying fava beans with different concentrations of amino acids improves photosynthesis in saltwater plants. This increase in chlorophyll content is likely due to the availability of higher levels of amino acids to the treated plants, as amino acids help increase chlorophyll content and this can lead to increases in various growth parameters. **Arafa *et al*., (2011)** showed that algae extract foliar application were recommended for increasing photosynthetic pigments, because algae extract contains cytokines which induce the physiological activities and increase total chlorophyll in plants. Algae extract increases the content of plant pigments in snap bean **(Abu Seif et al., 2016)**. This effect can be explained by the antioxidant activity **(El-Sayed et al., 2018)** and the growth-promoting components of the algal extract **(El Eslamboly et al., 2019).** The presence of salinity decreased significantly chlorophyll contents and carotenoids in beans plants, but when using spirulina extract improved the pigment contents as compared to plants grown under salinity **(Selem, 2019)**.

**Table (6): Effect of different concentrations of spirulina extract and amino acid on pigment contents of leaves snap bean during two seasons.**

| Spirulina extract $cm^3$ $L^{-1}$ | Amino acids mg $L^{-1}$ | Chlorophyll a mg/g F.W. | Chlorophyll b | Carotenoids |
|---|---|---|---|---|
| Season (1) | | | | |
| 0 | 0 | 2.81 | 0.94 | 1.05 |
| | 500 | 2.98 | 1.01 | 1.10 |
| | 1000 | 3.12 | 1.14 | 1.38 |
| 1 | 0 | 2.96 | 1.00 | 1.19 |
| | 500 | 3.01 | 1.03 | 1.22 |
| | 1000 | 3.44 | 1.20 | 1.49 |
| 2 | 0 | 3.10 | 1.03 | 1.29 |
| | 500 | 3.32 | 1.11 | 1.36 |
| | 1000 | 3.62 | 1.28 | 1.51 |
| **LSD $_{0.05}$** | | **0.08** | **0.05** | **0.12** |
| Season (2) | | | | |
| 0 | 0 | 2.77 | 0.92 | 1.04 |
| | 500 | 3.00 | 1.02 | 1.09 |
| | 1000 | 3.15 | 1.12 | 1.32 |
| 1 | 0 | 2.95 | 1.00 | 1.17 |
| | 500 | 3.01 | 1.03 | 1.21 |
| | 1000 | 3.42 | 1.19 | 1.48 |
| 2 | 0 | 3.11 | 1.02 | 1.27 |
| | 500 | 3.36 | 1.16 | 1.35 |
| | 1000 | 3.60 | 1.26 | 1.50 |
| **LSD $_{0.05}$** | | **0.10** | **0.05** | **0.11** |

LSD least significant difference

**Pod yield quality**

The encouraging effect continues as a result of spraying both spirulina extract and amino acids on the yield quality of snap bean grown in saline soil, the data illustrated in Figures (1,2 and 3). It was found that spraying both amino acids and spirulina extract resulted in an increase in the content of carbohydrates and total protein in pod of snap bean, compared to the treatment in which both were not sprayed on snap bean plants. Also, spraying them on snap bean plants reduced the total fiber content of pods, while in the case of treatment in which both were not sprayed, an increase in the fiber content was found. Spraying of both spirulina extract (2 $cm^3$ $L^{-1}$) and amino acids (1000 mg $L^{-1}$) produced the highest protein and carbohydrate content in the pods, but the lowest fiber content value.

Amino acids are precursors of growth substances and plant hormones. In addition, they function as building blocks for protein synthesis through the formation of organic nitrogen compounds (**Wahba *et al.*, 2015)**. Amino acids as bio-stimulants can improve grain quality of some crops by increasing mineral uptake and improving utilization efficiency of nutrients. Amino acids play an important role as iron, zinc, copper, magnesium and calcium chelators because these nutrients can be easily absorbed and transferred to the plant through amino acids **(Vernieri *et al.*, 2005)**. **Neri *et al.* (2002)** referred to the positive role of amino acids in enhancing the plant yield quality. **EL-Bassiouny (2005)** found an increment in the protein content by 18.52 % resulted from

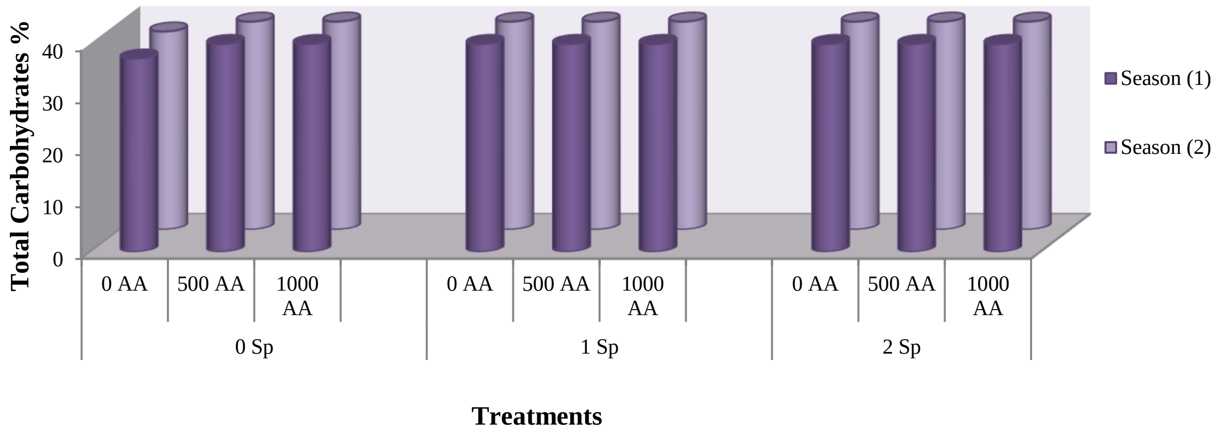


**Fig (1): Effect of spirulina extract (Sp) and amino acid (AA) concentrations on total carbohydrate of snap bean during two seasons.**

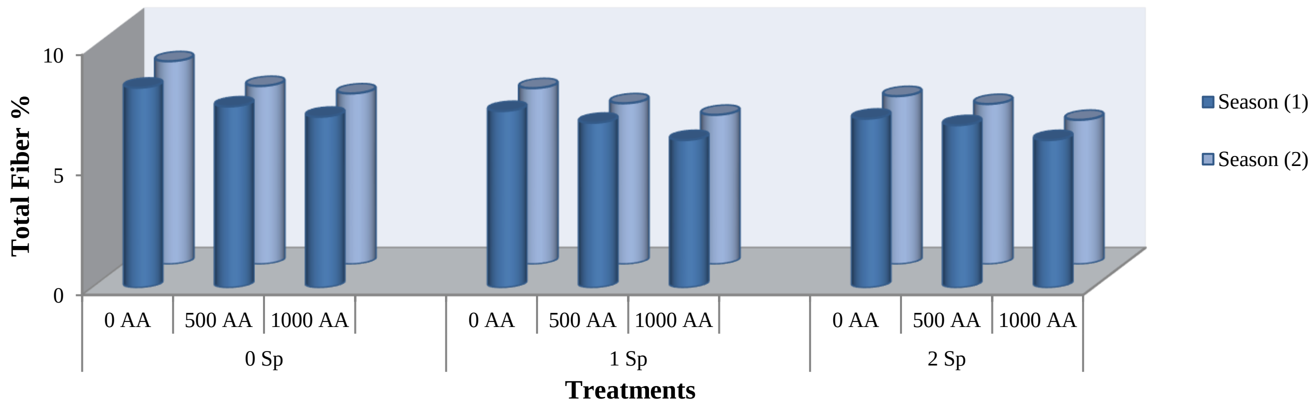


**Fig (2): Effect of spirulina extract (Sp) and amino acid (AA) concentrations on total fiber of snap bean during two seasons.**

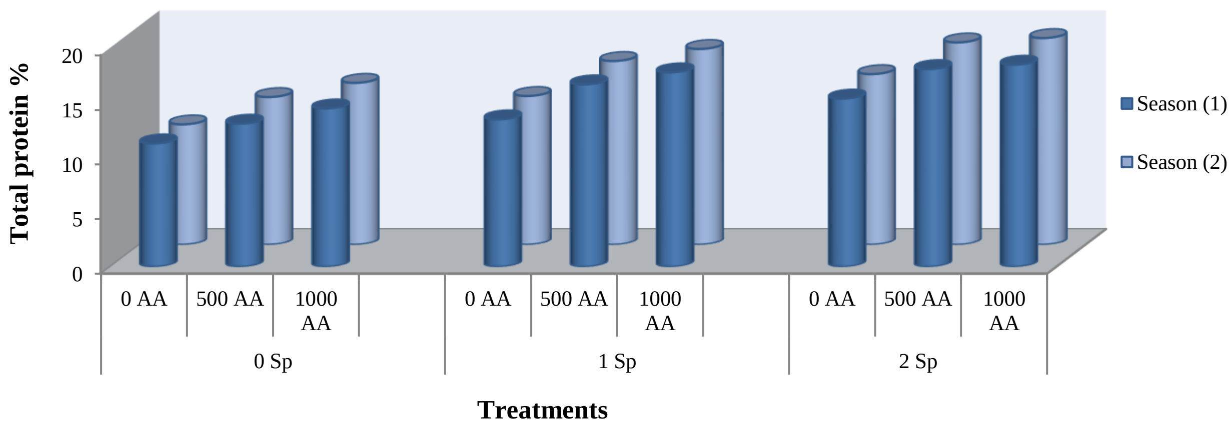


**Fig (3): Effect of spirulina extract (Sp) and amino acid (AA) concentrations on total protein of snap bean during two seasons.**

spraying amino acids. Seaweed and amino acids in legumes have been reported to increase carbohydrate and crude protein content. This is likely due to their important role in the biosynthesis of chlorophyll molecules, which in turn affected total carbohydrates content by increasing photosynthates translocation from source to sink **(Zewail, 2014). Hamouda et al. (2022)** showed that spirulina algae promoted the protein contents of wheat more than the protein contents in control (saline stress). The increase in protein content of wheat plant exits after treatment with spirulina platensis extract, which indicates that spirulina platensis extract may contain substances such as amino acid and zinc that cause this increase.

**Nutritional status**

Under saline soil condition, nutrients content of leaves were improved as a result of spraying each of the algae extract and amino acids, whether combined or alone, compared to the treatment in which both were not used, as shown in (Table 7). As a result of spraying the high rate of each of the amino acids (1000 mg $L^{-1}$) and the spirulina extract (2 $cm^3$ $l^{-1}$), this led to obtaining the highest value for each of nitrogen, phosphorus and potassium (3.44, 0.46 and 2.81 % respectively, at first season, and 3.51, 0.45 and 2.87 %, respectively at second season) inside the snap bean leaves compared to the rest of the other treatments, during the two consecutive growing seasons.

**Table (6): Effect of spirulina extract and amino acid on N, P and K content of leaves snap bean during two seasons.**

| Spirulina extract $cm^3$ $L^{-1}$ | Amino acids mg $L^{-1}$ | N % | P | K | N % | P | K |
|---|---|---|---|---|---|---|---|
| | | Season (1) | | | Season (2) | | |
| | 0 | 2.01 | 0.26 | 1.66 | 2.02 | 0.27 | 1.70 |
| 0 | 500 | 2.25 | 0.29 | 1.91 | 2.30 | 0.30 | 1.98 |
| | 1000 | 2.77 | 0.34 | 2.34 | 2.80 | 0.35 | 2.36 |
| | 0 | 2.66 | 0.32 | 2.00 | 2.70 | 0.31 | 2.02 |
| 1 | 500 | 3.21 | 0.40 | 2.52 | 3.25 | 0.41 | 2.61 |
| | 1000 | 3.24 | 0.42 | 2.77 | 3.30 | 0.43 | 2.70 |
| | 0 | 3.00 | 0.39 | 2.32 | 3.01 | 0.40 | 2.40 |
| 2 | 500 | 3.34 | 0.44 | 2.65 | 3.41 | 0.42 | 2.69 |
| | 1000 | 3.44 | 0.46 | 2.81 | 3.51 | 0.45 | 2.87 |
| **LSD $_{0.05}$** | | **0.14** | **0.04** | **0.22** | **0.15** | **0.04** | **0.24** |

LSD least significant difference

**Nour *et al*., (2010)** indicated that foliar spray with algae extracts on tomato, significantly increased N, P, K and protein percentages. **Rathore *et al*., (2009)** showed that foliar applications of different concentrations of algae extract improved nutrients uptake (N, P and K) of soybean plants. Spirulina extract is a rich source of nitrogen, potassium and potassium, thus enhancing the absorption and accumulation of these elements in plants **(Marrez *et al*., 2014). Shehata *et al*., (2011)** investigated the effects of amino acids and algae extracts on celery plants versus a control and found that spraying the plants with higher proportions of amino acids and seaweed extracts improved N, P and K content of leaves compared with control. **Abd El-Azeiz, et al., (2021)** reported that amino acid treatment's caused significant increases in N, P, and K content in soybean plants under salinity.

**Conclusion:**

Under saline soil spraying snap bean plants with both of spirulina extract at 2 $cm^3$ $L^{-1}$ and amino acids at 1000 mg $L^{-1}$ three times after 15, 30 and 45 days from sowing was the best treatment for improving snap bean plants productivity and its pods quality and this treatment recorded highest values of total yield/fed. Therefore, it can be said that spirulina algae extract and amino acids can be used as two important sources in reducing the effect of soil salinity on snap bean plants and increasing their production, yield quality and content of essential nutrients.

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