



ISSN: 0067-2904

## Effect of biofertilizer (Em1) and seaweed extract (Alga 600) on growth and productivity of strawberry *Fragaria × ananassa* plant

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Received: 4/9/2022

Accepted: 3/11/2022

Published: 30/10/2023

### Abstract:

This experiment was carried out in the greenhouse of Al-Adawi area of the Damascus Governorate, and labs of the Horticulture Department, Faculty of Agriculture, Damascus University during the period 2020-2021, to study the effect of biofertilizer, Em1 (0, 4, 8 ml/l), and seaweed extract, Alga 600 (0, 1, 2 g/l) and their interactions on growth and productivity of strawberry plant cv. Festival. data were calculated after six months of culture. The combination treatment of Em1, (8 ml/l) and Alga 600 (2 g/l) resulted in the best morphological parameters (23,93 cm, 27.87, 138.81 cm<sup>2</sup> for plant height, leaf number, and area respectively), physiological parameters (10.30 %, 60.00 mg/100 gm wet weight, 0.59 % for total soluble solids, vitamin C and titratable acidity respectively), and productivity parameters (20.07, 16.4, 250.72 g/ plant for flowers and fruits number/plant and plant yield respectively). The lowest values, however, were obtained in control non-treated plants.

**Key words:** Strawberry Plant, Seaweed Extract (Alga 600), Biofertilizer (Em1).

## في نمو وإنتاجية نبات (Alga 600) ومستخلص الأعشاب البحرية (Em1) تأثير السماد الحيوي الفريز

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### الخلاصة:

نُفذت التجربة في البيت المحمي بمنطقة العدوي بمحافظة دمشق والمختبرات التابعة لقسم علوم البستنة، كلية الزراعة، جامعة دمشق خلال الفترة 2020-2021، بهدف دراسة تأثير السماد الحيوي (Em1) (0، 4، 8 مل/ل) ومستخلص الأعشاب البحرية (Alga 600) (0، 1، 2 غ/ل) والتفاعل بينهما في نمو وإنتاجية نبات الفريز صنف Festival. تم أخذ القراءات بعد ستة أشهر من الزراعة. أعطت معاملة الخليط بين السماد الحيوي (Em1) بتركيز 8 مل/ل ومستخلص الأعشاب البحرية (Alga 600) بتركيز 2 غ/ل أفضل القيم بالنسبة لمعايير النمو المورفولوجية (23,93، 27.87، 138.81 سم<sup>2</sup> لارتفاع النبات وعدد الأوراق والمساحة الورقية على التوالي)، والمعايير الفيزيولوجية (10.30 %، 60.00 مغ/100 غ وزن رطب، 0.59 % لمجموع المواد الصلبة الذاتية، فيتامين C والحموضة القابلة للمعايرة على التوالي)، والمعايير الإنتاجية (20.07، 16.4، 250.72 غ/نبات للزهور والفاكهة وعدد النبات والنباتية على التوالي).

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250.72 غ/نبات لعدد الأزهار والثمار لكل نبات وإنتاجية النبات على التوالي). وذلك بالمقارنة مع نباتات الشاهد التي أعطت أقل القيم.

## 1. Introduction:

Strawberry (*Fragaria × ananassa* Duch.) is one of the most popular soft fruits, among the fruits, strawberry gives the quickest return in the shortest possible time [1]. belongs to the Rosaceae family, Genus *Fragaria*, Species *Fragaria×ananassa* [2]. The original origin of strawberry is the American continent [3].

It gives an early and very high yield per unit area compared to other fruits because its crop is ready for harvesting within six months after planting [4]. Its fruits are appealing with a distinct, enjoyable and refreshing aroma. It also contains a higher percentage of other components including phenols, flavonoids and anthocyanin [5]. Strawberry is a perfect source of Vitamin C (30-100 mg/100 g of fruit) as well as a foliate and photochemical compound such as the Agonic acid. Consuming strawberries can reduce the risk of increasing cancer by 50 % due to higher levels of Vitamin C which can increase the flow of blood and oxygen to the muscles by 7% due to nitrates [6]. Strawberry contains 89-90 % moisture 0.7-9.2 g protein, 8.4-9.2 g carbohydrate 0.5 g fat of fresh weight of fruit. The strawberry fruit contains 0.90 to 1.85 % acidity the prominent being malic and citric acid and 0.55 % total sugar [7].

The strawberry plants being herbaceous perennials and having shallow root system need effective nutrient management. Although chemical fertilizers contribute a lot in fulfilling the nutrient requirement but their regular, excessive, and unbalance use may lead to health and ecological, hazards depletion of physico-chemical properties of the soil, and ultimately poor crop yields. Hence, there is a need to find an alternative source of safe fertilizers which may enhance crop yields without having adverse effects on soil properties and the environment. Thus, the use of biofertilizers and natural extracts seems to be an array of hope in this direction [8, 9]. Biofertilizers and natural extracts have been considered as a cheap, eco-friendly ways of improving plant growth, productivity, quantity, quality, and soil fertility status [10, 11, 12].

Effective microorganisms (Em) are a commercial biofertilizer that contains a mixture of co-existing beneficial microorganisms collected from natural environments. Predominantly it consists of lactic acid bacteria, photosynthetic bacteria, yeast, fermenting fungi and actinomycetes, phosphorous solvents, and nitrogen fixers [13] (Em) produces many biological active agents such as amino acids, polysaccharides, hormones (Auxin, cytokinin, gibberellins), enzymes and increase soil macronutrients [14]. [15] found that the application of bio-fertilizer (Em) with mineral fertilizers on strawberry plants increased vegetative growth parameters (leaf area, plant length, number of crowns, diameter, number of leaves and yield), macro-mineral content of leaves (N.P.K), physiological parameters (weight, size) and chemical parameters (total sugars, total soluble solids, vitamin C). In a field experiment on the biofertilizer (Em1) effect on vegetative growth of three species of strawberry plant (Honeye, Selva, Elsanta), [16] found that Em1 stimulates the growth of shoots and roots of the Honeye cultivar. on the other hand, it increased the roots biomass of Selva cultivar. In an experiment to study the effect of three levels of biofertilizer (Em1) (1,2,3 %) on the growth and productivity of strawberry plants. [17] proved that treatment with 2 % Em1 significantly increased leaves and roots dry weight, roots length, shoots number, Chlorophyll a and b, leaves number, leaf area, and yield compared with other treatments and with control.

Biofertilizer (Em1) application on strawberry plants resulted in an increment of plant growth and root system, Moreover, it decreased the fungal diseases of the leaves [18]. The application

of biofertilizer (Em1) (1 L/h) in combination with organic fertilizer resulted in highest yield, fruits number, fruits weight, and fruits content of total soluble solids in the strawberry plant [19].

Seaweed extract is considered a natural fertilizer and used as an organic source in improving the growth and productivity of horticultural products [20]. Application of seaweed extract in low concentrations stimulates plant growth and development [21].

Seaweed extract is considered as important source of macro and micro elements [22], amino and organic acids, osmosis preservatives, antimicrobial compounds, vitamins and plant growth promoters (Auxins, Cytokinins, Gibberellins) [23], working with strawberry plants, [24] mentioned that application of seaweed extract (5 ml.l<sup>-1</sup> with irrigation water) and spraying (2 ml.l<sup>-1</sup>) resulted in highest shoots number, leaves number, crown diameter, plant length, and roots number. Moreover, [25] found that spraying of strawberry plants (cvs, Cadonca and Tethis) with seaweed extract (Matrix-15) in of 2 ml.l<sup>-1</sup> resulted in increment of all studied parameters (crown diameter, leaves number, shoots and roots fresh and dry weight and chlorophyll content) comparing with control in both species under study. [26] proved that spraying of strawberry plant (cv. Albion) with three concentrations (2, 4, and 8 g.l<sup>-1</sup>) of seaweed extract (Alga 600) increased crowns number, flowers number, fruits number and size, plant yield, and fruits quality.

To study the effect of foliar application of seaweed on Strawberry plants, [27] found that spraying seaweed extract at concentrations (1 and 2 ml.l<sup>-1</sup>) promoted all vegetative growth characteristics (plants length, Leaves number, Leaf area, Fresh and dry weight of shoots and roots). On the other hand, foliar application of seaweed (Algren) at a concentration of 2 ml.l<sup>-1</sup> increased carbohydrate content, phosphorous and potassium content, Fruits weight and quality and total soluble Solids (TSS) and titratable acidity (TA). [28] found that treatment of strawberry plants with seaweed extract at concentrations of 1 and 2 ml.l<sup>-1</sup> resulted in improvement of all vegetative growth parameters, chemical, and morphological parameters. in addition, treatment with seaweed extract at concentration of 2 ml.l<sup>-1</sup> resulted in a significant increment in plant height, leaves number, carbohydrate content, phosphorous and potassium content, fruits weight, and quality, total soluble Solids, and titratable acidity.

Strawberry is considered as one of the most important economic crops in the world. Chemical fertilizers are required for the plant to achieve the best growth and the highest productivity. Biofertilizers (Em1) and seaweed extract are good alternatives to chemical fertilizers and important fertilizers in the area of organic culture. It is the main source of plant growth regulators which promote plants growth and productivity. Due to the harmful effect of chemical fertilizers on the human health and environment, this search aimed to use the bio-fertilizers as an alternative to chemical fertilizers. Moreover, to study the effect of biofertilizer (Em1) and seaweed-extract (Alga 600) on the growth and productivity of strawberry plants.

## 2. Materials and methods:

- Strawberry plant cv. Festival was used as plant material. Festival species is short day plant, moderately growing, the fruits are medium sized comical shaped and dark red shing color [29].
- The present study was carried out in the greenhouses of Al-Adawi area of the Damascus Governorate, Syria, during the period from 2020-2021. The chemical analysis was carried out in the labs of the Faculty of Agriculture, Damascus University.

- Culture was performed in 25/ 12/ 2021 and data were calculated six months after culture.  
 - The soil was plowed up to a 0.25 m depth, then smoothed planted in terraces form. The seedling on lines with a 70 cm distance between lines and a 20 cm distance between the plants.

- During the experiment period, plants were irrigated and fertilized as recommended for strawberry plant. Organic fertilizer was added (1 ton/dunum) before planting, chemical fertilizer N, P, K (20:20:20 at a rate of 1 g/l) was added after two weeks of planting and five weeks of planting.

#### - **Treatments:**

Biofertilizer (Em1) was applied in two concentrations (4 and 8 ml/l) with irrigation water. Seaweed extract (Alga 600) was applied in two sprays in two concentrations (1 and 2 g/l).

#### - **The experiment treatments were as follows:**

- Un-Treated plants (control plants).
- Treatment with bio-fertilizer (Em1) at a concentration of 4 ml / l.
- Treatment with bio-fertilizer (Em1) at a concentration of 8 ml / l.
- Treatment with seaweed extract (Alga 600) at a concentration of 1 g/l.
- Treatment with seaweed extract (Alga 600) at a concentration of 2 g/l.
- Treatment with bio-fertilizer (Em1) at a concentration of 4 ml/l + seaweed extract (Alga 600) at a concentration of 1 g/l.
- Treatment with bio-fertilizer (Em1) at a concentration of 4 ml/l + seaweed extract (Alga 600) at a concentration of 2 g/l.
- Treatment with bio-fertilizer (Em1) at a concentration of 8 ml/l + seaweed extract (Alga 600) at a concentration of 1 g/l.
- Treatment with bio-fertilizer (Em1) at a concentration of 8 ml/l + seaweed extract (Alga 600) at a concentration of 2 g/l.

Treatments were applied after one week for six times (7 days, 30 days, 45 days, 60 days, 75 days, and 90 days) after planting.

- The soil was physically analyzed to determine and chemical characteristics as shown in Table (1).

**Table 1:** the physical analysis to determine and chemical characteristics of the soil for the year 2020 before the start of cultivation:

K <sub>2</sub> O available	P <sub>2</sub> O <sub>5</sub> available	N total	Organic matter	EC Extract (1:5)	pH suspended (1:2.5)	mechanical analysis of soil (%)		
mg/kg			%	ds.m <sup>-1</sup>		Clay	silt	sand
386.5	4.42	0.12	2.4	0.65	7.8	52.8	18.3	28.9

-The study included 9 treatments, each treatment was repeated for three times, where each replicate contains 10 plants. A Simple Random Design (SRD) was used. Results were analyzed using the statistical analysis program (XL-STATE, 2016).

-The averages were compared according to fisher's test and calculated the least significant differences (LSD) at the level of 5 %.

#### - **Studied parameters:**

##### 1. **Morphological parameters**

- Plant height (cm) was determined from the soil surface up to the top of the middle leaf.
- Number of leaves per plant was calculated.

- Leaf area (cm<sup>2</sup>): five leaves were taken randomly from each plant, leaf was then scanned on A4 paper was de-measured using IMAGE-J program and estimated at cm<sup>2</sup>.

## 2. Physiological parameters:

- Vitamin C concentration (mg/ 100 g wet weight) in fruits, was determined using the area Ranganna method [30].
- Titrated Acidity (%) concentration in fruits was estimated in according to [31].
- Total Soluble Solids (TSS %) Concentration in fruits was determined using a digital refractometer

## 3. Productivity parameters:

- Flowers number and fruits number per plant were calculated. The productivity (g/ plant) was estimated as well.

## 3. Results and discussion:

### 3.1. Effect of biofertilizer (Em1) and seaweed extract (Alga 600) on morphological Parameters:

Data presented in Table (2) show the effect of biofertilizers on growth parameters (plant height (cm), leaves number and leaf area (cm<sup>2</sup>)).

All studied treatments improved studied parameters compared with control. The highest plant height (23.93 cm), leaves number (27.87) and leaf area (138.81 cm<sup>2</sup>) were observed in the combination treatment of Em1 (8 ml/l) and Alga 600 (2 g/l). Meanwhile, the lowest values (15.97 cm, 17.80 and 88.87 cm<sup>2</sup> for the plant height, leaves number and leaf area respectively were recorded in control plants.

The significant effect of bio-fertilizers and seaweed extract in improving the morphological parameters might be attributed to the mineral content of macro and microelements, amino acids, and growth regulators in seaweed extract, biofertilizer (Em) have the ability to harness carbon, solar energy and atmospheric nitrogen to soil effectively, to enrich soil for better plant growth. These are playing a significant role in improving nutrient availability (N, P, K) to crop plants [23, 28, 32].

Moreover, the important effect of micro-organisms in the biofertilizer which promote the bio-synthesis of auxins and gibberellins [14], consequently, stimulate cell growth and elongation, increase plant height, leave area and buds number [17].

**Table 2:** Effect of biofertilizer (Em1) and seaweed extract (Alga 600) on morphological Parameters

Treatments	Plant length (cm)	Number of leaves	Leaf area (cm <sup>2</sup> )
control	15.97 <sub>f</sub>	17.80 <sub>e</sub>	88.87 <sub>f</sub>
Em1= 4 ml/l	17.19 <sub>ef</sub>	19.80 <sub>e</sub>	95.93 <sub>e</sub>
Em1= 8 ml/l	18.87 <sub>de</sub>	20.53 <sub>de</sub>	104.14 <sub>d</sub>
Alga 600= 1 g/l	18.66 <sub>de</sub>	20.33 <sub>e</sub>	98.99 <sub>e</sub>
Alga 600= 2 g/l	20.39 <sub>cd</sub>	23.20 <sub>cd</sub>	115.11 <sub>c</sub>
Em1= 4 ml/l + Alga 600= 1 g/l	21.15 <sub>bc</sub>	23.27 <sub>c</sub>	127.93 <sub>b</sub>
Em1= 4 ml/l + Alga 600= 2 g/l	23.03 <sub>ab</sub>	26.53 <sub>ab</sub>	129.92 <sub>b</sub>
Em1= 8 ml/l + Alga 600= 1 g/l	21.78 <sub>bc</sub>	24.73 <sub>bc</sub>	125.53 <sub>b</sub>
Em1= 8 ml/l + Alga 600= 2 g/l	23.93 <sub>a</sub>	27.87 <sub>a</sub>	138.81 <sub>a</sub>
LSD <sub>0.05</sub>	2.1	2.72	4.62

The same letters at the level of columns indicate no significant differences at the 0.05 significance level.

### 3.2. Effect of biofertilizer (Em1) and seaweed extract (Alga 600) on physiological parameters :

The effect of biofertilizers on total soluble solids (%), titratable acidity (%) and vitamin c mg/ 100 g wet weight) was presented in Table (3). The lowest values (9.40 %, 0.68 %, 52.38 mg/ 100 gm fresh weight for total soluble solids, titratable acidity and vitamin C respectively) were observed in control plants. Meanwhile, the best values (10.30 %, 0.59 %, and 60 mg/ 100 gm wet weights respectively) were recorded when biofertilizer Em1 (8 ml/l) was added in combination with seaweed extract Alga 600 (2 g/l). Similar results were obtained by [27] working on seaweed [15] working on extract and biofertilizer Em1. The promotion effect of seaweed extract and biofertilizers in increasing total soluble solids, titratable acidity and vitamin c might be attributed to the indirect effect of plant growth regulators (Auxins, Gibberellins, Cytokinins) in seaweed extract, in combination with bacteria and yeasts effect in Em1, which enhance the effect of plant growth regulators in improving vegetative growth, increasing leaf area and photosynthesis efficiency, consequently, accumulation of organic and inorganic compounds that are necessary for the cell life cycle. Moreover, this result may be due to macro and microelements in seaweed extract. the role of biofertilizer (Em) could be related to improving soil structure by lowering the pH of the soil, the availability of nitrogen for plant absorption which is a structural component for plant body so significantly contributes to plant growth that improves plant dry matter [13, 23].

**Table 3:** Effect of biofertilizer (Em1) and seaweed extract (Alga 600) on physiological Parameters

Treatments	Total Soluble Solids (TSS %)	Titrated Acidity (TA %)	Vitamin C (mg/100g wet weight)
control	9.40 <sub>g</sub>	0.68 <sub>a</sub>	52.38 <sub>f</sub>
Em1= 4 ml/l	9.50 <sub>g</sub>	0.67 <sub>ab</sub>	53.65 <sub>ef</sub>
Em1= 8 ml/l	9.93 <sub>de</sub>	0.64 <sub>c</sub>	55.24 <sub>cd</sub>
Alga 600= 1 g/l	9.67 <sub>f</sub>	0.65 <sub>bc</sub>	54.60 <sub>de</sub>
Alga 600= 2 g/l	10.10 <sub>bc</sub>	0.62 <sub>de</sub>	56.83 <sub>b</sub>
Em1= 4 ml/l + Alga 600= 1 g/l	9.80 <sub>ef</sub>	0.63 <sub>de</sub>	55.56 <sub>bed</sub>
Em1= 4 ml/l + Alga 600= 2 g/l	10.13 <sub>b</sub>	0.60 <sub>ef</sub>	56.51 <sub>bc</sub>
Em1= 8 ml/l + Alga 600= 1 g/l	9.97 <sub>cd</sub>	0.61 <sub>de</sub>	56.19 <sub>bc</sub>
Em1= 8 ml/l + Alga 600= 2 g/l	10.30 <sub>a</sub>	0.59 <sub>f</sub>	60.00 <sub>a</sub>
LSD <sub>0.05</sub>	0.15	0.02	1.59

The same letters at the level of columns indicate no significant differences at the 0.05 significance level.

### 3.3. Effect of biofertilizer (Em1) and seaweed extract (Alga 600) on productivity Parameters:

Using biofertilizer (Em1) either alone or in combination with seaweed extract (Alga 600) increased flowers number, fruits number, and productivity (gm/plant) (Table 4), however, the highest values (20.07, 16.40, 250.72 g/plant for flowers number, fruits number and productivity respectively) when Em1 (8 ml/l) was added in combination with Alga 600 (2 g/l).

The promotion effect of the biofertilizer (Em1), seaweed extract (Alga 600) in improving the productivity parameters might be due to direct effect in increasing plant content of growth substances (Auxins, Gibberellins, Cytokinins) which promote cell division and elongation [33,

14] enhance production of vital pollen, increase pollination, fertilization rate and fruits set, consequently improve the productivity [19, 26]. In addition, it seems that the application of (Em) has increased the availability of nutrients for plant roots. The availability of nutrients has stimulated plant growth and increased yield components (weight, length, and diameter of fruit) and consequently increased yield

**Table 4:** Effect of Effect of biofertilizer (Em1) and seaweed extract (Alga 600) on productivity Parameters

Treatments	Number of flowers (flower/plant)	Number of fruits (fruit/plant)	Yield (g/plant)
control	12.90 <sub>h</sub>	9.30 <sub>h</sub>	128.27 <sub>g</sub>
Em1= 4 ml/l	14.60 <sub>g</sub>	10.73 <sub>g</sub>	140.80 <sub>f</sub>
Em1= 8 ml/l	16.53 <sub>e</sub>	12.60 <sub>e</sub>	168.22 <sub>d</sub>
Alga 600= 1 g/l	15.87 <sub>f</sub>	12.00 <sub>f</sub>	154.29 <sub>e</sub>
Alga 600= 2 g/l	17.27 <sub>c</sub>	13.33 <sub>c</sub>	178.34 <sub>c</sub>
Em1= 4 ml/l + Alga 600= 1 g/l	16.87 <sub>de</sub>	12.93 <sub>d</sub>	166.35 <sub>d</sub>
Em1= 4 ml/l + Alga 600= 2 g/l	18.67 <sub>b</sub>	14.67 <sub>b</sub>	210.90 <sub>b</sub>
Em1= 8 ml/l + Alga 600= 1 g/l	16.90 <sub>d</sub>	13.00 <sub>d</sub>	180.46 <sub>c</sub>
Em1= 8 ml/l + Alga 600= 2 g/l	20.07 <sub>a</sub>	16.4 <sub>a</sub>	250.72 <sub>a</sub>
LSD <sub>0.05</sub>	0.35	0.26	2.62

The same letters at the level of columns indicate no significant differences at the 0.05 significance level.

#### 4. Conclusions:

The combination treatment of biofertilizer (Em1) (8 ml/l) and seaweed extract (Alga 600) (2 g/l) resulted in the best-studied parameters (the morphological, physiological, and productivity parameters).

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