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Effect of some growth stimulants on production and quality of strawberry transplants

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Abstract

This study was undertaken during the two successive seasons of 2013 and 2014 under sandy soil conditions at private Sector Farm at Kafr Elsohbi Village, Shibin Elqantar, Qalubia Governorate Egypt, to study the effect of using some growth stimulants treatments, i.e., humic acid at 5g/plant, seaweed extract at 5ml/plant, compost tea at10ml/plant and effective microorganisms (EM) at 5ml/plant through soil application and amino acids at 2ml/l, seaweed extract at 2ml/l and gibberellic acid at 50 ppm as a foliar spray and their interactions on growth, chemical compostion, production and quality of strawberry transplants cv. Festival. The obtained results showed that the highest number of main runners/plant, number of leaves/transplant, the thickest transplant crown and the highest number of roots as well as the tallest roots/transplant were recorded by seaweed extract as a soil addition combined with seaweed extracts foliar spray treatment. In addition, the same treatment of seaweed extract either as a soil and foliar spray application induced the maximum number of produced transplants per plant and fedden during both seasons of study. Moreover, the combined treatment between soil addition of seaweed extract and folier spray exhibited the highest content of carbohydrates, phosphorus and potassium in tissues of produced transplants, whereas the highest total nitrogen content was recorded by soil addition of seaweed extract treatment combined with spraying transplants with amino acids in the two seasons. However, the tallest transplants were scored by combination treatment of seaweed extract added to the soil and GA_3 folior spray. Furthermore, the lowest percentage of transplants infection was gained as a result of the combination treatment of EM soil addition and seaweed foliar spray.

Key words: Strawberry transplants cv. Festival, growth stimulants, soil addition, spraying, growth, chemical composition and quality.

Introduction

Strawberry (*Fragaria X ananassa* Duch.) is one of the most important vegetable crops grown in Egypt for fresh consumption, processing and exportation. It's the unique vegetable crop belong to Rosaceae family. Due to the expansion of strawberry nursery cultivation transplants production has become an important industry in Egypt. Increasing the production with high quality transplants per feddan is very desirable by strawberry nurserymen. This may be achieved by using some growth stimulators, i.e., gibberellic acid, seaweed extract, amino acids, humic acid, compost tea and effective microorganisms (EM) either as soil addition or as foliar spray.

The plant growth regulator, gibberellin functions as one of the key signals regulating the developmental fate of vegetative buds in strawberry and runners production (**Hytonen *et al*., 2009**). In this connection, **Ozdemir *et al*. (2009)** showed that the application of GA_3 significantly increased the growth and number of runners of strawberry plants as compared to thecontrol. Also**, Ragab *et al.* (2010)** showed that GA_3 at 50ppm significantly increased number of transplants, crown diameter and total carbohydrates content in roots and crown of strawberry transplants.

Amino acids are extremely important biological compounds that play central roles both as building blocks of proteins and as intermediates in metabolism **(Aberg, 1961),** as well as stimulantion of pigment accumulation, resulting in greener leaves with greater photosynthetic efficiency which positively affect plant growth. In this regard, **Abo Sedera *et al.* (2010)** reported that spraying strawberry plants with amino acids at 0.5 and 1g/l increased vegetaative growth (plant height, number of crowns and number of leaves). Also, **Shafshak *et al.* (2011)** found that amino acids increased vegetative growth and chemical constituents of strawberry plant foliage. Fruthermore**, Shehata *et al.*(2011)** reported that limited effects on growth of strawberry plants were observed by foliar fertilizer with either amino or humic acids .

Compost tea is a liquid extract produced by disolvig compost with water. It will contain soluble nutrients as both organic and inorganic and microorganisms including bacteria, fungi and protozoa. Anecdotal evidence suggests that these teas may be effective against pathogens. These organisms may work by inducing plant resistance, inhibiting pathogen growth, or outcompeting the pathogens. (**Pane *et al*., 2012**). The diverse microbial profile in compost tea help the plant leaves absorb nutrients from the air, and as they find their way into the soil, they help the plants root system to uptake nutreints from the soil (**Scheuerell and Mahaffee, 2004**). **Jennifer *et al*. (2009)** demonstrated that compost tea treatments provided simliar amounts of most macroand micronutrients compared to compost and increased N, P, K, Ca content of strawberry plant.

Humic acid (polymeric polyhydroxy acid) is the most significant component of organic substances in aquatic systems. Humic acid is highly beneficial to both plant and soil; through increasing microbial activity. It is considered as a plant growth bio-stimulant and an effective soil enhancer since it promotes nutrient uptake as chelating agent and improves vegetative characteristics of plant nutritional status and leaf pigments, it also activates the beneficial soil microorganisms and the availability of soil nutrients, particularly in alkaline soils and soils of low organic matter content. Also, humic materials may increase root growth in a similar manner to auxins (**Berlyn and Russo, 1990**). **Khalid *et al.* (2013)** reported that humic acid postively improved plant height, crown diameter, number of runners and number of leaves as well as enhaning root length of strawberry plants.

Bio-fertilization is considered an important tool to enhance the growth and quality of vegetable crops and it becomes, as positive alternative to chemical fertilizers. It is safe for human and environment and it is accompanied with reducing the great pollution occurred on our environment as well as for producing organic foods for export. Effective Microorganisms (EM) preparation contains milk bacteria (*Lactobacillus casei*, *Streptococcus lactis*), photosynthetic bacteria (*Rhodopseudomonas palustrus* and *Rhodobacter space*), yeast (*Saccharomyces albus* and *Candida utilis*), actinomycetes (*Streptomyces albus* and *Streptomyces griseus*) and moulds (*Aspergillus oryzae* and *Mucom hiemalis*) **(Allahverdiyev *et al*., 2011**)

Seaweed extract components are known as a source of plant growth regulators. Moreover, seaweed extracts have been found to contain significant amounts of cytokinins, auxins and betaines, which influence cell division during the early stages of growth along with the induction of flower formation (**Jameson, 1993)**. Seaweed extract application could have promoted cell division, which increases the vegetative growth and fruit size in later stages. Also, it increases flower formation and thus total fruit production, while by enhancing chlorophyll concentration could enhance CO2 assimilation rate. Moreover, seaweed has been shown to increase the source of plant assimilates by enhancing nutrient uptake, nitrate reduction and photosynthesis thus increasing assimilates supply to the plant **(Blunden *et al*., 1997)**. **Shafshak *et al.* (2011)** reported that soil addition of seaweed extract increased strawberry vegetative growth. **Rosalba *et al*. (2013)** studied the effect of seaweed extract either as soil addition or foliar spray on tomato growth. Results indicated that using seaweed extract increased plant vegetative growth traits (plant height, fresh and dry weight of plant) and plant productivity. Also, **Abo Sedera *et al.* (2014)** reported that foliar spray of strawberry plants with two levels of seaweed extract 0.75 and 1.5ml/l gave the highest significant values in all tested vegetative growth characters compared with other treatments.

Therefore, this study was an attempt to enhance the production and quality of strawberry transplants cv. Festival by using humic acid, seaweed extract, compost tea and effective microorganisms (EM) through soil addition and the foliar spray with amino acids, seaweed extract and gibberellic acid.

Materials and Methods

Two field experiments were carried out during two successive seasons of 2013 and 2014 in private Sector Farm at Kafr Elsohbi Village, Qalubia Governorate, to investigate the effect of soil addition of humic acid, seaweed extract, compost tea and effective microorganisms (EM) and the foliar spray with amino acids, seaweed extract and gibberellic acid as well as their combination on growth, chemical composition, production and quality of strawberry transplants *(Fragaria X ananassa* Duch) cv. Festival. Nursery mother transplants of the used cultivar were obtained from Peico Company and planted on 23th April and 1st May in the first and second seasons, respectively. Mechanical and chemical analyses of the used soil are shown in Table a.

Table a: Mechanical and chemical analyses of the used soil.

Physical analysis		Chemical analysis			
		Cations (meq/l)		Anions (meq/l)	
Coarse sand	19.5%	Ca^{++}	8.90	CO_3^{--}	Zero
Fine sand	35.6%	Mg^{++}	3.15	HCO_3^-	4.60
Silt	26.8%	Na^+	4.20	Cl^-	5.35
Clay	18.1 %	K^+	1.18	SO_4^{--}	7.23
Texture class: Sandy loam					
Soil pH	7.2	Available N	24.1 mg/kg		
E.C (dS/m)	1.73	Available P	11.8 mg/kg		
Organic matter	2.1%	Available K	178 mg/kg		

Mixture of compost and chicken manure were added at rate of 40m^3 /feddan during soil preparation, three weeks before cultivation process. Soil fumigation by methyl bromide at 50g/m^2 was used to sterilize the soil. Mother plants were dipped in 0.3% rhizolex solution for 20 minutes before transplanting. The transplants were spaced at 1.25m between plants and 1.25m between rows. Flowers were continuously removed from mother plants during the first month after transplanting. Drip irrigation system in the first two months was used, and then the micro sprinkler irrigation system (4m x 5m) was used. All agricultural practices for cultivation, fertilization, irrigation, pest and diseases control were conducted as commonly followed according to the recommendation of the Ministry of Agriculture, Egypt for the commercial production of strawberry transplants in nursery.

The experimental design was split plot design with three replicates where the soil addition treatments were distributed in the main plots, while the spray treatments were located randomly in the sub plots. Each experimental plot contained one row with 1.25m wide and12.50 m long (plot area =15.62m^2) which containing ten mother plants planted at distance 1.25m in-between.

This experiment included 20 treatments resulted from the combination between five soil additions treatments and four spray treatments as follows.

a. Soil addition treatments:

1- Humic acid as Humic total at 5g/plant.
2- Seaweed extract as Rootmost at 5ml/plant.
3- Compost tea at 10ml/ plant (its chemical composition are shown in Table, b).
4- Effective microorganisms (EM) (contains photosynthetic bacteria +lactic acid +yeasts) at 5ml/plant, which purchased from Department of Microbiology, Agric. Res. Center., Giza.
5- The control treatment (without any addition).

b. Spray treatments.

1- Amino acids as Amino power at 2ml/l.
2- Seaweed extract at 2ml/l.
3- Gibberellic acid (GA_3) at 50 ppm.
4-The control treatment (spray with tap water).

Humic Total: 80% soluble potassium humate. It is commercial product by Leili Agrochemistry Co. Ltd. It includes: Humic acid 80% - K_2O 11-13%- Moisture 5-7%.

Rootmost: Seaweed root growth promoter. It is commercial product by Leili Agrochemistry Co.Ltd. It includes: Seaweed extract 400g/l - Organic Matter 20g/l.

Amino power: Is commercial product from Union for Agriculture Development (UAD) contain 20% free L. amino acids , 40% total amino acids , 3% mix of vitamins , 3.5% potassium citrate and some micro nutrients such as 1500ppm Fe, 500ppm Zn and 500ppm Mn.

Compost tea preparation: compost tea was prepared by soaking 10kg of mature plant compost with 100 liter of water + 100ml molasses for 7days in special unit, attached to air pump and the aerator provides continuous flow of air bubbles to extract compost tea until completion of the fermentation process and extract color becomes light Brown (**Fayek *et al*., 2014)**

Table b: Chemical and microbiological analyses of compost tea.

parameter	PH	EC (dS/m)	Total N%	Total p%	Total k%	Total count of bacteria(cfu/ml)	Total count of fungi (cfu/ml)	Total count of actinomycetes(cfu/ml)
value	7.14	2.83	0.34	0.08	0.56	$8.7x10^6$	$7.7x10^4$	$1.1x10^5$

The soil addition treatments were added through drip irrigation water (fertigation) three times starting 15 days after transplanting and every two weeks by interval.

The spray treatments were started one month from transplanting and repeated at 15 days intervals conducted six times through the growing season. The spray solution was maintained just to cover completely the plant foliage. As for the agricultural practices, runners were manual fixed twice a week during the growing season, starting from the first runnering (after 30days from transplanting) till late August, then stopped until the end of the growing season. In addition, mother plants were defoliated by removing the old, dry and dead leaves three times monthly during June, July and August, then stopped until the end of season.

Data recorded

Representative samples of three mother plants with their runners and daughter plants were dug on 20th September to record the vegetative growth characteristics, i.e., number of main runners/plant, number of leaves/transplant, plant height, crown diameter, number of fresh transplants per plant and per feddan, number of roots and root length of transplant. Total carbohydrates, nitrogen, phosphorus and potassium were determined according to **A. O. A. C. (1990), Pregl (1945), John (1970)** and **Brown and Lilleland (1946),** respectively. As for disease assessment, infection percentage was estimated in 20th September in transplants according to the method of **Dhingra and Sinclair (1995).**

Statistical analysis:

All data obtained in both seasons of study were subjected to analysis of variance as factorial experiments in split plot design. Duncan's analysis was used to differentiate means according to **Snedecor and Cochran (1991).**

Results and Discussion

1- Number of main runners and leaves/plant

Data in Table1 reveal that the number of main runners and leaves/plant was significantly increased by using all tested soil additions of growth stimulants compared with the control treatment. In this respect, seaweed extract at 5ml/plant exhibited the highest values for both number of main runners and leaves/plant, followed by 5g/plant humic acid–treated plant as compared with the control in the two seasons. In addition, all tested growth stimulants sprays succeeded in increasing the number of main runners and leaves /plant, especially the treatment of seaweed at 2ml/l, followed in descending order by amino acids at 2ml/l in the two seasons.

As for the interaction effect between soil addition and spray treatments of the tested growth stimulants, data in the same Table, clearly show that all resulted interactions statistically increased the number of main runners and leaves/plant when compared with un-treated plants "control" in the two seasons. Furthermore, the highest number of main runners and leaves /plant was recorded by the combination between seaweed extract at 5ml/plant as a soil addition and spraying seaweed extract at 2ml/l as it scored 12.95, 7.46 and 11.48, 6.80 main runners and leaves/plant during first and second seasons, respectively, followed in descending order by the combined treatment of humic acid at 5g/plant and spraying seaweed at 2ml/l as it recorded 12.26, 10.97 main runners in case of number of main runners and the combined treatments between seaweed extract and amino acids which scored 7.15 and 6.32 leaves/plant in the first and second seasons , respectively. Such increment in the studied vegetative growth traits may be due to the biological and physiological roles of the used growth stimulants where seaweed extract which contain large amount of cytokinins and auxin which induce cell division thus increase the vegetative growth. In addition, humic acid enhanced vegetative growth as it promotes nutrient uptake, nutritional status and leaf pigments. Moreover, EM produces adequate amounts of phytohormones such as IAA, GA_3 and cytokinins which affect the vegetative growth of strawberry transplants. Furthermore, compost tea containing soluble nutrients which were necessary for vegetative growth. Also, amino acids play an important role in protein synthesis as well as stimulation of pigment accumulation resulting in greener leaves with greater photosynthetic efficiency which positively affect vegetative growth. It may be also due to the role of GA_3 which caused an increase in the main runners number, length of cells and the elangation of internodes. The obtained results are in agreement with those reported by **Ragab (1996)**, **Hytonen *et al*.(2009**), **Jennifer *et al*.(2009)**, **Ozdemir *et al*. (2009)**, **Abo Sedera *et al.*(2010), Ragab *et al.* (2010)**, **Shafshak *et al.*(2011)**, **Shehata *et al.*(2011), Khalid *et al.*(2013),** and **Abo Sedera *et al.*(2014)** on strawberry. **Pane *et al.(*2012**) and **Rosalba *et al*.(2013)** on tomato.

2-plant height and crown diameter.

Data tabulated in Table 2 indicate that there were significant differences among the tested soil addition treatments in both plant height and crown diameter of produced strawberry transplants during both seasons of growth. In this respect , treating transplants with seaweed extract at 5ml/plant three times during the growth seasons reflected the highest values, followed by using the humic acid at 5g/plant, EM at 5ml/plant, compost tea at 10ml/plant and the control treatment in a descending order. Such increments in plant height and crown diameter may be due to the main role of chemical constituents of seaweed extract, humic acid, EM and compost tea on cell division and cell elongation which positively affect on transplants length and diameter of crown. Also, the enhancement effect may be due to the increasing of N, P, K absorption and carbohydrates assimilation (Tables 4 and 5) and in turn affected positively transplants growth.

Concerning the effect of foliar spray treatments, the same data in Table 2 show clearly that spraying strawberry transplants with all tested growth stimulants six times starting one month from transplanting and every two weeks by intervals significantly affected both transplants height and crown diameter compared to the control treatment. In this connection, using gibberellic acid at 50 ppm exhibited the highest values in this respect as compared with other tested treatments. In addition, seaweed extract ranks the second followed by using amino acids. Such results are true during both seasons of study in case of plant height. Furthermore, spraying strawberry transplants with seaweed extract gave the highest value of crown diameter.

As for the interaction treatments, data in Table 2 indicate that the highest values of transplants height and crown diameter were recorded as a result of using seaweed extract as a soil addition supported with spraying transplants with gibberellic acid in case of transplants height and seaweed as soil application combined with seaweed as a foliar spray in case of crown diameter in the two seasons.

Table 1. Effect of some plant biostimulants as soil addition and foliar spray and their interactions on number of main runners/plant and number of leaves /plant during 2013 and 2014 seasons

Treatments	Number of main runners/plant					Number of leaves /plant				
	First season (2013)									
Spray (B) / **Soil addition (A)**	**Amino acid**	**Seaweed extract**	**Gibberellic acid**	**Control**	**Mean**	**Amino acid**	**Seaweed extract**	**Gibberellic acid**	**Control**	**Mean**
Humic acid	10.27hi	12.26b	10.98ef	9.83k	**10.84B**	6.93cd	7.10b	6.72ef	6.25gh	**6.74B**
Seaweed extract	11.34d	12.95a	11.72c	10.13ij	**11.53A**	7.15b	7.46a	7.08bc	6.83de	**7.13A**
Compost tea	10.16ij	11.20de	10.25hi	9.71k	**10.33C**	6.36g	6.84de	6.27gh	5.41L	**6.22D**
Effective microorganism(EM)	10.52gk	11.84c	10.83f	9.95jk	**10.78B**	6.78d:h	6.90d	6.66f	5.81j	**6.55C**
Control	9.80k	10.79fg	9.82k	8.56l	**9.74D**	6.02ij	6.17hi	5.60k	5.10m	**5.72E**
Mean	**10.42C**	**11.81A**	**10.72B**	**9.63D**		**6.64B**	**6.89A**	**6.46C**	**5.89D**	
	Second season (2014)									
Humic acid	10.22d	10.97b	10.15de	9.20h	**10.14B**	5.92a:c	6.31ab	5.75bc	5.10c-e	**5.77B**
Seaweed extract	10.81bc	11.48a	10.93b	10.10de	**10.83A**	6.32ab	6.80a	6.18ab	5.43b-d	**6.18A**
Compost tea	9.56f	9.91e	9.27gh	8.63k	**9.34D**	5.16cd	5.51b-d	4.93c-e	4.53de	**5.03B**
Effective microorganism(EM)	9.57f	10.62c	9.45fg	9.12hi	**9.69C**	5.13cd	5.87a-c	5.10c-e	4.73de	**5.20B**
Control	8.90ij	9.36f-h	8.79jk	7.43l	**8.62E**	4.93c-e	5.18cd	4.74de	4.12e	**4.74B**
Mean	**9.81B**	**10.47A**	**9.71B**	**8.89c**		**5.49AB**	**5.93A**	**5.34B**	**4.78C**	

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at5%

Table 2. Effect of some plant biostimulants as soil addition and foliar spray and their interactions on plant height and crown diameter during 2013 and 2014 seasons.

Treatments	Plant height(cm)					Crown diameter(cm)				
	First season (2013)									
Spray (B) / Soil addition (A)	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean
Humic acid	25.13a-d	25.56a-c	25.80ab	23.80d-g	**25.07AB**	0.97c-f	1.06b	0.91g-i	0.87h-k	**0.95B**
Seaweed extract	25.65a-c	25.90a	26.13a	24.25c-g	**25.48A**	1.01g-i	1.13c-f	0.98b	0.91g-i	**1.01A**
Compost tea	24.76a-f	24.95a-e	25.17a-d	23.12g	**24.50B**	0.92f-h	0.95e-g	0.86i-k	0.80l	**0.88D**
Effective microorganism(EM)	24.98a-e	25.15a-d	25.62a-c	23.25fg	**24.75AB**	0.96d-g	1.02bc	0.88h-j	0.84j-l	**0.92C**
Control	23.50e-g	23.84d-g	24.36b-g	22.93g	**23.66C**	0.84j-l	0.91g-i	0.82kl	0.79l	**0.84E**
Mean	**24.80A**	**25.08A**	**25.42A**	**23.47B**		**0.94B**	**1.01A**	**0.89C**	**0.84D**	
	Second season (2014)									
Humic acid	23.15d-f	23.87b-d	24.36ab	22.10g-i	**23.37B**	0.95a-c	0.97ab	0.90b-e	0.84c-f	**0.91AB**
Seaweed extract	23.92bc	24.13ab	24.78a	22.64e-h	**23.87A**	0.99ab	1.04a	0.93a-d	0.90b-e	**0.96A**
Compost tea	22.72e-g	23.01ef	23.93bc	21.32k	**22.74C**	0.89b-e	0.92a-d	0.84c-f	0.81d-f	**0.86BC**
Effective microorganism(EM)	22.95ef	23.25c-e	24. 11ab	21.92h-k	**23.06BC**	0.93a-d	0.96a-c	0.89b-e	0.81d-f	**0.89A**
Control	21.35jk	21.84i-k	22.46f-i	20.16L	**21.45D**	0.81d-f	0.87b-f	0.78ef	0.76f	**0.80C**
Mean	**22.82C**	**23.22B**	**23.93A**	**21.63D**		**0.91AB**	**0.95A**	**0.86BC**	**0.82C**	

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at5%

Obtained results are in agreement with those reported by **Ragab (1996), Hytonen *et al*.(2009**), **Jennifer *et al*.(2009)**, **Ozdemir *et al*. (2009)**, **Abo Sedera *et al.*(2010), Ragab *et al.* (2010)**, **Shafshak *et al.*(2011)**, **Shehata *et al.*(2011), Khalid *et al.*(2013),** and **Abo Sedera *et al.*(2014)** on strawberry and **Pane *et al.(*2012**) and **Rosalba *et al*.(2013)** on tomato .

3-Number and length of the transplant roots:

Data in Table 3 illustrate the effect of soil addition and foliar spray with tested growth stimulant treatments as well as their interaction on number and length of roots per transplants. Such data indicate that soil treatments with humic acid at 5g/plant, seaweed extract at 5ml/plant, compost tea at 10ml/plant and EM at 5ml/plant three times during the growth season starting 15 days after transplanting and every two weeks by interval significantly increased both number and length of roots produced by treated transplants compared with the control treatment. In this connection, seaweed extract recorded the highest number of roots and longest roots /plant, followed in descendingly by humic acid, EM and compost tea during the two seasons of growth. In this respect, such positive effect of tested growth stimulants may be due to its physiological and biological constituents which enhanced roots formation and elongation and consequently increased its growth.

With regard to the effect of spray treatments, the same data in Table 3 show that spraying transplants six times during the growing season starting after one month from transplanting and two weeks by intervals with amino acids at 2ml/l, seaweed extract at 2ml/l and gibberellic acid at 50 ppm significantly increased number and length of roots per transplant compared to the check treatment (control) in both seasons of study. In addition, using seaweed extract reflected the highest values in this respect. Moreover, no significant differences were noticed between treatments of amino acid and gibberellic acid in this regard.

As for the interaction the same data in Table 3 indicate that the highest number of roots (26.42 and 25.75 roots/transplant) as well as the tallest roots/transplant (14.64 and 13.73 cm) were recorded by the combined treatment of soil addition of seaweed and spraying seaweed extract, followed by soil addition of humic acid provided with seaweed extract foliar spray in the two seasons. Furthermore, soil addition of seaweed extract enriched with amino acids registered high increments in these parameters .The enhancement in roots number and length may be due to the role of used growth stimulants, i.e., GA3, amino acids, humic acid, seaweed extract and EM in encouragement cell division and cell elongation as well as increasing nutrient uptake (Tables 4 and 5)and photosynthetic assimilation rate which in turn affect positively roots number and length . Obtained results go in line with those reported by **Ragab (1996), Ragab *et al.* (2010)** and **Khalid *et al.* (2013)** on strawberry.

4- Chemical composition determination

Data in Tables 4 and 5 show clearly that all tested soil additions of growth stimulants increased total carbohydrates, nitrogen, phosphprus and potassium contents of strawberry cv. Festival transplants compared with the control treatment. In this respect, seaweed extract treatment show the superiority, followed in a descending order by humic acid and EM treatments in the two seasons. With regard to the effect of foliar spray treatments, the same data in Tables 4 and 5 show that chemical composition determination of strawberry transplants statistically increased by using all studied spray treatments of growth stimulants, particularly seaweed extract, followed by amino acid with the exception of nitrogen% as amino acids foliar spray treatment show its superiority in this respect as compared with the control plants in the two seasons. However, the combined treatments between soil addition of seaweed extract and spraying seaweed extract showed to be the most effective one for producing the highest total carbohydrates (8.30 and 7.72%), phosphorus (0.46 and 0.39 %) and potassium (1.93 and 1.85 %), whereas the highest nitrogen content (2.89 and 2.79 %) was registered by soil addition of seaweed extract treatment combined with spraying amino acids treatment in the first and second seasons, respectively.

The increases in the studied chemical composition may be due to the physiological effects of growth stimulants, amino acids stimulated pigment accumulation, resulting in greener leaves with greater photosynthetic efficiency which was reflected on more chemical composition in strawberry plants. In addition, compost tea help the plants root system to absorb nutrients from the soil which induced more chemical composition in strawberry plants. Also, humic acid promotes nutrient uptake and improve leaf pigments and chemical composition of strawberry plants. Moreover, EM stimulates the meristematic activities of cells and tissues, thereby promoting vegetative growth aspects which were reflected in chemical constituents (**Allahverdiyer *et al.*, 2011**). Obtained results are similar to those reported by **Ragab (1996), Hytonen *et al*. (2009**), **Jennifer *et al*.(2009)**, **Ozdemir *et al*. (2009)**, **Abo Sedera *et al.*(2010), Ragab *et al.* (2010)**, **Shafshak *et al.*(2011)**, **Shehata *et al.*(2011), Khalid *et al.*(2013)** and **Abo Sedera *et al.*(2014)** on strawberry .

5- Number of transplants/ plant and per feddan.

Data in Table 6 illustrate that all tested soil additions of growth stimulants significantly increased the number of transplants/plant and per fed. In this connection, seaweed extract treatment reflected the highest number of produced transplants followed in a descending order by humic acid and E.M treatments as compared with the control in the two seasons. Additionally, all tested spray treatments of the used growth stimulants resulted in highly significant increments in these aforementioned parameters. Moreover, spraying seaweed extract exhibited the highest values followed in a descending order by amino acid and GA_3 treatments when compared with the control plants in the two seasons.

Referring to the interaction effect between soil addition and spray treatments of the used growth stimulants, data in Table 6 demonstrated also that all resulted combinations succeeded in increasing the number of transplants/plant and per fed., with significant increase in most cases when compared with un-treated plants in the two seasons. Moreover, the highest number of transplants /plant and per feddan was scored by the combined treatment between soil addition of seaweed and spraying seaweed as it scored 94.35 and 89.83 transplants /plant and 254018 and 241849 transplants / fed. In the first and second seasons, respectively. Furthermore, soil addition of seaweed extract supplemented with amino acid or GA3 sprays recorded high significant increments in these parameters in the two seasons. Obtained results are similar to those reported by **Ragab (1996)**, **Hytonen *et al*.(2009**), **Jennifer *et al*.(2009)**, **Ozdemir *et al*. (2009)**, **Abo Sedera *et al.*(2010), Ragab *et al.* (2010)**, **Shafshak *et al.*(2011)**, **Shehata *et al.*(2011), Khalid *et al.*(2013)** and **Abo Sedera *et al.*(2014)** on strawberry and **Pane *et al.(*2012**) and **Rosalba *et al*.(2013)** on tomato.

6- Infection %:

It is quite clear from Table 7 that infection percentage of strawberry transplants cv. Festival was significantly decreased by using all growth stimulants treatments which applied either by soil addition or by foliar spraying, as well as their combinations, when compared with un-treated plants in the two seasons. However, the lowest infection percentage was gained by the combined treatment between soil addition of E.M and spraying seaweed extract as it recorded 2.60 and 2.20 % in the first and second seasons, respectively. Obtained results are in agreement with those reported by **Ragab (1996)**, **Hytonen *et al*.(2009**), **Jennifer *et al*.(2009)**, **Ozdemir *et al*. (2009)**, **Abo Sedera *et al.*(2010)** and **Ragab *et al.* (2010)** on strawberry.

Conclusively, it could be concluded that under such condition, it is preferable to use growth stimulants, i.e., humic acid, seaweed extract, compost tea and effective microorganisms (EM) through soil addition and the foliar spray with amino acids, seaweed extract and gibberellic acid were recommended for enhancing the production and improving the quality of strawberry transplants.

Table 3. Effect of some plant biostimulants as soil addition and foliar spray and their interactions on number of roots/transplant and root length during 2013 and 2014 seasons.

Treatments	**Number of roots**					**Root length(cm)**				
	First season (2013)									
Spray (B) **Soil addition (A)**	**Amino acid**	**Seaweed extract**	**Gibberellic acid**	**Control**	**Mean**	**Amino acid**	**Seaweed extract**	**Gibberellic acid**	**Control**	**Mean**
Humic acid	25.43bc	25.96ab	24.86c-e	23.65f-i	**24.95B**	13.98b-d	14.19ab	13.91b-d	13.25e-g	**13.83B**
Seaweed extract	25.80a-c	26.42a	25.64a-c	24.22d-f	**25.52A**	14.18ab	14.64a	14.07a-c	13.92b-d	**14.20A**
Compost tea	24.05e-g	24.97b-e	23.91e-h	22.63i	**23.89C**	13.26e-g	13.54c-f	13.09fg	12.21ij	**13.03D**
Effective microorganism(EM)	24.76c-f	25.18b-d	24.13d-g	23.11g-i	**24.30C**	13.62b-f	13.87b-e	13.40d-g	12.88gh	**13.44C**
Control	22.90hi	23.25f-i	22.83i	21.54j	**22.63D**	11.93ij	12.40hi	12.64j	11.72j	**11.92E**
Mean	**24.57B**	**25.16A**	**24.27B**	**23.03C**		**13.39B**	**13.73A**	**13.62B**	**12.80C**	
	Second Season (2014)									
Humic acid	23.37de	24.66b	23.05e-g	22.48g-i	**23.39B**	12.85d	13.33b	12.25fg	12.04hi	**12.62B**
Seaweed extract	24.20bc	25.75a	24.10bc	23.18d-f	**24.31A**	13.12c	13.73a	12.95cd	12.40ef	**13.05A**
Compost tea	22.65f-h	23.72cd	22.44g-i	21.60i	**22.60C**	12.17gh	12.86d	12.04hi	11.55k	**12.15D**
Effective microorganism(EM)	23.14d-f	24.22bc	22.93e-g	22.17h-j	**23.11B**	12.52e	13.07c	12.12g-i	11.96ij	**12.42C**
Control	20.66k	21.91ij	20.14k	19.35l	**20.51D**	11.16l	11.80j	11.05l	10.84l	**11.30E**
Mean	**22.80B**	**24.05A**	**22.53B**	**21.76C**		**12.36B**	**12.96A**	**12.08C**	**11.83D**	

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at5%

Table 4. Effect of some plant biostimulants as soil addition and foliar spray and their interactions on total carbohydrates and nitrogen % during 2013 and 2014 seasons.

Treatments	Total carbohydrates%					Nitrogen %				
	First season (2013)									
Spray (B) / Soil addition (A)	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean
Humic acid	7.90d-f	8.06b-d	7.84e-f	7.28h	**7.76B**	2.76c	2.72cd	2.64e-g	2.95g-j	**2.67B**
Seaweed extract	8.16a-c	8.30a	8.20ab	7.96c-e	**8.14A**	2.89a	2.83b	2.74c	2.68de	**2.78A**
Compost tea	7.28h	7.52g	6.96i	6.62j	**7.08D**	2.63e-h	2.60g-i	2.54j-l	2.50k-m	**2.56D**
Effective microorganism(EM)	7.74f	7.98c-e	7.72fg	7.04i	**7.62C**	2.66ef	2.61f-h	2.58h-j	2.55i-k	**2.60C**
Control	6.24k	6.86i	6.08k	5.72l	**6.22E**	2.51kl	2.49lm	2.45mn	2.41n	**2.46E**
Mean	**7.46B**	**7.74A**	**7.36C**	**7.28D**		**2.69A**	**2.65B**	**2.59C**	**2.54D**	
	Second season (2014)									
Humic acid	6.44e	7.30b	6.36ef	6.02hi	**6.52B**	2.68b	2.57de	2.56de	2.32h-j	**2.53B**
Seaweed extract	7.04c	7.72a	6.78d	6.22fg	**6.94A**	2.79a	2.65bc	2.59cd	2.45f	**2.62a**
Compost tea	6.02hi	6.24fg	5.92i	5.48k	**5.90D**	2.52e	2.41fg	2.36gh	2.21kl	**2.37D**
Effective microorganism(EM)	6.26f	6.04d	6.10gh	5.88i	**6.22C**	2.56de	2.43f	2.40fg	2.27i-k	**2.41C**
Control	5.12l	5.72j	4.98l	4.20m	**5.00E**	2.33hi	2.26jk	2.19l	2.12m	**2.22E**
Mean	**6.16B**	**6.72A**	**6.02C**	**5.56D**		**2.57A**	**2.46B**	**2.42C**	**2.27D**	

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at5%

Table 5. Effect of some plant biostimulants as soil addition and foliar spray and their interactions on phosphorus and potassium precentage during 2013 and 2014 seasons.

Treatments	Phosphorus%					Potassium%				
	First season (2013)									
Spray (B) / Soil addition (A)	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean
Humic acid	0.39a-e	0.43ab	0.37b-f	0.32e-i	**0.37AB**	1.81c-f	1.86bc	1.77e-h	1.73h-k	**1.79B**
Seaweed extract	0.42a-c	0.46a	0.41a-d	0.36b-g	**0.41A**	1.87b	1.93a	1.84b-d	1.79d-g	**1.85A**
Compost tea	0.34d-h	0.38b-f	0.31f-i	0.28h-i	**0.32C**	1.76f-i	1.80d-g	1.71i-l	1.68kl	**1.73D**
Effective microorganism(EM)	0.36b-g	0.40a-d	0.35c-h	0.31f-i	**0.35BC**	1.79d-g	1.82b-e	1.75g-j	1.70j-l	**1.76C**
Control	0.29g-i	0.31f-i	0.26i-j	0.23j	**0.27D**	1.70j-l	1.76f-i	1.66lm	1.62m	**1.68E**
Mean	**0.36B**	**0.39A**	**0.34B**	**0.30C**		**1.78B**	**1.83A**	**1.74C**	**1.70D**	
	Second season (2014)									
Humic acid	0.36a-c	0.37ab	0.33b-d	0.30de	**0.34A**	1.75b-f	1.78a-d	1.73c-f	1.69e-h	**1.73B**
Seaweed extract	0.37ab	0.39a	0.36a-c	0.32c-e	**0.36A**	1.82ab	1.85a	1.80a-c	1.76b-e	**1.80A**
Compost tea	0.30de	0.31de	0.28ef	0.25fg	**0.28B**	1.65g-i	1.72d-g	1.63hi	1.60ij	**1.65D**
Effective microorganism(EM)	0.31de	0.34b-d	0.30de	0.28ef	**0.30B**	1.70eh	1.75b-f	1.68f-h	1.63hi	**1.69C**
Control	0.25fg	0.28ef	0.24fg	0.21g	**0.24C**	1.58ij	1.63hi	1.54jk	1.50k	**1.56E**
Mean	**0.31AB**	**0.33A**	**0.30B**	**0.27C**		**1.70B**	**1.74A**	**1.67B**	**1.63C**	

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at5%

Table 6:- Effect of some plant biostimulants as soil addition and foliar spray and their interactions on number of transplants/plant and number of transplants /feddan during 2013 and 2014 seasons.

Treatments / Spray (B) / Soil addition (A)	Number of transplants/plant					Number of transplants /feddan				
	First season (2013)									
	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean
Humic acid	90.15cd	91.98bc	88.75de	85.36g-i	**89.06B**	242710cd	247637bc	238941de	229814g-i	**239776B**
Seaweed extract	92.87ab	94.35a	91.46bc	87.29e-g	**91.49A**	250033ab	254018a	246237bc	235010e-g	**246325A**
Compost tea	82.35jk	83.56ij	80.75k	77.94l	**81.15D**	221710jk	224968ij	217403k	209837l	**218480D**
Effective microorganism(EM)	86.18f-h	87.84e-f	84.66hi	81.52jk	**85.05C**	232022f-h	236491ef	227930hi	219476jk	**228980C**
Control	78.12l	80.63k	76.40l	71.14m	**76.57E**	210322l	217080k	205691l	191530m	**206156E**
Mean	**85.93B**	**87.67A**	**84.40C**	**80.65D**		**231360B**	**236039A**	**227240C**	**217133D**	
	Second season (2014)									
Humic acid	84.98b-d	87.10b	83.67de	82.15ef	**84.47B**	228791b-d	234499b	225264de	221172ef	**227432B**
Seaweed extract	87.25b	89.83a	86.19bc	84.42c-e	**86.92A**	234903b	241849a	232049bc	227283c-e	**234021A**
Compost tea	78.19g	80.75f	76.25gh	72.98ij	**77.04D**	210510g	217403f	205287gh	196484ij	**207421D**
Effective microorganism(EM)	81.13f	84.26c-e	80.82f	75.25hi	**80.36C**	218426f	226853c-e	217591f	202595hi	**216366C**
Control	73.36ij	76.16gh	72.82j	68.37k	**72.68E**	197507ij	205045gh	196053j	184072k	**195669E**
Mean	**80.98B**	**83.62A**	**79.95C**	**76.63D**		**218027B**	**225130A**	**215249C**	**206321D**	

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at5%

Table 7:- Effect of some plant biostimulants as soil addition and foliar spray and their interactions on diseases infection percentages during 2013 and 2014 seasons.

Treatments	Infection%									
	First season (2013)					Second season (2014)				
Spray (B) / Soil addition (A)	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean	Amino acid	Seaweed extract	Gibberellic acid	Control	Mean
Humic acid	13.60cd	11.20f-h	12.80de	15.10b	**13.18B**	11.90c	9.70e	11.10d	12.60b	**11.32B**
Sea weed extrat	7.90i	6.30jk	7.80i	10.20h	**8.05D**	6.20i	4.30k	5.50j	7.90gh	**5.97D**
Compost tea	12.10ef	10.80gh	11.50fg	13.30c-e	**11.93C**	8.70f	7.40h	8.20fg	10.20e	**8.62C**
Effective microorganism(EM)	6.50j	2.60l	5.10k	7.40ij	**5.40E**	4.10k	2.20l	3.90k	5.60ij	**3.95E**
Control	15.70b	13.60cd	14.50bc	17.80a	**15.40A**	13.60a	11.80c	12.40bc	14.20a	**13.00A**
Mean	**11.16B**	**8.90D**	**10.34C**	**12.76A**		**8.90B**	**7.08D**	**8.22C**	**10.10A**	

Means of the same column followed by the same letter were not significantly different according to Duncan MRT at5%

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تأثير بعض منشطات النمو على إنتاج وجودة شتلات الفراولة

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أجريت تجربتان حقليتان بمزرعة خاصة مركز شبين القناطر بمحافظة القليوبية خلال موسمي 2013– 2014 لدراسة تأثير الإضافة الأرضية لكلا من حمض الهيوميك بمعدل 5 جرام/النبات ومستخلص الطحالب البحرية بمعدل 5 مل/النبات وشاى الكمبوست بمعدل 10مل/النبات والكائنات النافعة بمعدل 5مل/النبات وكذلك الرش بكلا من الأحماض الامينية 2مل/لتر ومستخلص الطحالب البحرية 2مل/لتر وحمض الجبرلليك بتركيز 50 جزء في المليون بالإضافة إلى معاملة الكنترول والتفاعل بينهما علي النمو الخضري والتركيب الكيماوي وإنتاجية وجودة شتلات الفراولة من صنف فيستيفال.

وقد أوضحت النتائج أن الإضافة الأرضية لمستخلص الطحالب البحرية بمعدل5مل/للنبات ثلاث مرات خلال موسم النمو وذلك بعد أسبوعين من الشتل وعلى فترات كل أسبوعين مقترنة برش النباتات بمستخلص الطحالب البحرية بمعدل 2مل/لتر ستة مرات بعد 30 يوم من الشتل وعلى فترات كل 15يوم إلى الحصول علي أفضل عدد من المدادات الرئيسية وعدد الأوراق/الشتلة و اكبر سمك للتاج واكبر عدد للجذور وزيادة طولها. بالإضافة إلى ذلك أدت نفس المعاملة إلى الحصول على أعلى عدد للشتلات لكلا من النبات والفدان خلال موسمي الدراسة كما أدت الإضافة الأرضية والرش بمستخلص الطحالب إلى الحصول على أعلى محتوى من الكربوهيدات والفوسفورو البوتاسيوم في أنسجة الشتلات بينما كان أعلى محتوى من النتروجين في حالة الإضافة الأرضية لمستخلص الطحالب البحرية ورش النباتات بالأحماض الامينية. وبالإضافة إلى ذلك تم الحصول على أطول الشتلات من الإضافة الأرضية لمستخلص الطحالب البحرية والرش بحمض الجبرلليك.بينما تم الحصول على اقل نسبة إصابة للشتلات من الإضافة الأرضية للكائنات النافعة الدقيقة (EM) والرش بمستخلص الطحالب البحرية خلال موسمي الدراسة.

وتوصى الدراسة باستخدام مستخلص الطحالب البحرية بمعدل5مل/للنبات كاضافة ارضية ثلاث مرات خلال موسم النمو وذلك بعد أسبوعين من الشتل وعلى فترات كل أسبوعين مقترنة برش النباتات بمستخلص الطحالب البحرية بمعدل 2مل/لتر او الاحماض الامينية ستة مرات بعد 30 يوم من الشتل وعلى فترات كل 15يوم لزيادة عدد وجودة الشتلات فى المشتل.