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INFLUENCE OF FOLIAR APPLICATION OF ALGAE SEAWEED AND LICORICE ROOTS EXTRACT ON GROWTH AND YIELD OF STRAWBERRY (*FRAGARIA ANANASSA*) PLANTS UNDER PROTECTED CONDITION

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***Abstract*— An experiment was conducted inside a plastic house (500m2) at the olericulture research field of the protected cultivation department in Technical Institute of Zakho, Dohuk Polytechnic University, Kurdistan Region-Iraq within Autumn season of (2018-2019) to find out the influence of seaweed extracts applied with three levels (0, 2 and 4) ml/L and the licorice extract with three levels (0, 2 and 4) ml/L on the growth and yield of strawberry crop grown under greenhouse conditions. The seaweed extracts and licorice extracts were sprayed three times about 10 days' intervals. The obtained results have showed that spraying the strawberry plants with the seaweed extract at (4) ml/L and the licorice extract at (4) ml/L caused a significant enhancement in the chlorophyll content of leaves as well as yield parameters (fruit number per plant, fruit weight (gm) and total yield (ton. ha-1) and percentage total soluble solids (TSS) in comparison with control and other treatments. Our results suggesting that both seaweed extracts and licorice extracts are recommending for production of healthier and higher crop with less costs and environmental hazards.**

***Index Terms*— *Fragaria Ananassa*, Algae Seawood, Licorice Roots, Strawberry Plants.**

I. INTRODUCTION

Strawberry (*Fragaria ananassa* is one of the members of Rosaceae family, subfamily Rosoideae. The first breeding of garden strawberry was implemented in Brittany, France, in the 1750s and it was mainly obtained from a cross between F. virginiana from Eastern North America and F. chiloensis from Chile and Argentina (Ullah et al., 2017). It is generally grown for fresh consumption and processing and Its fruits have a great popularity among berries and are proved to be effective against oxidation, cancer and inflammations. This effectiveness is favored to its fruits that contain high levels of polyphenolics, especially anthocyanins which are the most abundant and important polyphenols type found in the strawberry fruits as well as flavonoids, phenolic acids and vitamin C (Cordenunsi et al., 2005)

seaweed extract is considered as a modern generation of natural organic fertilizers and remarkably valuable from nutritious aspect due to its quick stimulation of seeds germination and increment of yield and tolerance capability of several crops against various abiotic stresses like salinity, extreme temperatures, nutrient insufficiency and water deficit. (Dhargalkar and Pereira, 2005). The chemical components of seaweed extract encompass complex polysaccharide, fatty acids, vitamins, phytohormones and mineral nutrients (Battacharyya et al., 2015).

Licorice (*Glycyrrhiza glabra*) extract is derived from plants and belongs to the family Leguminoseae. It is well-known for its content of more than 100 compounds such as triterpene saponins and phenolic compounds (Shibata 2000; Shabani et al. 2009). It is also a good biofertilizer that enriched with amino acids, vitamins and promoting photohormones (Rawlings et al. 1994) as well as several minerals like potassium, phosphorus, magnesium and iron, (Laroche et al. 2001). Therefore, this research had been executed to investigate the influence of seaweeds and licorice extracts on the growth, productivity and quality of the strawberry crop.

II. MATERIAL AND METHODS

The field experiment comprised of foliar spraying of seaweed extracts with three levels (0, 2, and 4) ml/L and licorice extract at three levels (0, 2, and 4) ml/L on the strawberry crop grown under greenhouse conditions. The date of sowing of strawberry seeds was on 15th October, 2018. The first spray of seaweed extracts and licorice extract was implemented on 15/12/2018. The second one was done on 25/12/2015 and the last spray was carried out on 4/1/2019. The experimental treatments were regulated according to the randomized complete block design (RCBD). The SAS program has been used for data analysis and the following parameters were measured :-

A. Vegetative growth parameters

Chlorophyll Percentage (%)

The chlorophyll percentage of leaves was measured in fully grown leaves of four plants from each experimental unit within the inner rows by using (Chlorophyll Meter, SPAD-502, Konica Minolta) and the average was calculated.

B. Yield Quantitative Parameter

Number of Fruits Per Plant

The number of fruits per plant was accounted from four plants in each experimental unit beginning from the first harvest until the last harvest at the end of the growing season and estimated according to the following equation :-

$$\text{Fruit. plant}^{-1} = \frac{\text{Total fruit number/experiment unit}}{\text{Plant number in each experimental unit}}$$

Fruit Weight (gm)

The average fruit weight was estimated via weighting the fruit of each experimental unit at each harvest thereafter dividing it by the fruit number in each experimental unit as illustrated below:

$$\text{Average fruit weight (gm)} = \frac{\text{Yield of experiment unit (kg)}}{\text{Number of fruit of experimental unit}} \times 1000$$

Plant Yield (gm. plant-1)

The yield per plant was determined from each experimental unit, from the beginning of harvesting and continued till the end of the growing season according to the following equation:

$$\text{Plant yield (gm. plant}^{-1}) = \frac{\text{Yield of experimental unit (kg)}}{\text{Number of plants in experimental unit}}$$

C. Yield Quantitative Parameter

Total Soluble Solids (TSS%)

The total soluble solids were measured in the juice using a Hand Refractometer for four fruits in each experiment unit (A.O.A.C , 1980)

III. Result and Discussion

A. Vegetative Growth Parameters

Chlorophyll Content

Results listed down in the table (1) have showed that the foliar spraying of seaweed extracts and licorice extract and their interference resulted in a magnitude enhancement in the chlorophyll percentage of strawberry crop. Strawberry plants that dosed with the seaweed extract at level (4 ml/L) and the licorice extract at level (4 ml/L) contained the highest percentage of chlorophyll (58.36) % comparing to the control and the remaining treatments. The same significant value was recorded for mean values of seaweed and licorice extract application and the best mean percentages of chlorophyll (56.51%) and (56.23%) have been measured for seaweed extracts and licorice extracts respectively (see table 1).

Table 1. Effect of seaweed extracts and licorice extract on chlorophyll content of strawberry

Seaweed Extract ml/L	Licorices ml/L			Seaweed Extract
	0	2	4	
0	52.51 c	54.86 bc	53.93 bc	53.77 b
2	54.69 bc	54.21 bc	56.39 ab	55.10 ab
4	56.64 ab	54.52 bc	58.36 a	56.51 a
Licorices	54.61 b	54.53 b	56.23 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at level (α=0.05).

B. Yield Quantitative Parameters

Number of Fruits Per Plant

The number of fruits per plant was prominently increased with foliar feeding of seaweed extracts and licorice extracts as obvious in the table (2). The maximum number of fruits per plant was enumerated for strawberry plants that delivered both seaweed extract and licorice extracts at the level (4ml/L) owning an average of (23.33) fruits and surpassing the control and the rest of treatments.

Concerning the mean value effect of both bio-fertilizers, significant variations were also noted among the mean values of number of fruits per plant and the premium mean number of fruits (19.56) was accounted for seaweed extract at the level (4 ml/L) and mean value of (19.89) was calculated for licorice extract at the dose (4 ml/L).

Table 2. Effect of seaweed extracts and licorice extract on number of fruits of strawberry.

Seaweed Extract ml/L	Licorices ml/L			Seaweed Extract
	0	2	4	
0	15.33 b	18.33 ab	17.33 ab	17.00 c
2	16.67 ab	19.67 ab	19.00 ab	18.44 b
4	17.00 ab	18.33 ab	23.33 a	19.56 a
Licorices	16.33 b	18.78 a	19.89 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at level (α=0.05).

Fruit Weight (gm)

The fruit weight of strawberry crop was significantly increased by foliar application of the seaweed extract and the licorice extract according to the results in the table (3). Treating plants with the seaweed extract at the level (4 ml/L) and the licorice extract at the level (4 ml/L) produced the heaviest fruits with the average (16.44 gm) in comparison with the control and other treatments.

On the other hand, significant variations were also found in mean value of fruit weight in attribution to the application of the seaweed and licorice extract. The mean value effect of the seaweed at the level (4 ml/L) was superior to the other levels resulting in (14.04 gm) and the same highest mean value effect of the licorice extract at the same level caused the premier mean value of fruit weight (14.68 gm).

Table 3. Effect of seaweed extracts and licorice extract on fruit weight of strawberry.

Seaweed Extract ml/L	Licorices ml/L			Seaweed Extract
	0	2	4	
0	9.81 d	11.87 cd	12.30 c	11.33 b
2	12.30 c	12.09 cd	13.39 bc	12.59 b
4	12.60 c	15.00 ab	16.44 a	14.68 a
Licorices	11.57 b	12.98 a	14.04 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at level (α=0.05).

Plant Yield (gm. plant^{-1})

The data showed in the table (4) reported a positive response of the strawberry crop to the application of the seaweed extract and the licorice extract to the foliage in term of plant yield as compared to the untreated plants. The greatest plant yield (gm. plant^{-1}) was estimated for plants given the seaweed extract at the dose (4 ml/L) and the licorice extract at the dose (4 ml/L) producing (394.97 gm. plant^{-1}) when encountered with the other treatments.

In case of mean value effect for the seaweed extract and the licorice extract application, the same significant results were earned regarding the plant yield (gm. plant^{-1}). The peak mean plant yield (284.90 gm. plant^{-1}) was measured for seaweed extract application and the similar highest mean plant yield (258.03 gm. plant^{-1}) as demonstrated in the table (4).

Table 4. Effect of seaweed extracts and licorice extract on plant yield (gm. plant^{-1}) of strawberry.

Seaweed Extract ml/L	Licorices ml/L			Seaweed Extract
	0	2	4	
0	159.52 c	206.11 bc	205.46 bc	190.36 b
2	224.53 b	237.69 b	254.26 b	238.83 a
4	200.52 bc	178.60 b	394.97 a	258.03 a
Licorices	194.86 c	207.47 b	284.90 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at level (α=0.05).

C. Yield Qualitative Parameters

Total Soluble Solids (TSS %)

The effect of the seaweed extract and the licorice extract made a profound increment in the total soluble solids (%) when comparing with control. The highest percentage of total soluble solids was determined in the fruits of plant received both biofertilizers at the dosage (4 ml/L) that contained (5.13 %) of total soluble solids whereas the lowest total soluble solids was found in the fruit of control plant (3.87 %).

The same positive influence was observed relating the mean value for the seaweed and licorice extract application at the level (4 ml/L) with the maximum mean total soluble solid (4.91 %) for seaweed extract application and mean total soluble solid (4.79 %) for licorice extract application as shown in the table (5).

Table 5. Effect of seaweed extracts and licorice extract on total soluble solids (TSS) of strawberry.

Seaweed Extract ml/L	Licorices ml/L			Seaweed Extract
	0	2	4	
0	3.87 d	4.63 c	4.80 a-c	4.43 b
2	4.60 c	4.73 bc	4.43 c	4.59 b
4	4.57 c	5.03 ab	5.13 a	4.91 a
Licorices	4.34 b	4.80 a	4.79 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at level (α=0.05).

It can be observed from the previous results that foliar feeding the strawberry plants with the seaweed extracts and licorice extract had a significant influence on the growth, yield and quality of the crop, especially at the dose (4ml/L) for each biofertilzer. The increase in chlorophyll content may refer to the physiological role of licorice extract in improving the efficiency of the photosynthesis process which positively reflected on chlorophyll percentage (Kessel, 2006, Sahy, 2005). This was found by Zuhair (2010) who detected the influence of different levels of licorice on the strawberry and showed that it caused a prominent amelioration in total chlorophyll content. The improved chlorophyll percentage may also ascribe to the action of seaweed extract in decreasing the chlorophyll degradation since they contain betaine and betaine-like compounds which enhance the chlorophyll content. Thirumaran et al. (2009) reported a significant increase in the total chlorophyll content by application of seaweed extracts.

The improved yield and quality (number of fruits per plant, fruit weight, plant yield and total soluble solids) of the plant maybe due to the beneficial impact of the seaweed extracts and licorice extract as these natural extracts contain a wide range of natural compounds that mimics the growth promoters for instance, licorice extract are rich in numerous minerals (N, P, K, Mg, Fe, Zn and Ca), amino acids (alanine, lysine, arginine), vitamins like B1, B2, and B6, and carbohydrates and mevalonic acid that used in gibberellins synthesis (AL-Marsoumi et al., 1999). At the same time, seaweed extracts are also proved to have a high content of nutrients and growth regulators including cytokinins, auxins, vitamins, cytokinins and gibberellins which stimulate flowering and flower number and thereby enhancing the yield and its quality (Al-Jubouri et al., 2009; Spinelli et al., 2009). Hamza and Abbas (2020) revealed that spraying broad bean (Vacia Faba L.) with seaweed extracts and licorice extracts remarkably increased growth and yield characters of the crop.

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