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RESPONSE OF SWEET BASIL PLANTS (*Ocimum basilicum*, L.) TO SPRAYING SEAWEED EXTRACT GROWN UNDER SALINITY STRES

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ABSTRACT

A greenhouse experiment was carried out during two successive seasons (2015/2016 and 2016/2017) on sweet basil plants (*Ocimum basilicum*, L.) grown, in sandy soil, under salinity stress to study the effect of spraying seaweed extract on growth, leaf chemical composition and essential oil percentage of basil plants**.** The experiment was conducted under controlled conditions in greenhouse, with temperature fixed at 25 ± 3C°, relative humidity between 75 – 85% and 14 hours light exposure. The Spraying seaweed extract exhibited higher tolerance to high salinity as compared to unsprayed plants. Under high level of salinity (2000 and 4000 ppm NaCl), the plants received seaweed extract at High concentrations (100 and 200 ppm) present higher values of plant height, shoot length, branch numbers/plant and chlorophyll contents and carotenoids as compared to unsprayed plants or those sprayed with lowest seaweed concentration (50 ppm). The chemical analysis of mature leaves of plant sprayed with higher seaweed extract (100 and 200 ppm) showed significantly higher ratio of N, P and K than those sprayed with lower concentrations or those untreated plants. However, N, P and K contents decreased significantly as a result of increasing NaCl concentration in nutrient solution from 500 to 4000 ppm. However, gradual and significant increase in leave calcium % due to increasing NaCl level in the nutrient solution from 500ppm to 3000ppm.

Key words: *Ocimum basilicum L., Salinity, NaCl, Seaweed extract, Vegetative growth, Mineral nutrients, Chemical composition.*

INTRODUCTION

The genus *Ocimum* belongs to family *Lamiaceae*, which includes various shrubs and herbs. It is widespread in the tropical and subtropical regions. However, the sweet basil (*Ocimum basilicum* L.) is the most important species of this genus. Sweet basil plant well known as one of the most aromatic and recognizable herbs, it is growing and thrives in lot types of soils, however, it well grown in pots (**Abd El-Salam, 2014; Bekhradi *et al*., 2015** and **Caliskan *et al*., 2017)**

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There is a great interest in the commercial production of sweet basil in Egypt, particularly in Beni suif governorate, due to its multiple uses. Actually, sweet basil considered as one of the most important oulinary herbs grown worldwide for flavouring and confectionery of foodstuffs and condiments (***Said*-Al Ahl *et al*., 2010** and **Bekhradi *et al*., 2015**).Salinity is a problem of grave concern, because it adversely affects growth and development of plants, especially in arid and semi-arid regions (**Pitman & Läuchli,**

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2002; Parihar *et al.*, 2015 and **Attia, *et al*., 2011** and **Ibrahim, 2016**). Those plants holding a healthy soil have a higher probability to cope up the abiotic stress conditions (**Parihar *et al.*, 2015**). Salt stress has been found to disrupt several physiological processes leading to reduction in growth and yield (**Mizrahi** & **Pasternak, 1985** and **Parihar *et al.*, 2015**). Salinity tolerance is a complex feature depends on both genetic and physiological properties (**Mizrahi** & **Pasternak 1985**, **Munns 2002** and **Attia, *et al*., 2011**). The effects of salinity appear to be dependent on the species and cultivars and on the stage of the plant development (**Grattan and Grieve, 1999**). However, **Zahedi *et al*. (2011)** stated that basil plants growth did not affect by salinity in the range of 750 ppm. Seaweeds extracts are potentially excellent sources of highly bioactive secondary metabolites that could represent useful leads in the development of new functional ingredients. Many reports have been published regarding isolated compounds from seaweeds with various biological activities, demonstrating their ability to produce important metabolites unlike those found in terrestrial species **(Featonby-Smith and Van Staden (1984), Hu *et al*., 2004; Wang *et al*., 2005** and **El-Bakry *et al*., 2006)**.Furthermore, the effect of seaweed extract on rapid growth and flowering of medicinal and aromatic plants have been extensively studied and confirmed through field trials. Moreover, seaweed extracts are often classified as plant biostimulants (**Featonby-Smith & Van Staden (1984)** and **Khan *et al.*, 2009**) and are generally thought to contain trace amounts of macro- and micronutrient elements, amino acids, vitamins, cytokinins, auxins, abscisic acid-like compounds (**Crouch *et al.*, 1990; Crouch and Staden, 1993; Reitz & Trumble, 1996** and **Stirk *et al*., 2004**). The current investigation aimed to study the effect of spraying sweet basil with seaweed extract on vegetative growth, essential oil % and leaf chemical composition under salinity stress.

MATERIALS AND METHODS

This study was carried out during two successive seasons (2015/2016 and 2016/2017) on sweet basil plants (*Ocimum basilicum*, L.), under controlled condition in greenhouse located at the medical plants nursery (Agriculture Research Center - Seds Research Station Bini Suef governorate). The temperature adjusted to 25 ± 3C°, relative humidity ranged between 75:85% and 14 hours exposure to light, and then the samples were taken and analyzed at seds research station laboratory. The effect of seaweed extract on vegetative growth, fresh and dray weight (g/plant) essential oil yield and leaf chemical composition of sweet basil plants (*Ocimum basilicum*, L.) grown in pots, filled with sand and irrigated with standard nutrient solution with different levels of NaCl, were investigated.

Plant materials: Seeds of sweet basil plants were obtained from the Research Center of Medicinal and Aromatic Plant Section, Sseds Station Beni suef (Egypt) and sowed (at November 15th) in wooden boxes (50 cm width and 15 cm depth, filled with sand washed several times with tap water then washed with diluted HCl) placed in greenhouse during three weeks. The boxes irrigated with standard solution of pH 6.5 and 500 ppm NaCl (**Morard, 1995**). The seedlings at the stage of 4-5 leaves and 11-12 cm in height (One from sweet, at January15th), were transplanted into 30 cm diameter pots (2 plants/pot) filled with sand washed by several times by water then by diluted HCl.

Nutrient solutions: Standard nutrient solution reported by **Morard (1995),** supplemented with the nutrients requirements of medical plants was prepared. The nutrient solution contained Macro-nutrients (meq/l) 8.5 NO_3, 1.0 H_2PO_5, 1.3 SO_4, 1.0 NH_4, 2.1 K, 6.7 Ca, 2.0 Mg and Micro-nutrients (meq/l); 5.9 Fe, 2.0 Mn, 0.05 Mo, 1.5 B, 0.5 Zn, 0.25 Cu. pH was adjusted to 6.5 using HCl or KOH solutions and salinity was adjusted to 500, 1000, 2000, and 4000 ppm using analar grade NaCl.

Experimental work: Under greenhouse conditions, a complete randomized block experiment in split plot design was arranged in four replicate. The main plot

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included four salinity levels, while the sub-plot was consisted four seaweed extract concentrations. The plants were transplanting in 30 cm in diameter plastic pots, each pot filled with 7 Kg of washed sand. Each pot was supplied by two plants. Chemical analysis of seaweed extract used in this experiment was presented in Table 1.

Data recorded

Vegetative growth characters:

At the end of the experiment Augusts 15th during both seasons, twenty mature leaves from the medal part of main shoots were picked from each replicate. Leaf area (cm^2) was estimated. Leaf area was measured by using an area meter (Area Meter Cl, 202). Plant height (cm) and average main shoot length (cm) was recorded as a result of measuring the length of six shoots /plant. The average main shoot numbers/plant was recorded at the end of experiment. The plants were cut above ground surface and the fresh weight of herb (g/plant) was recorded, then the plant dried in oven at 70 C° overnight and the dray weight (g/plant) of each plant was recorded.

Leaf Chemical composition:

Samples of 20 mature and fresh leaves from each replicate located at the middle part on each shoot were taken after one month from the last spraying of seaweed extract "at the middle of June" during the two experimental seasons and cut into small pieces then 0. 5 g weight from each sample was taken, homogenized and extracted by 25% acetone in the presence of little amounts of Na_2CO_3 then filtered. The residue was washed several times with acetone until the filtrate became colorless. The extract was completed to a known volume (20 ml) with acetone 85%. A portion of this extract was taken for the determination of chlorophylls a & b and total chlorophyll calorimetrically (as mg/ 100 g F.W) and acetone (85 % V/V) was used as a blank. The optical density of the filtrate was determined at the wave length of 662 and 664 nm to determine chlorophylls A and B, respectively. Concentration of each pigment was calculated by using the following equations according to **Wettstein (1957)**.

Determination of N, P, K and Ca percentages: 30 mature leaves picked "for each replicate", from the medal part of main shoots as described by **Martin-Préval *et al.*, (1984)** were taken at the end of experiment "15 Augusts" for each season. Leaves (blades + petioles) were saved for determining different nutrients. The leaves washed with distillated water and dried at air and oven at 70 C overnight, grounded, then 0.5 g weight was digested using H_2SO_4 and H_2O_2 until clear solution was obtained **(Martin-Préval *et al.*, 1984)**. The digested solution was quantitatively transferred to 100 ml volumetric flask and completed to 100 ml by distilled water. Thereafter, contents of N, K and for each sample were determined as described by **(Martin-Préval *et al.*, 1984)**. While, Phosphorus was determined by using colorimetric method, described by **AOAC (1984)**.

Determination of essential oil %: Determination of the essential oil percentage in random samples obtained from the air-dried herb of each pot was carried out in two experimental seasons according to the method described by **British Pharmacopoeia (1963)** by distilling 60 g of herb for 3 hours, in order to extract the essential oil. The essential oil percentage was calculated as follows:

Experimental design and statistical analysis: The obtained data were tabulated and statistically analyzed according to **MSTAT-C (1992)** and the L.S.D. test at 5 % was followed to compare between the means.

RESULTS AND DISCCUSION

1- Growth characters:

1-1: plant height, shoot lengths and number of branches/plant):

The plant height, shoot lengths and number of branches of sweet basil plants (*Ocimum basilicum*, L.) grown under different salinity levels and sprayed three times with gradual concentration of seaweed extract were studied. As shown in Table (2) and gradual decreases in plant height and shoot length were observed with increasing the salinity level from 500 to 4000 ppm. This reduction is

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pronounced in the plants grown in the highest salinity level (3000 ppm).

This work was carried out to examine the effect of solution salinity concentrations [500 (control), 1000, 2000 and 4000 ppm NaCl], seaweed extracts concentrations (0, 50, 100 and 200 ppm) as foliar applications and their interaction between them treatments to consist sixteen treatments

Each treatment was replicated four times; the total number of pots used was 64, each pot contained two sweet basil plants.

As shown in Table (3) the branch numbers/plant also negatively affected by increasing NaCl concentration in nutrient solution. However, sprayed seaweed extract decreased significantly this harmful effect in the two experimental seasons. Non-significant effect was observed between the two highest seaweed extract concentrations (100 and 200 ppm).

Increasing the concentration of seaweed extract significantly influenced the plant height, shoot lengths and branch numbers/plant. It is clear from the obtained data that treating basil plants with seaweed extract at 50 ppm to 200 ppm significantly was followed by stimulating the plant height, shoot length and branch numbers/plant. However, increasing seaweed concentration from 100 ppm to 200 ppm had no significant effects on the three growth parameters (plant height, shoot length and brunch numbers/plant) in the two experimental seasons. The maximum values of plant height (72.3 and 79 cm), main shoot lengths (39.8 and 42.4 cm) and branch numbers (19 and 21), in the two experimental season respectively, were recorded on the plants that received three sprays of seaweed extract at 200 ppm during 2015/2016 and 2016/2017 seasons. Except those of the shoot length in the second season, however, the seaweed extract at 100 ppm recorded the higher shoot length.

These results were in harmony with the finding **El-Sanafawy (2007)** and **Salama and Yousef (2015)** on *Ocimum spp*., **Brien and Barker (1996)**, **Khalil** & **El-Sherbeny (2003)** on *Mentha spp*., **Khalil (2002)** on rosemary plants and **Khalil *et al.* (2008)** on fennel. The role of seaweed as a source of gibberellins and cytokinins and its effect on stimulating leaf area was reported by numerous authors, such as **Luning (1990), Fan *et al.* (1993), Lobban and Harrison (1997)** and **Zamani *et al.* (2013**). Furthermore, It's well known that, seaweed extracts exhibit growth activity and it is well documented that Seaweed extracts are bioactive at low concentrations. The use of seaweed as biostimulants in plant growth is well established. Biostimulants are defined as materials, other than fertilizers, that promote plant growth when applied in small quantities and are also referred to as metabolic enhancers (**Zhang *et al*., 2003**). Seaweed components such as macro- and microelement nutrients, amino acids, vitamins, cytokinins, auxins, and abscisic acid (ABA) like growth substances affect cellular metabolism in treated plants leading to enhanced plant growth. So, we can attribute the superiority of seaweed spraying treatments in increasing the growth (plant

height, main shoot length and number of branches/plant) of sweet basil plant to seaweed extract contains of plant growth regulators and many essential major and minor nutrients, which will positively affect the precedent growth characters.

1-2: Leaf area

Leaf area (cm^2) of basil plants grown under deferent levels of salinity was significantly affected by increasing NaCl level in nutrient solution (Table 3). Furthermore, spraying seaweed at increasing concentration had a significant enhancing leaf area. However, increasing seaweed concentration from 100 ppm to 200 ppm had no significant effects on the leaf area (cm^2) in the two experimental seasons.

Regarding the NaCl concentration in nutrient solution, leaf area differed significantly among increasing salinity level in nutrient solution (Table 3). Remarkable decrement in leaf area as a result of increasing the salinity in nutrient solution was observed in all concentration used. However, the plants irrigated with nutrient solution at 4000 ppm NaCl present the lowest values of leaf area, in the two experimental seasons. In accordance with these results

1-3: Plant fresh and dry weights (g/plant):

Both plant fresh and dry weights of basil plant were significantly decreased in both experimental seasons, due to the increase in nutrient solution salinity level (Table 4). Such reduction in both traits

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was gradual parallel to the gradual increase in nutrient salinity with the lowest values being given due to high salinity level (4000 ppm). The numerical reduction in plant fresh weight due to 1000, 2000 and 4000 ppm NaCl reached 10.44 , 20.51 and 22.12 in the first season, and 5.40, 16.64 and 19.31% in the second one in comparison with that of control (500 ppm) unsalinized plants. Almost similar trend was observed for plant dry weight as clearly shown in Table (4). The reducing effect of salinity on plant fresh and dry weight was also reported by **Mohamed (2005)** on 4 ornamental plants, **Ibrahim (2013)** on *Khaya senegalensis* and those of **Heidari (2012), Abd El-Salam (2014)** and **Caliskan *et al.*, (2017)** on basil plant regarding salinity and seaweed extract were the findings of **Attia *et al.* (2011) Munns, R., (2002)**, **Abd El-Salam (2014), Bekhradi (2015)** and **Caliskan *et al.*, (2017)** on sweet basil herbs.

The promoting effect of seaweed extract on sweet basil plant leaf area, under salinity stress, may be due to positive effect of seaweed extract on endogenous level of growths promoter Auxins. These auxins have been found to encourage the growth of more cells in which they differ from more familiar types of auxin which simply enlarge the cells. The auxins also stimulate growth in both shoot and root stems of plants, which cause cells to elongate. It has been proved that Indol acetic acid and the other newly discovered seaweed auxins are extracted in increased quantities by the process of alkaline hydrolysis. We believe that the growth enhancing can be explained by the effect of seaweed auxin content. (**Featonby-Smith (1984)**, **Fan *et al.*, (1993)** and **Zamani *et al.*, (2013).**

1-3: Plant fresh and dry weights (g/plant):

Both plant fresh and dry weights of basil plant were significantly decreased in both experimental seasons, due to the increase in nutrient solution salinity level (Table 4). Such reduction in both traits was gradual parallel to the gradual increase in nutrient salinity with the lowest values being given due to high salinity level (4000 ppm). The numerical reduction in plant fresh weight due to 1000, 2000 and 4000 ppm NaCl reached 10.44 , 20.51 and 22.12 in the first season, and 5.40, 16.64 and 19.31% in the second one in comparison with that of control (500 ppm) unsalinized plants. Almost similar trend was observed for plant dry weight as clearly shown in Table (4). The reducing effect of salinity on plant fresh and dry weight was also reported by **Mohamed (2005)** on 4 ornamental plants, **Ibrahim (2013)** on *Khaya senegalensis* and those of **Heidari (2012), Abd El-Salam (2014)** and **Caliskan *et al.*, (2017)** on basil plant. In regard to seaweed extraction, significant differences were obtained, fresh and dry weight of basil plant, due to spraying the plants with 50 to 200 ppm over those untreated plants in both first and second seasons as clearly shown in Table (4). The numerical increment in plant fresh weight due to 50, 100 and 200 ppm seaweed reached 10.68, 24.79 and 26.51 in the first season, and 9.87, 20.95 and 39.06% in the second one in comparison with that of control unsalinized plants (500 ppm).

This significant and positive influence of application of the seaweed on the herb fresh and dry weight (g/plant) of sweet basil during the two experimental seasons facing untreated plants, can explained by the effect of seaweed as a source of gibberellins and cytokinins and its effect on stimulating plant vegetative growth. Also, this promoting effect of seaweed extract on herbs growth and fresh weight may be due to the positive effect of seaweed extract on endogenous level of growths promoter, Auxins **(Chouliraras *et al.*, 2009; Abd El-Motty *et al.*, 2010 ; Zahedi *et al.*, 2011** and **Abd El-Salam, 2014**.

2- Leaf chemical composition

2-1: Chlorophyll a, Chlorophyll b and carotenoids (mg/g F.W.):

Obtained data in Tables (5 and 6) showed that chlorophyll a, chlorophyll b and carotenoids (mg/g fresh weight) of sweet basil mature leaves were significantly decreased in both experimental seasons, due to the increase salinity level in nutrient solution. Such reduction in three traits was gradual parallel to the gradual increase in nutrient salinity with the lowest values being given due to high salinity level (4000 ppm).

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Regarding spraying seaweed extract, significant differences were obtained, chlorophyll a, chlorophyll b and total carotenoids of basil leaves, due to spraying the plants with 50 to 200 ppm over those untreated plants in both first and second seasons as clearly shown in Tables (5 and 6).

The interaction between salinity and seaweed extract treatments was significant in the two seasons as indicated in Tables (5 and 6). The data clearly show that sweet basil plants can tolerate salinity up to 1000 ppm but receiving seaweed at 100 and 200 ppm. Such combined treatment gave, statistically in the two seasons, equal chlorophyll a and b to that, grown in low salinity nutrient solution, treatment. The role of seaweed extract in alleviating the harmful influence of salinity on leaf pigment contents, as shown in the present study, was emphasized by **Lauchli** and **Epstein (1990); Whapham, *et al.* (1993); Munns, R., (2002); Ibrahim (2013)** and **Abo Aly (2019)**.

2-2: Essential oil percentage:

Data in Table (6) show clearly that the salinity level of nutrient solution, at the four examined level, was very effective in essential oil % in the leaves of sweet basil, such decrement was occurred parallel to the gradual increase in nutrient solution salinity, with significant differences being existed between each two successive salinity treatments. However, essential oil % was significantly improved due to increasing seaweed extract from 50 to 200 ppm in comparison with unsprayed plants (control) in the two experimental seasons.

Essential oil % was increased by 5.43, 10.99 and 11.75 % in the first season, as a result of spraying seaweed extract at 50, 100 and 200 respectively. The corresponding increment in the second season was 5.51, 11.87 and 13.70% respectively over the control treatment. On the other hand, increasing NaCl concentration from 500 ppm to 4000 ppm, in the nutrient solution, significantly decreased the percentage of essential oil %.

The interaction between salinity levels and spraying seaweed extract was significant for essential oil % in both experimental seasons. The best interaction treatments were obtained from sprayed sweet basil plants irrigated by nutrient solution contains 500 ppm NaCl and sprayed by seaweed extract at 200 ppm in both seasons. The promoting influence of seaweed extract on essential oil % recorded in the present study were detected also by **Khorasaninejed (2010)** on *Mentha piperita* L.; **Ziarati *et al.* (2014)** and **Foroutan *et al.* (2014)** on Rosemary plants.

2-3: Leaf Potassium, phosphorus, Nitrogen and magnesium contents:

Obtained data in Table (7 and 8) show that the four nutrients, nitrogen, phosphorus, potassium and magnesium % in the mature leaves of sweet basil plant were sharply and significantly decreased due to irrigating the plant with salinized nutrient solution (1000, 2000 and 4000 ppm NaCl) in the two seasons, in comparison with those irrigated with 500 ppm. This reduction is more pronounced for the N and K than those for the P and Mg contents.

All the seaweed concentrations caused significant increase in leaves contents of N,P, K and Ca in the two experimental seasons over the control treatment as shown in Tables (7 and 8).

The same Tables also show that the interaction between nutrient solution salinity and seaweed extract concentrations was significant in both first and second seasons. The lest N,P,K and Mg was obtained due to high salinity level in nutrient solution (4000 ppm) in combination with zero seaweed extract, while, the highest N,P,K and Mg contents was produced due to seaweed extract at 200 ppm in combination with 500 NaCl. However, spraying salinity stressed (2000 and 4000 ppm NaCl) sweet basil plant with seaweed extract enhanced leaf mineral content than those salinity stressed and unsprayed by seaweed.

On the other hand, leaf calcium % was gradually and consistently increased as the nutrient solution salinity level was gone upward with the highest calcium % being obtained due to the high NaCl level (4000 ppm) in the two experimental seasons as

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illustrated in Table (8). In agreement with our results were those of **Zahedi *et al.*, (2011**) on basil plant; **Abdou *et al.*, (2010)** on Jojoba; **Abd El-Fafattah (2001)** on Adhatoda, Hibiscus and Phyllanthus and **Nasr (2009)** on acokanthera. However, spraying seaweed at 50, 100 and 200 ppm significantly decreased leaves calcium % comparison with unsprayed plants (control treatment).

The interaction between nutrient solution salinity and seaweed extract concentrations was significant in both seasons as shown in Tables (7 and 8). The capability of seaweed extract at the three examined concentration in counteracting the effect of nutrient solution salinity in increasing calcium % in the leaves is very obvious, especially the high concentration (200 ppm).

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Table 1. Chemical analysis of seaweed extract used in this experiment

Compound	Concentration	Compound	Concentration
Organic Matter	45 ~ 55%	**Fe**	0.15 ~ 0.30 %
Total Nitrogen	0.5 ~ 1.5%	**Cu/**	25 ppm ~ 45 ppm
Phosphorus (P2O5)	6 %	**S**	1.5 ~ 2.5 %
Potassium	18 ~ 22%	**Na**	2.2 ~ 3.2 %
Mg	0.42 ~ 0.6%	**Alginc acid**	10 – 12%
Ca	0.40 ~ 1.60 %	**Soluble in water**	100%
Appearance		Flake or Particle	

Table 2. Effect of spraying seaweed extract (SW) on plant height and shoot lengths of sweet basil plants *Ocimum basilicum* L. grown in pots under NaCl stress, during 2015/2016 and 2016/2017 seasons.

Treatments	NaCl level in nutrient solution (A)					NaCl levels in nutrient solution (A)				
	500	**1000**	**2000**	**4000**	**Mean (B)**	**500**	**1000**	**2000**	**4000**	**Mean (B)**
	Plant height (cm)					**Shoot lengths (cm)**				
	First season (2015/2016)					**First season (2015/2016)**				
Control (0 SW)	52.4	50.2	42.9	40.7	**46.55**	27.2	24.3	18.5	12.2	**20.55**
50 ppm SW	61.9	53.9	39.1	39.7	**47.65**	31.6	24.7	20.6	13.3	**22.55**
100 ppm SW	69.3	68.2	58.9	54.5	**61.98**	38.4	31.5	29.7	24.6	**31.10**
200 ppm SW	72.3	73.4	69.1	50.0	**66.2**	39.8	30.5	26.3	23.9	**30.13**
Mean (A) NaCl	**63.98**	**61.43**	**52.50**	**46.11**		**34.25**	**27.75**	**23.78**	**18.50**	
LSD (0.05)	**A= 4.43 ; B= 3.55 ; AB= 5.182**					**A= 5.57 ; B= 4.66 ; AB = 6.76**				
	Second seasons (2016/2017)					**Second seasons (2016/2017)**				
Control (0 SW)	61.2	51.5	50.2	43.8	**51.63**	30.1	29.2	25.4	23.4	**27.03**
50 ppm SW	63.9	61.3	42.8	42.9	**52.53**	33.5	31,9	27.4	25.9	**29.68**
100 ppm SW	69.2	60.2	57.1	45.1	**58.10**	42.4	37.3	33.6	25.9	**34.80**
200 ppm SW	79.1	71.5	72.2	50.9	**68.43**	37.4	33.6	27.5	28.2	**31.67**
Mean (A) NaCl levels	**68.35**	**61.13**	**55.58**	**45.67**		**35.85**	**33.00**	**28.48**	**25.91**	
LSD (0.05)	**A= 4.77 ; B= 4,21 ; AB= 6.15**					**A=3.65 ; B= 3.77 ; AB= 4.37**				

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Table 3. Effect of spraying seaweed extract (SW) on number of branches/plant and leaf area (cm^2) of sweet basil plants *Ocimum basilicum* L. grown in pots under NaCl stress during 2015/2016 and 2016/2017 seasons

Treatments	NaCl level in nutrient solution (A)					NaCl level in nutrient solution (A)				
	500	1000	2000	4000	Mean (B)	500	1000	2000	4000	Mean (B)
	Number of branches/plant					Leaf area (cm2)				
	First season (2015/2016)					First season (2015/2016)				
Control (0 SW)	12	9	8	6	**8.8**	16.9	15.1	14.3	11.7	**14.50**
50 ppm SW	14	12	10	8	**11.0**	18.2	16.5	15.6	13.1	**15.85**
100 ppm SW	18	15	13	12	**14.5**	19.3	17.9	16.6	16.3	**17.48**
200 ppm SW	19	16	11	10	**14.0**	19.9	18.1	17.9	16.2	**17.29**
Mean (A) NaCl	**15.8**	**13.0**	**10.5**	**9.0**		**18.58**	**16.90**	**15.95**	**14.33**	
LSD (0.05)		**A= 1.36 ; B= 2.09 ; AB= 3.06**					**A= 1.01 ; B=0.82 ; AB= 1.18**			
	Second seasons (2016/2017)					Second seasons (2016/2017)				
Control (0 SW)	15	13	9	7	**11.5**	15.5	14.1	13.2	11.8	**13.68**
50 ppm SW	16	15	11	10	**13.0**	16.9	15.1	14.3	12.9	**14.80**
100 ppm SW	20	17	15	14	**16.5**	18.7	16.8	16.3	15.6	**16.85**
200 ppm SW	21	17	13	12	**15.8**	19.8	17.6	15.9	15.1	**17.13**
Mean (A) NaCl	**18.0**	**15.5**	**12.0**	**10.8**		**17.73**	**15.92**	**14.93**	**13.85**	
LSD (0.05)		**A= 1.42 ; B= 1.58 ; AB= 2.29**					**A= 1.01 ; B=0.92 ; AB= 1.33**			

Table 4. Effect of spraying seaweed extract (SW) on fresh and dry weight (g) of sweet basil plants *Ocimum basilicum* L. grown in pots under NaCl stress, during 2015/2016 and 2016/2017 seasons.

Treatments	NaCl level in nutrient solution (A)					NaCl level in nutrient solution (A)				
	500	1000	2000	4000	Mean (B)	500	1000	2000	4000	Mean (B)
	Fresh Weight (g)					Dry weight (g)				
	First season (2015/2016)					First season (2015/2016)				
Control (0 SW)	439.5	401.6	373.4	358.6	**393.28**	48.4	44.2	41.1	39.7	**43.35**
50 ppm SW	487.3	459.8	402.9	392.5	**435.63**	50.6	51.1	44.3	43.1	**47.38**
100 ppm SW	549.4	507.7	466.6	439.3	**490.8**	65.8	60.4	56.1	53.9	**59.05**
200 ppm SW	618.9	507.3	422.6	441.3	**497.53**	70.2	60.9	48.7	50.5	**57.58**
Mean (A) NaCl	**523.78**	**469.10**	**416.38**	**407.93**		**56.5**	**54.15**	**47.55**	**46.80**	
LSD (0.05)		**A = 19.62 ; B = 21.25 ; AB= 30.11**					**A= 2.88 ; B = 3.41 ; AB = 4.84**			
	Second seasons (2016/2017)					Second seasons (2016/2017)				
Control (0 SW)	448.7	401.3	389.7	341.8	**395.38**	44.9	41.2	39.1	35.5	**40.18**
50 ppm SW	489.5	439.7	408.8	399.6	**434.40**	49.2	45.1	42.1	40.9	**44.35**
100 ppm SW	539.6	488.9	399.9	429.4	**464.45**	55.6	51.8	42.9	43.7	**48.5**
200 ppm SW	589.6	576.1	524.9	497.5	**547.03**	69.5	63.1	54.9	51.4	**59.73**
Mean (A) NaCl	**516.85**	**488.95**	**430.83**	**417.08**		**54.80**	**50.32**	**44.75**	**42.88**	
LSD (0.05)		**A = 29.07 ; B = 35.71 ; AB= 50.75**					**A= 2.01 ; B = 3.21 ; AB = 4.62**			

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Table 5. Effect of spraying seaweed extract (SW) on Chlorophyll a and Chlorophyll b contents (mg/g F.W.) of sweet basil plants *Ocimum basilicum* L. grown in pots under NaCl stress during 2015/2016 and 2016/2017 seasons

Treatments	NaCl level in nutrient solution (A)					NaCl level in nutrient solution (A)				
	500	1000	2000	4000	Mean (B)	500	1000	2000	4000	Mean (B)
	Chlorophyll a (mg/g F.W)					Chlorophyll b (mg/g F.W)				
	First season (2015/2016)					First season (2015/2016)				
Control (0 SW)	2.461	2.421	2.302	2.178	2.341	0.612	0.533	0.401	0.432	0.495
50 ppm SW	2.761	2.577	2.405	2.382	2.531	0.669	0.608	0.532	0.431	0.560
100 ppm SW	2.894	2.788	2.602	2.584	2.717	0.812	0.789	0.687	0.569	0.714
200 ppm SW	2.903	2.802	2.612	2.401	2.680	0.821	0.803	0.765	0.601	0.748
Mean (A), NaCl	2.755	2.647	2.480	2.386		0.729	0.683	0.596	0.509	
LSD (0.05)	A = 0.087 ; B = 0.094 ; AB = 0.136					A = 0.092 ; B = 0.088 ; AB = 0.128				
	Second seasons (2016/2017)					Second seasons (2016/2017)				
Control (0 SW)	2.441	2.387	2.261	2.102	2.298	0.599	0.602	0.399	0.312	0.478
50 ppm SW	2.566	2.511	2.359	2.219	2.414	0.698	0.598	0.461	0.399	0.539
100 ppm SW	2.897	2.787	2.457	2.501	2.661	0.819	0.808	0.561	0.511	0.675
200 ppm SW	2.912	2.901	2.511	2.489	2.703	0.861	0.721	0.513	0.521	0.654
Mean (A) NaCl	2.704	2.647	2.397	2.328		0.744	0.682	0.484	0.436	
LSD (0.05)	A = 0.104 ; B = 0.132 ; AB = 0.187					A = 0.059 ; B = 0.065 ; AB = 0.095				

Table 6. Effect of spraying seaweed extract on total carotenoids contents (mg/g F.W.) and essential oil % of sweet basil plants *Ocimum basilicum* L. grown in pots under NaCl stress during 2015/2016 and 2016/2017 seasons

Treatments	NaCl level in nutrient solution (A)					NaCl level in nutrient solution (A)				
	500	1000	2000	4000	Mean (B)	500	1000	2000	4000	Mean (B)
	Carotenoids (mg/g F.W)					Essential oil %				
	First season (2015/2016)					First season (2015/2016)				
Control (0 SW)	0.802	0.769	0.727	0.688	**0.747**	0.735	0.731	0.601	0.589	**0.664**
50 ppm SW	0.822	0.801	0.719	0.723	**0.766**	0.765	0.751	0.694	0.592	**0.700**
100 ppm SW	0.843	0.805	0.771	0.789	**0.802**	0.789	0.781	0.723	0.655	**0.737**
200 ppm SW	0.898	0.862	0.822	0.802	**0.846**	0.795	0.777	0.743	0.651	**0.742**
Mean (A) NaCl	**0.841**	**0.809**	**0.760**	**0.751**		**0.776**	**0.760**	**0.689**	**0.622**	
LSD (0.05)	A = 0.076 ; B = 0.083 ; AB = 0.120					A =0.012 ; B = 0.022 ; AB = 0.032				
	Second seasons (2016/2017)					Second seasons (2016/2017)				
Control (0 SW)	0.882	0.784	0.657	0.543	**0.717**	0.699	0.659	0.641	0.629	**0.657**
50 ppm SW	0.843	0.741	0.702	0.672	**0.740**	0.743	0.689	0.677	0.661	**0.693**
100 ppm SW	0.862	0.721	0.673	0.642	**0.725**	0.769	0.732	0.719	0.721	**0.735**
200 ppm SW	0.899	0.822	0.691	0.644	**0.764**	0.785	0.741	0.708	0.712	**0.737**
Mean (A) NaCl	**0.872**	**0.767**	**0.681**	**0.625**		**0.749**	**0.705**	**0.679**	**0.681**	
LSD (0.05)	A = 0.055 ; B = 0.032 ; AB = 0.046					A = 0.035 ; B = 0.022 ; AB = 0.032				

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Table 7: Effect of spraying seaweed extract on Nitrogen and phosphorus % of sweet basil plants *Ocimum basilicum* L. grown in pots under NaCl stress during 2015/2016 and 2016/2017 seasons

Treatments	NaCl level in nutrient solution (A)					NaCl level in nutrient solution (A)				
	500	1000	2000	4000	Mean (B)	500	1000	2000	4000	Mean (B)
	Nitrogen (%)					Phosphorus (%)				
	First season (2015/2016)					First season (2015/2016)				
Control (0 SW)	1.52	1.41	1.32	1.22	**1.37**	0.22	0.21	0.20	0.15	**0.20**
50 ppm SW	1.78	1.66	1.51	1.39	**1.59**	0.23	0.24	0.21	0.16	**0.21**
100 ppm SW	2.20	1.91	1.88	1.55	**1.89**	0.32	0.32	0.27	0.18	**0.27**
200 ppm SW	2.31	2.11	1.91	1.61	**1.98**	0.33	0.30	0.29	0.18	**0.28**
Mean (A), NaCl	**1.95**	**1.77**	**1.65**	**1.44**		**0.27**	**0.26**	**0.24**	**0.17**	
LSD (0.05)	**A = 0.099 ; B = 0.101 ; AB = 0.146**					**A = 0.071 ; B = 0.052 ; AB = 0.075**				
	Second seasons (2016/2017)					Second seasons (2016/2017)				
Control (0 SW)	1.44	1.30	1.28	1.19	**1.30**	0.26	0.23	0.20	0.19	**0.220**
50 ppm SW	1.59	1.41	1.35	1.31	**1.42**	0.39	0.24	0.19	0.19	**0.241**
100 ppm SW	2.31	2.20	1.89	1.77	**2.06**	0.47	0.31	0.21	0.19	**0.295**
200 ppm SW	2.41	2.2 3	1.84	1.71	**2.05**	0.49	0.41	0.31	0.22	**0.357**
Mean (A) NaCl	**1.94**	**1.79**	**1.59**	**1.50**		**0.403**	**0.298**	**0.229**	**0.179**	
LSD (0.05)	**A = 0.124 ; B = 0.151 ; AB = 0.219**					**A = 0.071 ; B = 0.032 ; AB = 0.046**				

Table 8. Effect of spraying seaweed extract on potassium and calcium % of sweet basil plants *Ocimum basilicum* L. grown in pots under NaCl stress during 2015/2016 and 2016/2017 seasons

Treatments	NaCl level in nutrient solution (A)					NaCl level in nutrient solution (A)				
	500	1000	2000	4000	Mean (B)	500	1000	2000	4000	Mean (B)
	Potassium (%)					Calcium (%)				
	First season (2015/2016)					First season (2015/2016)				
Control (0 SW)	1.39	1.32	1.29	1.19	**1.29**	2.56	2.75	3.37	3.61	**3.09**
50 ppm SW	1.48	1.35	1.22	1.21	**1.32**	2.86	2.75	3.24	3.71	**3.17**
100 ppm SW	1.69	1.50	1.45	1.33	**1.49**	2.59	2.99	3.06	3.28	**2.97**
200 ppm SW	1.73	1.59	1.46	1.37	**1.54**	2.55	2.54	2.99	3.25	**2.83**
Mean (A) NaCl	**1.57**	**1.44**	**1.35**	**1.28**		**2.62**	**2.72**	**3.17**	**3.46**	
LSD (0.05)	**A = 0.091 ; B = 0.112 ; AB = 0.152**					**A = 0.10 ; B =0.09 ; AB = 0.129**				

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