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The Role of Boron and Some Growth Substances on Growth, Oil Productivity and Chemical Characterization of Volatile Oils in Basil (*Ocimum basilicum* L.) Cv. Genovese.

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Abstract: Two field experiments were carried out at the Experimental Farm of Horticulture Department, Faculty of Agriculture, Benha University, Egypt during the two successive seasons of 2013/14 and 2014/15 seasons to study the effect of boron and some growth substances (Seaweeds extracts, amino acids and salicylic acid) either applied individually or as in their combinations on growth and oil productivity of basil (*Ocimum basilicum* L.) cv. Genovese. In this respect, the all applied treatments in general statistically and positively affected each of the studied growth parameters and the oil productivity. Application of growth substances significantly increased plant height, number of branches, fresh and dry weights, photosynthetic pigments (Chlorophyll a, b and carotenoids), macronutrients (N, P, K) and total carbohydrates by using seaweeds extract at a rate 2 ml/L or amino acids at a rate of 1g/L at the two cuts in both seasons. Also, all concentrations of boron significantly improved all the aforementioned parameters, especially by using the high rates. Additionally, all the combinations between growth substances and levels of boron concentrations improved all the studied parameters, particularly using the combinations of seaweeds extract at a rate of 2 ml/L and boron at 100 ppm at the two cuts in both seasons. Moreover, the combined treatments of 1g/l amino acids and boron (100 ppm) induced high significant increments in this concern in the two seasons. Also, essential oil percentage in leaves gave the maximum values when plants treated with the combined treatments of seaweeds extract (2ml/L) or amino acids (1g/L) and boron (100ppm) compared with untreated plants. The volatile oil composition of basil produced 10 compounds were identified; the main component was the linalool (57.41 to 62.72 %). Thereby, the abovementioned results strongly admit the use of those combinations treatment of seaweeds extract 2ml/L) or amino acids (1g/L) and boron (100ppm) for improving the growth, oil productivity and essential oil composition of basil plant.

Key words: *Ocimum basilicum* L. · Seaweeds extract · Amino acids · Salicylic acid · Boron · Growth · Oil productivity · Chemical composition

INTRODUCTION

Basil (*Ocimum basilicum* L.) is a well-known and appreciated as an aromatic spice and medicinal plant belongs to the Lamiaceae family [1, 2]. The useful parts of the basil plant are their leaves and seeds. Where each of, the fresh and dry leaves are commonly used in food and spice industries. Furthermore, it is also considered as a source of aroma compounds and thus, possesses a range of biological properties such as insect repellent, nematocidal, antibacterial, antifungal agents and antioxidant properties [3, 4]. The major components of the oil are linalool, estragole, methyl cinnamate, eugenol, 1, 8-cineole, methyl chavicol, geranial, neral and caryophyllene oxide [5]. Recently, some efforts are paid to minimize the amounts of chemical fertilizers in which applied to medicinal and aromatic plants in order to reduce each of production cost and environmental pollution without reduction of yield [6, 7]. The great effort in this respect is applying the bio fertilizers and/or antioxidants. Here, the bio fertilizers are microbial inoculants in which many living cells of bacteria, algae and fungi each alone or in combination. These bio fertilizers comprise of many growth substances as amino acids, vitamins, cytokinins,

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auxin, macro and micro nutrients and many other growth and production promoting substances [8-11]. Also the most widely applied as foliar spray on many vegetables, fruits and ornamental plants to significantly enhance and stimulate their growth and productivity as well.

The aim of this work was to evaluate the benefits of supplementing some growth stimulating substances (Seaweeds extract, amino acids and salicylic acid in the presence of boron on growth and essential oil productivity of Basil (*Ocimum basilicum* L.) cv. Genovese. The present study also investigated the integrity of basil plants when pretreated with growth stimulating substances followed by boron when foliar sprayed. Study also was prolonged to evaluate the chemical characterization of the essential oils yielded under different applied treatments.

MATERIALS AND METHODS

Two field experiments were conducted at the Experimental Farm of Faculty of Agriculture (Moshtohor), Benha University, Egypt during two successive seasons of 2013\14 and 2014\15 for studying the effect of some growth substances (Seaweeds extract, amino acids and salicylic acid in presence of boron on growth and oil productivity of basil plant. Seeds of Basil (*Ocimum basilicum* L.) cv. Genovese was obtained from Medicinal and Aromatic Plants Department, Horticultural Research Institute, Ministry of Agriculture and Land Reclamation, Dokki, Giza, Egypt. In the two experiments, seeds were sown in the outdoor nursery pots on 14th March in both seasons. Seedlings (15 cm in height with 6-8 leaves) were transplanted in the experimental plots on April 22 in the two seasons, the area of each plot was 1m^2 containing 6 plants in two rows and each row contained 3 plants with 60 cm distance between rows. Physical and chemical properties of soil site are presented in Table 1.

Table 1: Physical and chemical properties of soil site

Soil properties	Value
Physical properties	
Coarse sand (%)	7.73
Fine sand (%)	5.59
Clay %	54.57
Silt (%)	33.41
Texture	Clay
Chemical properties	
Organic matter (%)	1.52
pH	7.34
EC (dS/m)	0.62
$CaCO_3$ (%)	0.55
Total nitrogen (%)	0.30
Total phosphorus (%)	0.14
Total potassium (%)	0.28

Table 2: General distribution of amino acids in the amino zeid compound

No	Aminogram	Percentage % (w/w)
1	Aspartic acid	3.29
2	Tyrosine	0.52
3	Glutamic acid	8.18
4	Glycin	2.03
5	Alanine	2.26
6	Valine	2.51
7	Isoleucine	1.11
8	Leucine	2.03
9	Lysine	1.75
10	Arginine	4.64
11	Histidine	0.56
12	Proline	3.96
13	Phenyl alanine	0.99
14	Serine	4.99
15	Threonine	3.57

Table 3: Type and content of nitrogen and potassium in amino zeid compound

No	Supplementary	Percentage % (w/w)
1	Organic nitrogen	10.0
2	Potassium oxide	25.0
3	Free amino acids	42.0
4	Total amino acids	85.0

Treatments

Seaweeds Extract: Seaweeds extract produced by Orbital for Agrochemicals, 24 A Obour Bldgs – Salah Salem Cairo, Egypt. The used extract contains minerals as Fe, Zn, Cu, Mn and Mo, vitamins, enzymes, amino acids, sugars and plant hormones, (Auxins, cytokinins and gibberellins) was used.

Amino Acids: amino acids under the trade name of Amino zeid was sprayed at the rate of 1g/L for each spray. The components of amino acids as well as nitrogen and potassium contents in Amino zeid are shown in Tables 2 and 3.

Salicylic Acid: Salicylic acid solution was applied as foliar application at the concentration of 100 ppm

Boron (B): was applied as foliar application at the concentrations of 0, 50 and 100 ppm.

Seaweeds extract, amino acids and salicylic acid were applied as a foliar spray on plant leaves 4 times, the 1st after 15 days from transplanting, the 2nd at 15 days after the first, while the third was applied after cutting the herbs and the fourth was 15 days after the third, while boron was applied sprayed on plant leaves 3 times, the 1st at 21 days after transplanting, the 2nd at 21 days after the

first, while the third was sprayed after the herbs cutting. A complete randomized block design (CRBD) with three replicates (each replicate comprised 3 plots (each plot was containing 6 plants) was used according to Snedecore and Cochran [12], including 12 treatments represented the combinations between the growth substances (seaweeds extract at a rate of 2 ml/L, amino acids at a rate of 1 g/L and 100 ppm salicylic acid) and boron concentration at the concentrations of 0, 50 and 100 ppm each treatment was repeated three times. Irrigation and agricultural practices were done whenever plants needed. During the two seasons, basil plants were harvested at the full bloom stage. The plants were cut twice in each harvest. The first cut was done 15th of June, while the second cut was done on 15th of September in the two growing seasons.

Vegetative Growth Characters: some growth characters were determined such as plant height (10 cm above the soil surface), number of branches per plant, herbs fresh weight (g/plant), herbs dry weight (g/plant).

Chemical Composition: Total nitrogen, phosphorus, potassium and total carbohydrates were determined in dry basil herbs at the flowering stage according the methods described by Horneck and Miller [13], Hucker and Catroux [14], Horneck and Hanson [15] and Herbert *et al*. [16], respectively. Photosynthetic pigments as mg/g fresh weight (Chlorophyll a, b and carotenoids) were calorimetrically determined in leaves of basil according to the method described by Inskeep and Bloom [17].

Essential Oil Properties: The percentage of volatile oil was determined in the fresh herb using 100 g samples for each cut per plant. Distillation of volatile oil for 3hr in order to extract the essential oils according to the method described by British Pharmacopeia [18]. Gas liquid chromatography analysis of essential oil (GLC) was carried out at the Medicinal and Aromatic Plant Laboratory, Dokki, Egypt. Essential oil samples were performed using Ds chrom 6200 gas chromatograph equipped with a flame ionization detector for separation of volatile oil constituents. The analysis conditions were as follows: The chromatograph apparatus was fitted with capillary column BPX-5.5% phenyl (eguiv.) polysillphenylene – siloxane 30m x 0.25mm ID x 0.25ìm film. Temperature program ramp increased with the rate of 10°C/min from 70° to 200°C. Flow rates of gases were nitrogen at 1ml/min, hydrogenat 30ml/min and 330ml/min for air. Detector and injector temperatures were 300°C and 250°C, respectively. The obtained chromatogram and report of GC analysis for each sample were analyzed to calculate the percentage of main components of volatile oil.

Statistical Analysis: All data obtained during both seasons were subjected to analysis of variance according to Snedecor and Cochran [12]. The treatments means were compared according to Duncan's multiple test range [19].

RESULTS AND DISCUSSION

Effect of Some Growth Substances, Boron and their Combination Treatments on Vegetative Growth of Basil (*Ocimum basilicum* L.) cv. Genovese.

Plant Height (cm): Data presented in Table 4 indicated that all growth substances treatments (seaweeds at the rate of 2 ml/L extract, amino acids at the rate of 1g/L and salicylic acid at 100 ppm) significantly increased plant height (cm) compared to the control in the1st and 2nd seasons. In this respect, amino acids at the rate 1g/L gave the maximum plant height at the two cuts in both seasons followed by seaweeds extract (2ml/L). Also, application of different boron concentrations (50 and 100 ppm) significantly increased plant height (cm) compared to the control plants. In this concern, it could be noticed that spraying the plants with 100 ppm boron statistically induced the highest plant height at the two cuts in the 1st and 2nd seasons. In addition, data in Table 4 indicated that, all the interactions between growth substances treatments and boron concentrations statistically increased plant height. However, the combined treatment between amino acids and boron at 100 ppm significantly produced the tallest plant height compared to the control plant at two cuts in both seasons, followed in descending order by using the combined treatment between amino acids and boron at 50 ppm. On the other hand, control treatment produced the lowest plant height at both cuts in the first and second seasons.

Number of Branches/Plant: Data presented in Table 4 indicated that, the all growth substances treatments significantly increased the mean number of branches per plant in the two seasons. In this concern, the highest number of branches per plant was obtained with seaweeds extract (2 ml/L) in the two cuts during the two seasons. On the other side, there was a positive relationship between the number of branches per plant and the applied boron concentrations, hence the number of branches per plant increased as the concentrations of boron increased. Thereby, boron at 100 ppm showed to be

Table 4: Effect of some growth substances, boron and their combination on plant height (cm) and branches number of *Ocimum basilicum* cv.Genovese plants during 2013/2014 and 2014/2015 seasons

	1st cut				2nd cut			
Boron concentrations	B (ppm)				B (ppm)			
Growth substances	0	50	100	Mean	0	50	100	Mean
				Plant height (cm)				
				1st season				
Control	33.79l	44.20k	47.71j	41.90D	39.88l	49.00k	51.07j	46.65D
Seaweeds extract (2 ml/L)	71.02f	78.26e	81.69d	76.99B	76.90f	79.42e	82.92d	79.75B
Amino acids (1 g/L)	85.09c	91.35b	96.93a	91.12A	91.07c	95.10b	98.63a	94.93A
Salicylic acid (100 ppm)	58.67i	60.91h	66.51g	62.03C	63.80i	68.17h	74.58g	68.85C
Mean	62.14C	68.68B	73.21A	--	67.91C	72.92B	76.80A	--
				2nd season				
Control	37.13k	43.01j	49.10i	43.08D	42.49l	47.16k	50.70j	46.79D
Seaweeds extract (2 ml/L)	73.65e	79.13d	83.74c	78.84B	79.31f	80.06e	83.26d	80.54B
Amino acids (1 g/L)	84.19c	92.57b	98.25a	91.67A	89.46c	98.73b	100.1a	96.10A
Salicylic acid (100 ppm)	61.14h	66.75g	71.07f	66.32C	65.48i	69.72h	75.45g	70.22C
Mean	64.03C	70.36C	75.54A	--	68.94C	73.92B	77.38A	--
				Number of branches				
				1st season				
Control	28.33k	30.67j	36.67i	31.89D	27.38k	30.92j	37.36i	31.89D
Seaweeds extract (2 ml/L)	86.00c	90.33b	95.33a	90.56A	88.44c	93.79b	101.2a	94.47A
Amino acids (1 g/L)	79.00e	83.67d	89.33b	84.00B	81.24e	86.31d	92.72b	86.76B
Salicylic acid (100 ppm)	60.33h	68.33g	71.33f	66.67C	61.47h	72.22g	75.28f	69.33C
Mean	63.42C	68.25B	73.17A	--	64.63C	70.81B	76.64A	--
				2nd season				
Control	30.67l	32.33k	40.67j	29.76D	29.31k	33.80j	39.73i	34.28D
Seaweeds extract (2 ml/L)	89.00c	94.67b	97.33a	97.12A	90.73c	95.36b	101.8a	95.95A
Amino acids (1 g/L)	77.33a	80.67e	86.33d	83.37B	82.20e	85.60d	90.60c	86.13B
Salicylic acid (100 ppm)	65.33i	70.33h	75.00g	69.64C	64.60h	74.60g	77.04f	72.08C
Mean	62.33C	69.87B	77.72A	--	66.71C	72.34B	77.28A	--

the most effective level for producing the highest number of branches per plant in the two seasons in both cuts. Moreover, all combinations between growth substances treatments and boron concentrations led to an increase in number of branches per plant in both seasons. However, the highest number of branches per plant was obtained by using the combined treatment between seaweeds extract and boron at 100 ppm, followed descendingly by the combined treatment between seaweeds extract and boron at 50 ppm in the first and the second cuts in both seasons. Generally, using the combined treatments between amino acids (1g/L) and boron (100 ppm) ranked the third order in the two cuts during the two seasons.

Fresh and Dry Weights of Herbs/Plant: Data presented in Table 5 revealed that all the growth substances treatments, boron concentrations and their combinations increased the fresh and dry weights of herbs/plant of basil plants in both seasons. In this concern, the increments in fresh and dry weights of herbs/plant scored the level of significance with applying seaweeds extract at a rate of 2ml/L or 100 ppm boron, respectively at both cuts in the first and second seasons. However, the heaviest fresh and dry weights of herbs/plant were obtained by using the combined treatments between seaweeds extract (2ml/L) and 100 ppm boron in both cuts and in the two seasons. On the other hand, the combined treatments between seaweeds extract (2ml/L) and 50 ppm boron ranked the second order in the first and second cuts during the two seasons. Moreover, the combination between amino acids and 100 ppm boron ranked the third order in this respect. Also of interest is to note that the combination treatments between salicylic acid (100 ppm) and boron (50 ppm) at both cuts in the first and second seasons produced the lowest fresh and dry weights of herbs. The main function of B is correlated to cell wall formation, nitrogen fixation, sugar transportation, phenol, nucleic acid, carbohydrate and indole acetic acid (IAA) metabolism and membrane stability. These results are in agreement with those obtained by Maryam *et al.* [20],

Table 5: Effect of some growth substances, boron and their combination on fresh and dry weights (g/plant) of *Ocimum basilicum* cv. Genovese plants during 2013/2014 and 2014/2015 seasons

	1st cut				2nd cut			
Boron concentrations	B (ppm)				B (ppm)			
Growth substances	0	50	100	Mean	0	50	100	Mean
				Fresh weight (g/plant)				
				1st season				
Control	261.6k	268.1j	270.7i	266.8D	263.8k	271.2j	275.9i	270.3D
Seaweeds extract (2 ml/L)	1201.0c	1232.0b	1239.0a	1224.0A	1210.0c	1236.0b	1245.0a	1230.0A
Amino acids (1 g/L)	1190.0e	1196.0d	1201.0c	1195.0B	1191.0e	1205.0d	1211.0c	1202.0B
Salicylic acid (100 ppm)	581.2h	592.3g	608.1f	593.9C	589.2h	595.7g	605.5f	596.8C
Mean	808.3C	822.1B	826.6A	--	813.6C	827.0B	834.2A	--
				2nd season				
Control	267.7l	274.0k	278.2j	273.3D	267.5l	275.8k	280.6j	274.6D
Seaweeds extract (2 ml/L)	1211.0c	1242.0b	1248.0a	1234.0A	1212.0d	1241.0b	1250.0a	1234.0A
Amino acids (1 g/L)	1186.0f	1191.0e	1196.0d	1191.0B	1193.0f	1206.0e	1216.0c	1205.0B
Salicylic acid (100 ppm)	589.0i	597.3h	611.9g	599.4C	590.5i	599.2h	613.1g	600.9C
Mean	813.3C	826.2B	833.7A	--	815.7C	830.5B	839.9A	--
				Dry weight (g/plant)				
				1st season				
Control	68.77l	75.67k	80.38j	75.19D	71.44l	77.94k	82.44j	77.27D
Seaweeds extract (2 ml/L)	235.2d	245.2b	257.4a	245.9A	238.7d	246.3b	260.2a	248.4A
Amino acids (1 g/L)	225.7f	232.8e	236.7c	231.7B	227.3f	237.5e	240.7c	235.2B
Salicylic acid (100 ppm)	139.2i	142.2h	146.8g	165.0C	142.5i	146.7h	148.6g	145.9C
Mean	167.2C	174.0B	180.4A	--	170.0C	177.1B	183.0A	--
				2nd season				
Control	73.89l	78.38k	84.26j	78.84D	73.99k	80.25j	85.91i	80.05D
Seaweeds extract (2 ml/L)	238.5c	248.1b	257.6a	248.1A	240.7c	247.2b	257.0a	248.3A
Amino acids (1 g/L)	224.4f	230.2e	232.4d	229.0B	226.6e	237.8d	240.2c	234.9B
Salicylic acid (100 ppm)	143.9i	146.9h	148.5g	146.4C	144.3h	147.2g	150.4f	147.3C
Mean	170.1C	175.9B	180.7A	--	171.4C	178.1B	183.4A	--

Mohamed *et al.* [7] on *Ocimum basilicum* L. cv. Genovese and Shekofteh *et al.* [21] on *Plantago ovata* plants. The increase of these traits could be attributed to the effect of these bio stimulants to promote plant growth when applied in small quantities. These bio stimulants function as metabolic enhancers because they contained components such as macro- and micro element nutrients, amino acids, vitamins, cytokinins and auxins like growth substances in which affect cellular metabolism in treated plants leading to enhanced growth and to increase crop yield [22]. Also, because, amino acids are the fundamental ingredients of the process of protein synthesis the importance of amino acids may came from their responsibility to initiate for the biosynthesis of alarge variety of non-nitrogenous materials that are, pigments, vitamins, coenzymes, purine and pyrimidine bases [23]. In addition, salicylic acid (SA) is a signaling or messenger molecule in plants and can induce plant tolerance against various biotic and abiotic stresses [24]. SA also plays an important role in regulation of some physiological processes in plants such as effects on growth and development, ion uptake and transport and membrane permeability [6]. Exogenous SA alters the activities of antioxidant enzymes and increases plant tolerance to abiotic stress by decreasing generation of ROS. It has been found that SA has different effects on stress adaptation and damage development of plants that depend on plant species, concentration, method and time of SA application [25]. Boron (B) deficiency among microelements is the most harmful to the crop exactly as in use of iron and zinc [11].

Effect of Some Growth Substances, Boron and Their Interaction Treatments on Chemical Composition of Basil Plants

Chlorophyll a, b and Carotenoids Contents in the Fresh Leaves: Data in Table 6 revealed that all applied growth substances treatments significantly increased the Chlorophyll a, b and carotenoids in the fresh leaves of basil plants compared to control treatment in both

Table 6: Effect of some growth substances, boron and their combination on chlorophyll a, b and carotenoids (mg/g FW) of leaves in *Ocimum basilicum* cv. Genovese plants during 2013/2014 and 2014/2015 seasons

	Chlorophyll a				Chlorophyll b				Crotenoids			
Boron concentrations	B (ppm)				B (ppm)				B (ppm)			
Growth substances	0	50	100	Mean	0	50	100	Mean	0	50	100	Mean
						1st season						
Control	0.91g	0.93fg	0.97ef	0.94C	0.0.61h	0.67g	0.68g	0.65C	0.34g	0.39fg	0.42ef	0.38D
Seaweeds extract (2 ml/L)	1.11d	1.22ab	1.25a	1.19A	0.81ef	0.91b	0.95a	0.89A	0.43ef	0.55bc	0.65a	0.55A
Amino acids (1 g/L)	1.17bc	1.19b	1.22ab	1.19A	0.85cd	0.89bc	0.91b	0.88A	0.41ef	0.51cd	0.59b	0.50B
Salicylic acid (100 ppm)	0.92fg	0.98e	1.14cd	1.01B	0.78f	0.82def	0.85cde	0.82B	0.40ef	0.45e	0.50d	0.45C
Mean	1.03C	1.08B	1.14A	--	0.76C	0.82B	0.85A	--	0.39C	0.47B	0.54A	--
						2nd season						
Control	0.72h	0.91fg	0.96f	0.86C	0.61g	0.67f	0.69f	0.66C	0.39f	0.40f	0.46e	0.42D
Seaweeds extract (2 ml/L)	1.13d	1.28bc	1.34a	1.25A	0.84cd	0.91ab	0.95a	0.90A	0.48e	0.61b	0.70a	0.59A
Amino acids (1 g/L)	1.17d	1.24c	1.30ab	1.24A	0.81de	0.91ab	0.92a	0.88A	0.48e	0.56bc	0.61b	0.55B
Salicylic acid (100 ppm)	0.87g	1.01e	1.16d	1.02B	0.78e	0.81de	0.87bc	0.82B	0.41f	0.49de	0.53cd	0.47C
Mean	0.97C	1.11B	1.19A	--	0.76C	0.82B	0.86A	--	0.44C	0.51B	0.57A	--

seasons. In this respect, seaweeds extract gave the highest values, followed by applying amino acids compared to control in the two seasons. Also, free amino acids produced the second highest values in this concern. Data in Table 6 also indicated that application of boron up to high concentration increased chlorophyll a, b and carotenoids in the fresh leaves and the highest contents were obtained by using 100 ppm. Moreover, all combinations between growth substances treatments and boron concentrations statistically increased chlorophyll a, b and carotenoids in the fresh leaves of basil plants compared to control treatment in both seasons. However, the highest values of these parameters were recorded by using the combinations between seaweeds extract and boron (100 ppm), followed descendingly by the combination between amino acids and boron (100 ppm) or in combination between seaweeds extract and boron (50 ppm) in the two seasons. In this respect, Mohamed *et al.* [7] on *Ocimum basilicum* L. cv. Genovese stated that seaweeds extract (Algreen 600) increased leaf chlorophyll a, b and carotenoids concentration more than control plants.

Nitrogen, Phosphorus, Potassium and Total Carbohydrates Contents in Dry Herbs of Basil Plants: Data presented in Table 7 demonstrated that all applied growth substances treatments significantly increased N, P, K and total carbohydrates contents in the dry leaves of basil plants. However, the highest percentages were obtained by using seaweeds extract compared to control plants in the two seasons, besides applying of 100 ppm boron showed to be the most effective for N%, P%, K% and total carbohydrates % in dry leaves of basil plants compared to control in both seasons. Generally, the combination between amino acids and boron (100 ppm) resulted in the highest values of N and total carbohydrates % in the dry leaves of basil plants in the two seasons. In addition, the highest values of P and K% were recorded by using the combinations between seaweeds extract and boron (100 ppm), while the lowest values of these parameters were recorded by the control treatment in the two seasons. In this concern, Mohamed *et al.* [7] stated that seaweeds extract (Algreen 600) increased leaf N, P, K and total carbohydrates contents of *Ocimum basilicum* L. cv. Genovese compared to control in both seasons.

Essential Oil Percentage: Data presented in Table 8 indicated that essential oil percentage of basil was more affected by using growth substances treatments, boron concentrations and their combinations at the two cuts in the first and second seasons. In this concern, seaweeds extract (2ml/L) or boron (100ppm) significantly gave the maximum values of essential oil percentage/plant at both cuts in the first and second seasons. However, using the combination between seaweeds extract (2ml/L) and boron (100 ppm) was the most effective one for increasing essential oil percentage/plant that gave (1.23,1.35,1.38 and 1.35), followed by amino acids and boron (100 ppm) (1.27,1.30,1.34 and 1.34), respectively at the first and second cuts in both seasons. On the other side, using the combined treatment of seaweeds extract (2ml/L) and boron (50 ppm) ranked the third order in this respect. The lowest value of oil percentage per plant was produced by un-treated plants at both cuts in the two seasons. These results are in agreement with those reported by

Table 7: Effect of some growth substances, boron and their combination on nitrogen, phosphorus, potassium and total carbohydrate percentages of *Ocimum basilicum* cv. Genovese plants during 2013/2014 and 2014/2015 seasons

	N%				P%			
Boron concentrations	B (ppm)				B (ppm)			
Growth substances	0	50	100	Mean	0	50	100	Mean
				1st season				
Control	1.27h	1.87f	2.23e	1.79D	0.22f	0.29e	0.31de	0.27C
Seaweeds extract (2 ml/L)	2.67d	2.93c	3.23b	2.94B	0.39bc	0.40b	0.45a	0.41A
Amino acids (1 g/L)	2.90c	3.53a	3.63a	3.36A	0.34d	0.41ab	0.43ab	0.39A
Salicylic acid (100 ppm)	1.57g	2.13e	2.83c	2.18C	0.29e	0.35cd	0.39bc	0.34B
Mean	2.10C	2.62B	2.98A	--	0.31C	0.36B	0.40A	--
				2nd season				
Control	1.53i	1.97g	2.43f	1.98D	0.21h	0.30g	0.32fg	0.27D
Seaweeds extract (2 ml/L)	2.57e	3.10c	3.23b	2.97B	0.37cde	0.41b	0.49a	0.42A
Amino acids (1 g/L)	3.00d	3.27b	3.67a	3.31A	0.33efg	0.41bc	0.46a	0.40B
Salicylic acid (100 ppm)	1.73h	2.57e	2.97d	2.42C	0.31g	0.36def	0.39bcd	0.35C
Mean	2.21C	2.73B	3.08A	--	0.30C	0.37B	0.41A	--
	K %				Total Carbohydrates			
				1st season				
Control	1.13j	1.23j	1.44i	1.27D	9.93j	11.77h	12.17gh	11.29D
Seaweeds extract (2 ml/L)	2.60d	2.93b	3.17a	2.90A	13.93e	15.20d	15.83c	14.99B
Amino acids (1 g/L)	2.40e	2.60d	2.77c	2.59B	14.83d	16.77b	17.57a	16.39A
Salicylic acid (100 ppm)	1.67h	2.03g	2.20f	1.97C	10.83i	12.43g	13.10f	12.12C
Mean	1.95C	2.20B	2.39A	--	12.38C	14.04B	14.67A	--
				2nd season				
Control	1.10j	1.23i	1.50h	1.28D	8.68j	11.16h	12.62g	10.82D
Seaweeds extract (2 ml/L)	2.60cd	3.03b	3.33a	2.99A	14.26e	16.52c	17.59b	16.12B
Amino acids (1 g/L)	2.53d	2.67c	2.93b	2.71B	14.34e	17.71b	19.41a	17.15A
Salicylic acid (100 ppm)	1.77g	2.23f	2.37e	2.12C	9.81i	13.44f	14.85d	12.70C
Mean	2.00C	2.29B	2.53A	--	11.77C	14.71B	16.12A	--

Table 8: Effect of some growth substances, boron and their combination on the percentages of essential oil *in Ocimum basilicum* cv. Genovese plants during the two seasons of 2013/2014 and 2014/2015.

	1st cut				2nd cut			
Boron concentrations	B (ppm)				B (ppm)			
Growth substances	0	50	100	Mean	0	50	100	Mean
				Essential oil %				
				1st season				
Control	0.83g	0.93e	0.99d	0.91C	0.74h	0.85g	0.96f	0.85D
Seaweeds extract (2 ml/L)	1.15c	1.23ab	1.23ab	1.20A	1.22cd	1.26bc	1.35a	1.28A
Amino acids (1 g/L)	1.14c	1.21b	1.27a	1.21A	1.03e	1.24c	1.30b	1.19B
Salicylic acid (100 ppm)	0.88f	0.97de	1.13c	0.99B	0.88g	1.02e	1.17d	1.03C
Mean	0.99C	1.09B	1.15a	--	0.97C	1.09B	1.20A	--
				2nd season				
Control	0.72g	0.87f	1.03e	0.87D	0.81e	0.91e	1.03d	0.92C
Seaweeds extract (2 ml/L)	1.21c	1.34a	1.38a	1.31A	1.23bc	1.30ab	1.35a	1.29A
Amino acids (1 g/L)	1.20c	1.28b	1.34a	1.27B	1.15c	1.30ab	1.34a	1.26A
Salicylic acid (100 ppm)	0.84f	1.11d	1.24bc	1.07C	0.90e	1.11cd	1.22bc	1.08B
Mean	0.99C	1.15B	1.25A	--	1.02C	1.15B	1.23A	--

Table 9: Effect of different treatments on essential oil composition.

		Area %			
Peak No	Component name	Control	Salicylic acid (100 ppm) + Boron (100 ppm)	Amino acids (1g/L) + Boron (100ppm)	Seaweeds extract (2ml/L) + Boron (100ppm)
1	α-Pinene	0.78	1.14	0.50	0.56
2	Sabinene	1.85	0.94	1.33	1.64
3	β- pinene	0.78	0.88	0.72	0.84
4	1, 8-Cineole	11.36	11.91	8.41	10.49
5	Linalool	59.39	57.41	62.26	62.72
6	Camphor	5.21	5.45	5.41	4.44
7	α -Terpineneol	2.53	2.77	2.30	2.34
8	General acetate	1.76	1.96	1.85	1.50
9	Methyl charicole	0.87	0.76	1.40	0.74
10	β-caryophyllene	8.58	9.23	8.19	8.60
*	Unknown	6.89	7.55	7.63	6.13
Total	--	100	100	100	100

Maryam *et al.* [20] on *Ocimum basilicum* L., who indicated that, there were significant differences in essential oil content between the plants sprayed with various levels of amino acids and those untreated ones. They also reported that foliar application of aminolforte gave the greatest essential oil content in treated plants. Furthermore, Mohamed *et al.* [7] showed that in *Ocimum basilicum* L. cv. Genovese plants which received seaweeds extract (Algreen 600) exhibited highly significant increase of essential oil percentage compared with control plants.

Essential Oil Composition: Data presented in Table 9 and Figs. 1-4 show the effect of the assigned treatments of salicylic acid, amino acids and seaweeds extract in combination with boron on the constituents of essential oil distilled from basil plants. The volatile oil composition of basil included 10 compounds were identified, i.e. linalool, 1, 8-cineole, β-caryophyllene, camphor, α-Pinene, β-pinene, α–Terpineneol, general acetate, methyl charicole and sabinene. The main component was the linalool ranged from (57.41 to 62.72 %) followed by 1, 8-cineole (8.41 to 11.36), β-caryophyllene (8.19 to 9.23%) and camphor (4.44 to 5.45%), in addition to unknown component (6.13 to 7.63%). Furthermore, the combination between seaweeds extract and 100 ppm boron gave the maximum values of linalool (62.72 %) followed by the combined treatment of amino acids and 100 ppm boron (62.26%) compared to the values of 59.39 and 57.41% for the control and the combined treatment of 100 ppm salicylic acid + 100 ppm boron, respectively. On the other hand, different treatments caused reduction in the percentage of 1, 8-cineole from 11.36 in control to 10.49-8.41%, with the exception of the combined treatment of salicylic acid + 100 ppm boron surpassed control as 11.91%. Similar findings had been obtained by Juliani and Simon [3], Lee *et al*. [4] and Sajjadi [5], who stated that, the major components of the basil oil (*O. basilicum* L.) are linalool, estragole, methyl cinnamate, eugenol, 1,8-cineole, methyl chavicol, geranial, neral and caryophyllene oxide. Also, it could be noticed that the content of linalool existed in the present study was higher than the results of Khalid [26] and Telci *et al.* [27].

In general, applied of seaweeds extract and amino acids either separately or when combination with boron at a rate of 50 or 100 ppm exhibited vigorous growth regarding the plant height and branches number (Table 4) gave the highest fresh and dry weights (Table 5), all of that was proceeded with obvious and significant increases of chlorophylls (Table 6). Also, these treatments significantly in most cases increased nitrogen, phosphorus, potassium and total carbohydrates in treated plants (Table 7). So, the above enhancement of different aspects of basil growth, positively were reversed upon the increase of essential oil yielded and their constituents, as well (Tables 8 & 9). Therefore, the present study strongly admits the use of such treatments as foliar spray with seaweeds extract and amino acids and to some extend with salicylic acid on basil plant to improve its growth and economic productivity.

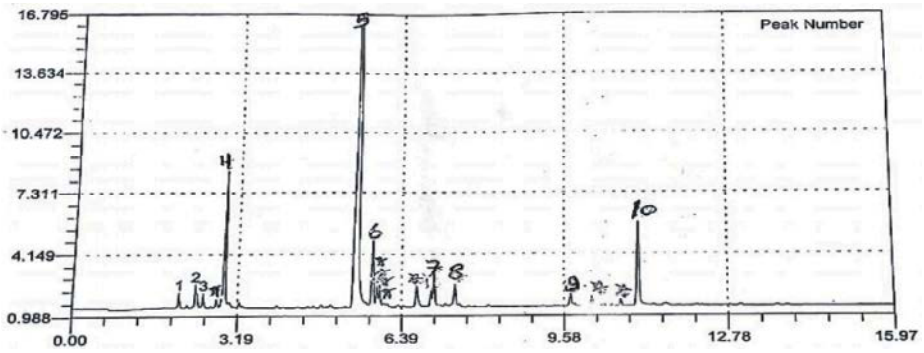

Fig. 1: Effect of control treatment on essential oil composition

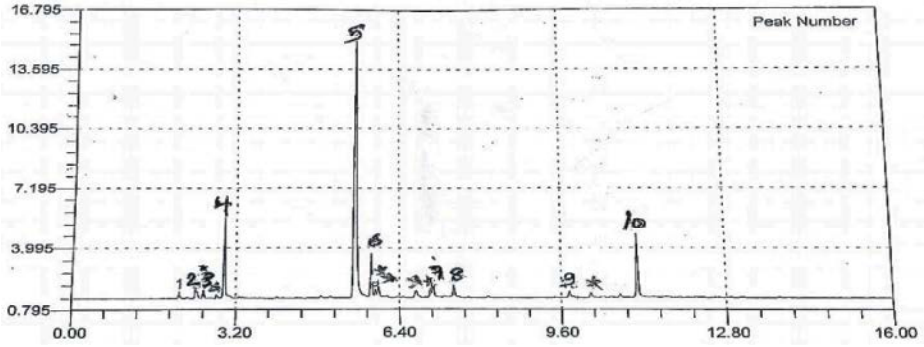

Fig. 2: Effect of the combined treatment of salicylic acid (100 ppm) and boron (100ppm) on essential oil composition

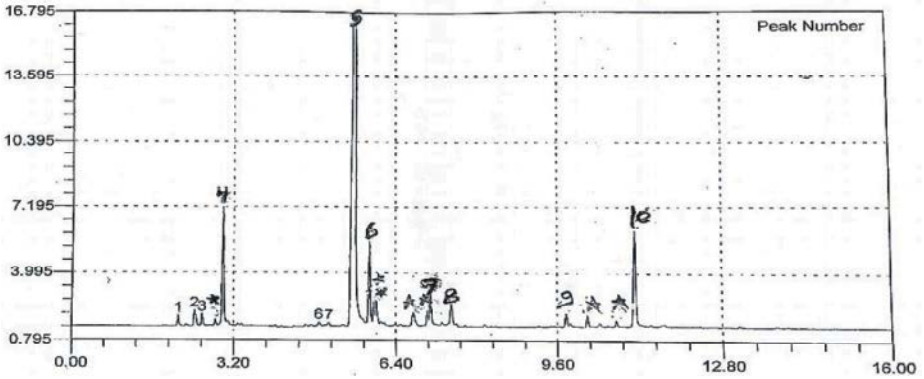

Fig. 3: Effect of the combined treatment of amino acids (1 g/L) and boron (100 ppm) on essential oil composition

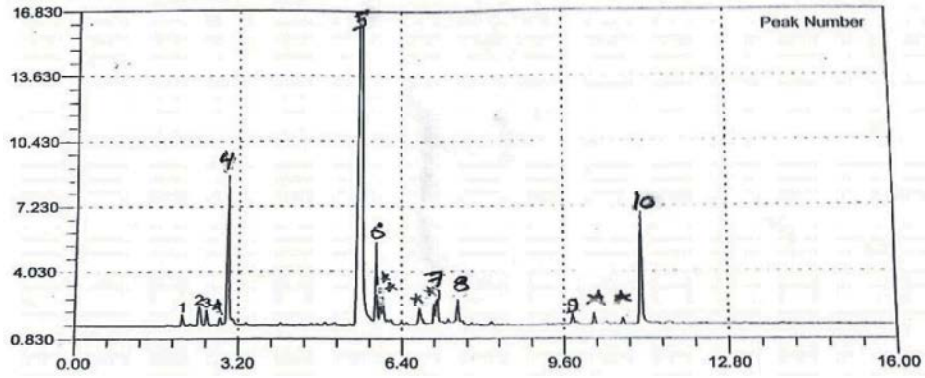

Fig. 4: Effect of the combined treatment of seaweeds extract (2 ml/L) and boron (100 ppm) on essential oil composition

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