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Response of Basil Plant (*Ocimum sanctum* L.) to Foliar Spray with Amino Acids or Seaweed Extract

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Abstract: Field experiments were conducted to study the effect of foliar spray with various concentrations of amino acids (0.5, 1.5 and 2.5ml/L) or seaweed extract (0.5, 1.0 and 1.5ml/L) on the vegetative growth, seed yield components, anatomical structure and some chemical analysis of *Ocimum sanctum* L. during the two successive seasons of 2013 and 2014 at Research Station of Faculty of Pharmacy, Cairo University, Giza, Egypt. The results revealed that foliar application of amino acids or seaweed extract enhanced the vegetative characters (plant height, stem diameter, branches number, leaves number and fresh and dry weight of whole herb), seed yield components (number of inflorescences and seed per plant, number of fruit per inflorescences and seed yield per plant) and the chemical constituents of leaves (total soluble sugars, protein, soluble amino acids and antioxidants activity, in addition chemical composition of volatile oil). Also, leaf and stem structure were investigated. The maximum significant increase in any of the studied characters was detected at 1.5ml/L amino acids or seaweed extract.

Key words: *Ocimum sanctum* L. · Basil · Amino acids · Seaweed extract · Vegetative growth · Anatomy · Yield · Antioxidants · Chemical constituents

INTRODUCTION

Ocimum (basil) belongs to the Family *Lamiaceae,* is one of the most popular plants grown extensively in many countries around the world, especially in Asia, Europe and North America. *Ocimum* includes around 30 species from tropical and subtropical areas, which are much differentiated in respect of morphological and chemical features [1-3].

Among the species of this genus, *Ocimum sanctum* L. (known as Tulsi in Hindi and Holy basil or Sacred in English), a small herb seen throughout India, has been recommended for the treatment of bronchitis, bronchial asthma, malaria, diarrhea, dysentery, skin diseases, arthritis, painful eye diseases, chronic fever, insect bite etc. *Ocimum sanctum* L. has also been suggested to possess antifertility, anticancer, antidiabetic, antifungal, antimicrobial, hepatoprotective, cardioprotective, antiemetic, antispasmodic, analgesic, adaptogenic and diaphoretic actions. A number of studies have demonstrated, either directly or indirectly, that sacred basil possesses good antioxidant activity. Sacred basil demonstrated protective effects against copper sulphate toxicity in rats [4].

The application of amino acids is a well known biostimulant which has positive effects on plant growth, yield and significantly mitigates the injuries caused by abiotic stresses [5]. Amino acids foliar spray increased total soluble sugars and total free amino acids in *Antholyza aethiopica* [6]. Also, seaweed extract for different crops was a great importance due to its contain a high levels of organic matter, micro elements, vitamins and fatty acids and also rich in phytohormones such as auxins, cytokinin and gibberellins [7].

The beneficial effect of seaweed extract application is a result of foliar application with many components that may work synergistically at different concentrations, although the mode of action still remains unknown [8].

Therefore, this investigation aimed to study the effect of amino acids or seaweed extract on vegetative growth, yield characters, leaf and stem anatomy, some chemical contents and antioxidants activity of *Ocimum sanctum* L.

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MATERIALS AND METHODS

Filed experiments were conducted during the two growing s uccessive seasons of 2013 and 2014 at Research Station of Faculty of Pharmacy, Cairo University, Giza, Egypt, to study the effect of foliar application of amino acids and seaweed extract on vegetative growth, yield characters, anatomical structure, chemical contents and antioxidants activity of basil plant.

Seeds of *Ocimum sancatum* L. were secured from Ornamental Horticulture Department, Faculty of Agriculture, Cairo University, Egypt.

Amino Acids Preparation: Hydrochloric acid solution of each concentration was added to sample of defatted soya flour in a glass beaker and stirred by a mechanical stirrer (the ratio of defatted soya flour to Hcl solution was 1:3 (w: v). The temperature of hydrolyses was controlled in the water bath; also the glass beaker was covered by using silver paper. After finishing each trial, the hydrolysized product was cooled directly to 25°C and then it was neutralized by sodium hydroxide solution. The volume of neutralized hydrolyzed product was modified to a constant volume for all trials by adding deionized water and then it was filtered through Whatman filter paper No.541, filtration was carried out under vacuum. After that, the filtrate volume was modified to a constant volume for all trials after that, the final filtrate volume was used to determine the total amino acids [9, 10].

A commercial seaweed extract product was used. Seaweed extract contains N (1%), K (2.5%), Ca (0.17%), Mg (0.43%), Fe (0.06%), S (2.2%), Zn (0.99 ppm), Boron (3.87 ppm), alganic acids (10-12%) and plant hormones (500 ppm).

Basil seeds were sown on 25th March in both seasons; after 25 days from sowing, the plants were thinned to one plant/hill and all plants received recommended dose of NPK fertilizers.

The experiment layout was randomized complete block design of three replicates. Each replicate was comprised of seven plots, each plot representing one treatment. The treatments were:

Tap water (control), Amino acids at 0.5ml/L, Amino acids at 1.5ml/L, Amino acids at 2.5ml/L, Seaweed extract at 0.5 ml /L, Seaweed extract at 1ml /L and Seaweed extract at 1.5 ml /L.

The tested concentrations of amino acids and seaweed extract were applied twice by means of an atomizer sprayer. The first application was 50 days from sowing (at vegetative growth stage) and the second application was two weeks from the first one (at flowering stage).

Recording of Data

Morphological Characters of Vegetative Growth: A random sample of 12 plants from each tested treatment (4 plants from each replicate) was assigned for investigation. Vegetative characters were recorded after two weeks from the second application of amino acids or seaweed extract. The following characters were studied in both growing seasons:

- Plant height, cm.
- Stem diameter at median portion, cm.
- Number of primary branches/plant.
- Number of leaves/plant.
- Fresh weight of herb, g.
- Dry weight of herb, g.

Anatomical Studies: A comparative microscopical examination was performed on plant material for treatments which showed remarkable response. In addition to the control, plants of basil sprayed with 1.5 ml/L amino acid or seaweed extract were considered in details. Tested materials included the main stem at its median portion and lamina of the fourth leaf developed toward the main stem apex. Specimens were taken throughout the first season of 2013 at the age of 80 days from sowing date. Specimens were killed and fixed for at least 48 hrs. in F.A.A. (10 ml formalin, 5 ml glacial acetic acid and 85 ml ethyl alcohol 70%). The selected materials were washed in 50% ethyl alcohol, dehydrated in a normal butyl alcohol series, embedded in paraffin wax of melting point 56°C, sectioned to a thickness of 20 microns, double stained with crystal violet-erythrosin, cleared in xylene and mounted in Canada balsam [11]. Sections were read to detect histological manifestations of noticeable responses resulted from application of amino acids or seaweed extract compared to control and photomicrographed.

Reproductive Characters and Yield Components: A random sample of 15 plants for each tested treatment was taken at harvest time, 135 days from sowing date, to investigate the following yield characters in each of the two growing seasons.

- Number of inflorescences/plant.
- Number of fruits/ Inflorescence.
- Weight of 1000 seed (g).
- Number of seeds/plant.
- Yield of seeds/plant (g).

Chemical Analysis: Chemical analysis was determined in leaves at vegetative stage (80 days from sowing). Total compounds were extracted from the basil leaves as follows. The leaves (1 g) were mixed with 5 ml 80% ethanol (in triplicate) for control and all treatments. The extract was then made up to 10 ml with 80% ethanol. The extraction was performed by an orbital shaker for 24 h at room temperature and then the extract filtered through filter paper (Whatman No. 42) and was stored at 4°C.

Total hydrolysable carbohydrates and total soluble sugar were determined according to Dubois *et al*. [12].

The protein content was determined as described by Stoscheck [13] and total amino acids were determined according to the method of Rosein [14].

The Antioxidant Activity: The total phenolic content of extracts was determined using spectrophotometry according to Singleton and Rossi [15].

Flavonoids concentrations of samples were measured spectrophotometrically according to the procedure of Park *et al*. [16].

The hydroxyl radical scavenging activity was determined according to the methods described by Singh *et al.* [17].

Superoxide anion radical-scavenging activity was generated by the method of Ginnopolites and Ries [18].

Determination and analysis of the volatile oil using gas chromatography–mass spectrometry (GC-MS) technique.

Statistical Analysis: All data were calculated with three replicates and were expressed as mean ± standard errors or standard divisions. Differences were analyzed with one ways ANOVA using completely randomized design (CRD) and LSD *P* values of <0.05 were considered to be significant according to Snedecor and Cochran [19].

RESULTS AND DISCUSSION

Morphological Characters of Vegetative Growth: It is clear from Table (1) that all sprayed concentrations of amino acids or seaweed extract increased significantly all investigated morphological characters of basil plant except that of plants which were sprayed with seaweed extract at concentration of 0.5 ml /L where the difference with the control plants proved insignificant in this respect.

The highest values of vegetative growth characters were recorded when plants were sprayed with amino acids or seaweed extract at 1.5 ml/L.

The maximum increases in morphological characters due to spraying with amino acids at 1.5 ml /L, were 14.5 % for plant height, 25 % for stem diameter, 50.5% for number of branches/ plant, 19.7 % for number of leaves/plant, 92.2 % for fresh weight of herb / plant and 54.3 % for dry weight of herb / plant more than those of the control plants, respectively. The same trend was observed with spraying seaweed extract, whereas the percentages of increases at rate of 1.5 ml/L, were 9.8, 15, 47.6, 16.6, 70.2 and 51.4 % for plant height, stem diameter, number of branches/plant, number of leaves/plant and fresh and dry weight of herb/plant, respectively.

Generally, the best results in this respect were obtained from amino acids followed by seaweed extract.

Seed Yield Components: Data of seed yield characters of basil plant as affected by spraying with various concentrations of amino acids or seaweed extract are given in Table (2).

Results in Table (2) clearly showed that specific weight of basil seeds (weight of 1000 seed in grams) did not affected by foliar application with any of the three tested concentrations of amino acids or seaweed extract. At the same time, all assigned concentrations of amino acids or seaweed extract showed promotive effect on all other seed yield characters of basil plant.

The maximum significant increase in number of inflorescences, seeds per plant, number of fruits per inflorescence and seed yield per plant were detected at 1.5 ml /L, for amino acids, being 33.7, 85.2, 37.7 and 97.7 %, respectively more than untreated plant (control). Also, the same trend was observed by treated with seaweed extract, being 25.4% for number of inflorescences/plant, 64.8% for number of seeds/plant, 33.3% for number of fruits /inflorescence and 86.9% for seed yield per plant, more than control.

Similar findings were obtained by Darwish and Reda [20] on tobacco, El- Bahr *et al*. [21] on Datura, Gamal El-Din *et al*. [22] on Lemon-grass, Reda *et al*. [23] on *Hyoscyamus muticus* L. and Attoa *et al.* [24] on *Iberis amara* L., where different concentrations of amino

Table 1: Effect of applied amino acids and seaweed extract on vegetative growth characteristics of basil (*Ocimum sancatum* L.) plants at 80 days from sowing date (mean of two seasons)

Treatments	Conc. Ml/L	Plant height (cm)	Stem diameter (mm)	No. of branches/plant	No. of leaves/plant	Fresh weight g /plant	Dry weight g /plant
Control	0	56.0	4.0	10.5	243.3	42.3	10.5
Amino acids	0.5	60.3	4.4	12.6	267.5	66.2	13.0
	1.5	64.1	5.0	15.8	291.3	79.4	16.2
	2.5	60.8	4.5	13.0	274.5	67.3	14.5
Seaweed	0.5	57.6	3.9	11.3	256.6	50.2	11.2
	1.0	59.3	4.2	13.6	269.5	55.8	13.3
	1.5	61.5	4.6	15.5	277.6	63.6	15.9
L.S.D. (0.05)		3.17	0. 35	2.02	23.92	8.29	1.88

Table 2: Effect of amino acids and seaweed extract on seed yield components of basil (*Ocimum sancatum* L.) plants at harvest time, 135 days after sowing (mean of two seasons)

Treatments	Conc. Ml/l	No. of Inflorescence/plant	No. of fruits/ Inflorescence	Weight of 1000 seed (g)	No. of seeds/plant	Yield of seed/plant (g)
Control	0.0	84.5	85.0	1.5	28560	42.8
Amino acids	0.5	92	99.5	1.6	36616	58.6
	1.5	113	117.6	1.6	52884	84.6
	2.5	108	112.8	1.5	38024	57.0
Seaweed	0.5	88	85.8	1.5	29568	44.3
	1.0	98	96.9	1.6	37632	60.2
	1.5	106	111.9	1.7	47064	80.0
L.S.D. (0.05)		7.125	11.505	NS	7580	14.022

Table 3: Measurements in microns of certain histological features in transverse sections through the blade of the fourth leaf developed toward the main stem apex of basil at the age of 80 days as affected by foliar application with amino acids and seaweed extract (Means of three sections from three specimens)

	Treatments				
Histological characters	Control	Amino acids (1.5ml/L)	± % to control	Seaweed extract (1.5 ml/L)	± % to control
Midvein thickness	480	590	+22.9	485	+1.5
Lamina thickness	320	340	+6.2	330	+3.1
Palisade tissue thickness	120	128	+6.7	140	+16.7
Spongy tissue thickness	180	198	+10	185	+2.8
Dimensions of the main vascular bundle of midvein					
- Length	170	185	+8.8	195	+14.7
- Width	168	310	+84.5	305	+81.5
Vessel diameter	20	28	+40	23	+15

acids enhanced plant growth. Similarly, it was found a pronounced increase in vegetative growth of basil plant as a result of Lysine and ornithine treatments by Talaat and Youssef [25]. El-Fawakhry and El-Tayeb [26] on *Chrysanthemum*, Mona and Iman [27] on *Pelargonium graveolens* L. plant and Nahed and Balbaa [28] on *Salvia farinacea* plants, they found that amino acids significantly increased vegetative growth.

These results may be due to that amino group compounds contain more amino acids, vitamins as well as some trace elements. The previous studies have been proved that amino acids can directly or indirectly influenced the physiological activities of the plants El-Shabasi *et al.* [29], Awad *et al.* [30], Al-Said and Kamal [31] and Faten *et al.* [32].

Seaweeds stimulate the growth and yield of plants by increasing nutrient uptake, carbohydrates, proteins, free amino acids, polyphenol [33]. Foliar spray of seaweed extract increased yield of cherry tomato, shoot growth and development in *Trigonella foenumgraecum*, being in accordance with the present findings [34].

Anatomical Studies

Anatomy of the Leaf: Microscopical measurements of certain histological characters in transverse sections through the blade of the fourth leaf developed towards the main stem apex of control plants of basil and of those sprayed with 1.5 ml /L with amino acids or seaweed extract are given in Table (3).

Likewise, microphotographs illustrating these treatments are Figure (1). It is noted from Table (3) and Figure (1) that spraying amino acids or seaweed extract at concentration of 1.5 ml/L increased thickness of both midvein and lamina of leaf blades of basil by 22.9 and 1.5 % and 6.2 and 3.1 % more than the control, respectively.

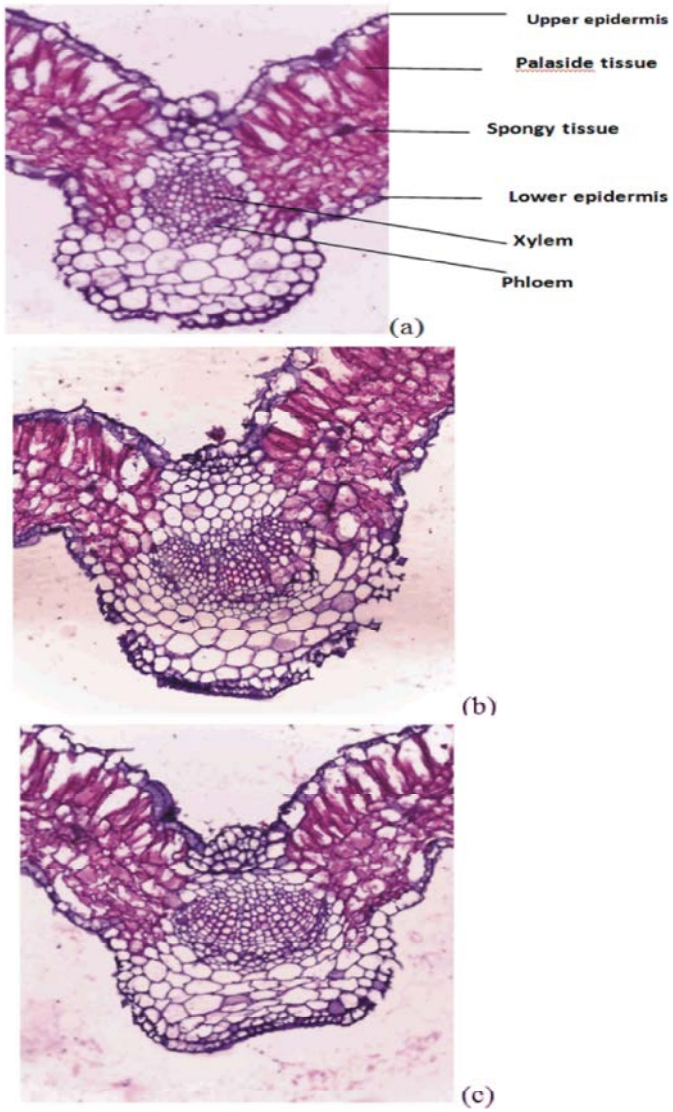

Fig. 1: Transverse sections through the blade of fourth leaf developed toward the main stem apex of basil plant at the age of 80 days, as affected by foliar application with amino acids and seaweed extract (a) Control, (b) Amino acids at 1.5 ml/L and (c) seaweed extract at 1.5 ml/L (40X)

It is clear that the increase in lamina thickness was accompanied with 6.7, 16.7% and 10, 2.8 % increments in thickness of palisade and spongy tissues compared with the control, respectively. Likewise, the main vascular bundle of the midvein was increased in size as a result of spraying amino acids or seaweed extract. The increment was mainly due to the increase in length by 8.8, 14.7% and in width by 84.5, 81.5% more than the control.

Moreover, xylem vessels increased in diameter, being 40 and 15 % more than the control.

Anatomy of the Main Stem: Microscopical measurements of certain histological characters in transverse sections through the median portion of the basil main stem sprayed with amino acids or seaweed extract at 1.5 ml /L and those of control are presented in Table (4). Also, microphotographs depict these treatments are shown in Figure (2).

It is realized from Table (4) and Figure (2) that foliar applications with amino acids or seaweed extract at concentration of 1.5 ml/L, increased the diameter of the main stem by 10.2 and 2.6% more than that of the control. The thickness of epidermis, cortex, phloem and xylem tissues were, 33.3 and 13.3%, 4.7 and 2.9%, 30.4 and 21.0% and 12.9 and 47.6% for amino acids and seaweed extracts, respectively, more than those of the control.

Table 4: Measurements in microns of certain histological features in transverse sections through the median portion of the main stem of basil at the age of 80 days, as affected by foliar application with amino acids or seaweed extract (Means of three sections from three specimens)

	Treatments				
Histological characters	Control	Amino acids (1.5ml/L)	± % to control	Seaweed extract (1.5 ml/L)	± % to control
Main stem diameter	2660	3010	+10.2	2730	+2.6
Epidermis thickness	15	20	+33.3	17	+13.3
Cortex thickness	260	280	+4.7	267.5	+2.9
Phloem tissue thickness	95	150	+30.4	115	+21.0
Xylem tissue thickness	210	350	+12.9	310	+47.6
Parenchymatous pith thickness	1560	1690	+13.6	1487.5	-4.6

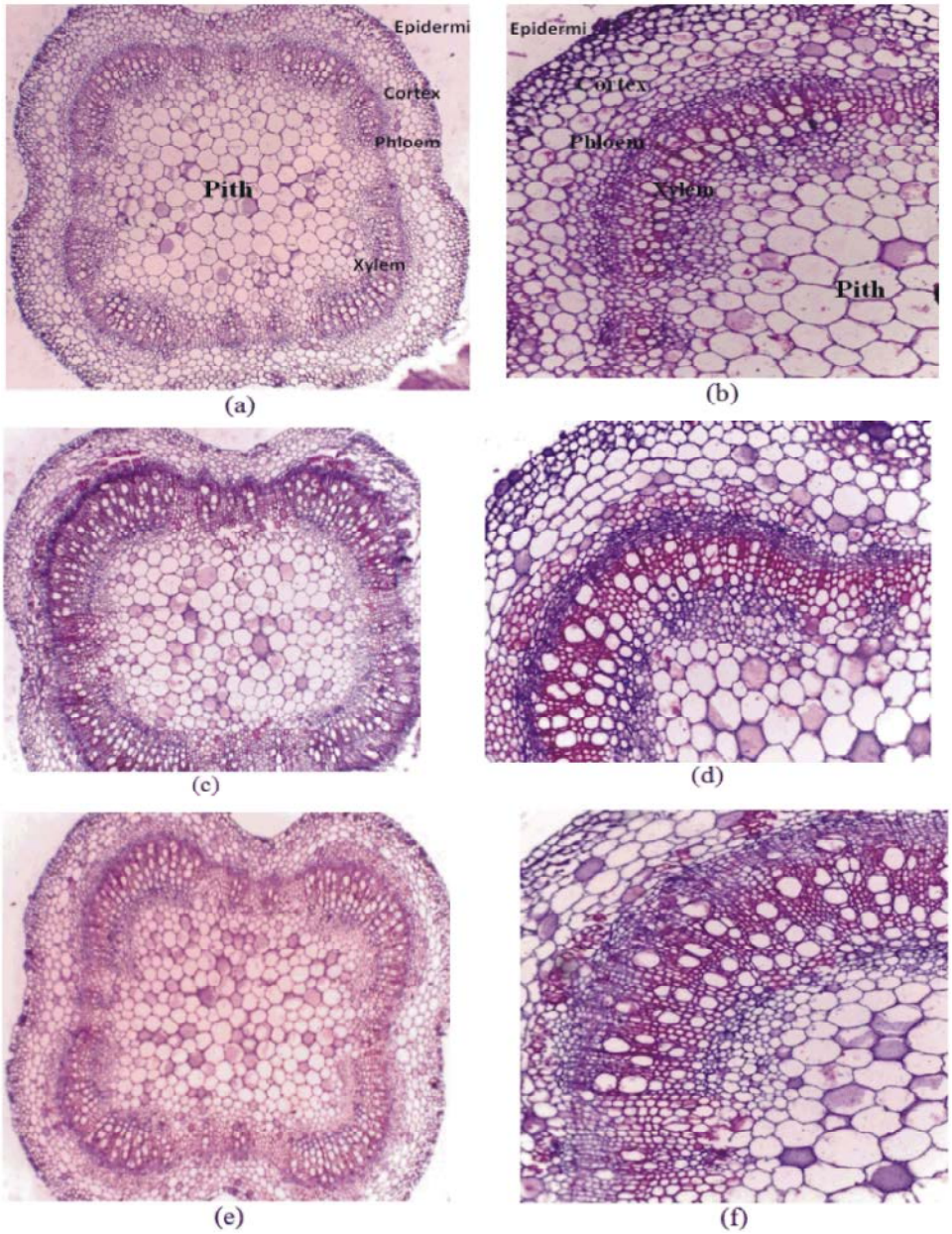

Fig. 2: Transverse sections through median portion of the main stem of basil plant at the age of 80 days, as affected by foliar application with amino acids and seaweed extract (a, b) Control, (c, d) Amino acids at 1.5 ml/L and (e, f) seaweed extract at 1.5 ml/L (40, 100X)

Table 5: Total soluble sugars, total hydrolysable sugars, total protein and total soluble amino acids contents in leaves of basil plant as affected by foliar application with amino acids or seaweed extract

Treatments	Conc. ml/L	Total soluble sugars (mg/g DW)	Total hydrolysable sugars (mg/g DW)	Total protein (mg/g DW)	Total soluble amino acids (m g/g DW)
Control	0.0	3.47667	19.07667	13.08000	1.17667
Amino acids	0.5	6.64667	21.29000	16.51333	1.47000
	1.5	8.80000	25.47667	19.55333	1.76667
	2.5	7.52333	22.99000	17.61333	1.62667
Seaweed	0.5	3.35000	21.22000	13.62667	1.30333
	1.0	3.75667	22.61333	15.47000	1.37000
	1.5	6.66333	24.88000	17.37000	1.45667
L.S.D. (0.05)		0.46303	1.57460	1.90516	0.21519

The percentage increases in parenchymatous pith area in plants treated with amino acids at 1.5 ml/L was 13.6%, while a decrement of 4.6% in parenchymatous pith thickness was observed in plants treated with seaweed extract at 1.5 ml/L less than control.

Majeed and Marhoon [35] reported that the thickness of cortex, vascular cylinder and diameter of vascular units increased significantly when they treated with the higher concentration of each of seaweed and amino acids as well in stem of pepper. Sabh and Shallan [36] studied stem cross sections of bean plant treated with seaweed extract and found that there is a clear increase in the thickness of the epidermis, cortex, size of paranchyma cells and pith with increasing concentrations of extract used in comparison to non-treated plants.

El-Desouky *et al.* [37] and Akladious and Abbas [38] mentioned that the use of a mixture of amino acids at different concentrations led to an increase in stem diameter of tomato plant as a result of increase in the thickness of epidermis and cortex as well as increasing the thickness of xylem, especially the number of vessels, compared to non-treated plants. While Ramya *et al*. [39] reported that materials involved in the composition of seaweed extract, such as natural hormones, act to stimulate many biological processes including cell division and enlargement.

Wareing and Phillips [40] confirmed that auxins action increasing cell growth and differentiation is due to its effect on the liberation of hydrogen ions and increasing the softening of cell wall to ease cell expansion and then build up proteins and nucleic acids that stimulate cell division and increase cell number. Sabh and Shallan [36] stated that the increase in stem diameter of beans plants treated with seaweed extract was caused by an increase in the thickness of the cortex layer and pith as a result of increasing the parenchyma layers number.

This was confirmed earlier on tomato plant, as noted by Akladious and Abbas [38] who mentioned that the use of amino acids has increased the thickness of the cortex layer, with increasing thickness of the xylem resulting from the increased in number of vascular units. Also the result is consistent with the results of El-Desouky, *et al*. [37] on the tomato plant, too.

Effect of Amino Acids and Seaweed Extract on Chemical Constituents

Total Soluble Sugars and Total Hydrolysable Sugars Contents: Data presented in Table (5) indicated that all sprayed concentrations of amino acids or seaweed extract increased significantly total soluble sugars, except that of plants which were sprayed with seaweed extract at concentration of 0.5 and 1 ml /L where the difference with the control proved insignificant in this respect. The maximum significant increase was detected at 0.5 ml /L amino acids, being 153.1% more than control. While application of amino acids or seaweed extract at any of the assigned concentrations increased significantly the total hydrolysable sugars

Results are in agreements with those of Talaat and Youssef [25] on *Ocimum basilicum* L. Wahba *et al*. [6] on *Antholyza aethiopica* plants and Abou Dahab and Abd El-Aziz [41] on *Philedendron erubescens*. Similar results were also reported by Shehata *et al*. [42] using celeriac plants and results indicated that either amino acids or seaweed extract increased total sugar content.

This may be attributed to more than one reason. First, this increase could refer to the existing content of carbohydrate (35 %) and mannitol (4.23 %) in seaweed extract. Second, this increase could refer to the stimulatory effect of seaweed extract on plant regulatin plant bio-physiological activities, which collectively resulted in maintaining higher photosynthetic activities [43].

Table 6: Total soluble phenolic compounds and total flavonoids content in leaves of basil plant as affected by foliar application with amino acids or seaweed extract

Treatments	Conc. (ml/L)	Total soluble phenolic compounds (mg/g DW)	Total flavonoids (mg/g DW)
Control	0.0	140.70000	27.13333
Amino acids	0.5	154.34000	34.07333
	1.5	161.73330	41.05000
	2.5	158.40670	37.09667
Seaweed	0.5	144.29000	29.56000
	1.0	145.71330	30.77333
	1.5	154.59000	37.26667
L.S.D. (0.05)	3.77652	3.69179	

Table 7: Percentages of hydroxyl radical scavenging activity (%) and super oxide radical scavenging activity (%) in leaves of basil plant as affected by foliar application with amino acids or seaweed extract

Treatments	Conc. (ml/L)	Hydroxyl radical scavenging activity (%)	Super oxide radical scavenging activity (%)
Control	0.0	50	63
Amino acids	0.5	53	66
	1.5	58	73
	2.5	56	71
Seaweed	0.5	53	67
	1.0	53	68
	1.5	55	69

Total Protein and Total Soluble Amino Acids Contents: It is realized from Table (5) that all assigned concentration of amino acids or seaweed extract induced significant increase in total protein contents except that of 0.5 ml/L seaweed extract which showed no significant effect in this respect. The most effective treatment in this respect was the amino acids extract at 1.5 ml/L. These results of total protein are similar to Fawzy *et al*. [44] on Chinese garlic plants.

Also there is a significant increase in soluble amino acids content among all treatments except that plants which were sprayed with seaweed extract at 0.5 and 1 ml /L proved insignificant results, while the application of amino acids at 1.5 ml/L caused the highest significant increase compared with other treatments as shown in Table (5).

These results are in agreement with those recorded by Abou Dahab and Abd El-Aziz [41] on *Philedendron erubescens* and Abdel Aziz *et al*. [45] on *antirrhinum majus* and Pise and Sabale [33] on fenugreek.

The effectiveness of bio-stimulators can be due to existence of amino acids that can promote metabolic activities and energize plant metabolism to the maximum levels [46].

The Antioxidant Activity

Total Soluble Phenolic Compounds and Total Flavonoids Contents: All applications of amino acids or seaweed extract increased significantly total soluble phenolic compounds and total flavonoids contents in the leaves, except that of plants which were sprayed with seaweed extract at 0.5 ml /L proved insignificant in this respect. The highest significant increase was achieved at 1.5 ml/L amino acids as shown in Table (6).

Similar results have been reported with El-Awadi and Hassan [47]. Six phenolic compounds isolated from sacred basil, including eugenol, rosmarinic acid, apigenin and three other flavonoids showed good to excellent antioxidant activity *in vitro* [48].

Ardebili *et al*. [49] indicated that foliar application of amino acids, at suitable concentrations, had positive effects on the content of secondary metabolites, antioxidants and antioxidant activity. The stimulated values of biochemical constituents strengthened the role of the applied amino acids in the metabolism of

Aloever Plants

Hydroxyl and Super Oxide Radical Scavenging Activity: Data presented in Table (7) indicated that all sprayed concentrations of amino acids or seaweed extract caused increasing in hydroxyl radical scavenging activity and super oxide radical scavenging activity and the most effective treatment in this respect was the amino acids at 1.5 ml/L followed by the amino acids at 2.5 ml/L then the seaweed extract at 1.5 ml/L.

Several studies have shown sacred basil leaf extract to be radioprotective, to protect against the damaging effects of ionising radiation. Free radical scavenging and antioxidant activity is the likely mechanism involved in this radioprotective effect [50].

Table 8: Chemical composition and their percentages of volatile oil of *Ocimum sanctum* L. herb at 80 days, as affected by foliar application with 1.5 ml/L amino acids and seaweed extract

Components	Control	1.5 ml/L amino acids	1.5 ml/L seaweed extract
Eucalyptol	----	2.57	-----
o-Cymene	4.30	-----	3.45
Benzene, 4-ethyl-1, 2-dimethyl	----	4.90	----
5-Hepten-2-one, 6-methyl	---	1.57	----
Ethyl 2-(5-methyl-5-vinyltetrahydrofuran-2-yl)propan-2-yl carbonatel	10.09	5.05	-----
trans-Linalool oxide (furanoid)	----	7.11	----
cis-Linaloloxide	11.17	----	-----
1, 6-Octadien-3-ol, 3, 7-dimethyl,	16.05	18.73	27.91
Bicyclo[3.1.1]hept-2-ene, 2, 6-dimethyl-6-(4-methyl-3-pentenyl)	----	3.93	----
Cyclohexanol	2.57	----	1.96
Cyclohexanol, 1-methyl-4-(1-methylethenyl)-, cis-	----	2.34	----
Terpinen-4-ol	4.12	7.18	12.60
Humulene	----	----	1.36
Bicyclo[3.1.1]hept-2-ene, 2, 6-dimethyl-6-(4-methyl-3-pentenyl)	-----	----	1.79
Butanoic acid	----	-----	2.25
Limonene	4.37	3.00	----
2H-Pyran-3-ol, 6-ethenyltetrahydro-2, 2, 6-trimethyl	3.92	----	-----
Geraniol	2.25	----	-----
2, 6-Octadien-1-ol, 3, 7-dimethyl	----	4.77	5.66
2, 6-Octadienal, 3, 7-dimethyl	4.13	19.75	16.04
Citral	3.54	8.30	16.20
3-Thiophenecarboxaldehyde	2.37	---	-----
3, 7-Octadiene-2, 6-diol, 2, 6-dimethyl	1.38	---	-----
2-Thiophenecarbonitrile	---	0.97	----
Epoxy-linalooloxide	2.24	---	---
Caryophyllene oxide	----	2.07	0.92
Caryophyllene oxide	5.50	5.60	3.02
Cyclohexanol, 2-methyl-5-(1-methylethyl)	1.40	----	----
Naphthalene, 1, 2, 3, 5, 6, 8a-hexahydro-4, 7-dimethyl-1-(1-methylethyl)-, (1S-cis)-	---	---	0.99
1H-Pyrazole-4-carboxylic acid, 3-amino	2.01	---	----
1, 6-Cyclodecadiene, 1-methyl-5-methylene-8-(1-methylethyl)	---	1.77	----
12-Oxabicyclo	1.36	2.76	1.10
Fumaric acid	----	1.46	-----
3-Buten-2-ol, 2, 3-dimethyl	----	1.48	0.50
Ethyl 2-(5-methyl-5-vinyltetrahydrofuran-2-yl)propan-2-yl carbonate	1.46	----	-----
Benzaldehyde, 2, 5-dimethoxy	1.13	----	----
Fumaric acid, butyl ethyl ester	6.22	----	----
Neric acid	----	1.31	----
Isobutyraldehyde, diethylhydrazone	1.61	---	----
Cyclohexanone, 2-ethyl	1.65	---	----
1-Cyclohexyl-3-isopropylcarbodiimide	1.70	1.10	----
Imidazole-4-carboxylic acid, 1-methyl	0.82	----	----

Bio stimulants, even those containing minerals, are not able to supply all the essential nutrients in the quantities required by plants [51]. But exogenous application of seaweed extract has already been shown to enhance antioxidants status of *Kentucky bluegrass* [52].

Analysis of the Volatile Oil: The composition and percentage of volatile oil of basil herb at 80 days, as affected by foliar spraying with amino acids and seaweed extract at 1.5 ml/L are presented in Table (8). Likewise, components of volatile oil analyzed by GC-MS are shown in Figure (3 a, b and c).

The control plants show 26 compounds, the major constituents of basil were Octadien (16.05%) and cis-Linaloloxide (11.17%) also some amounts of cymene, Terpinen-4-ol, Limonene, Geraniol, Caryophyllene oxide and citral. While, the plants spraying with amino acids at 1.5 ml/L show 23 compounds, the major constituents of

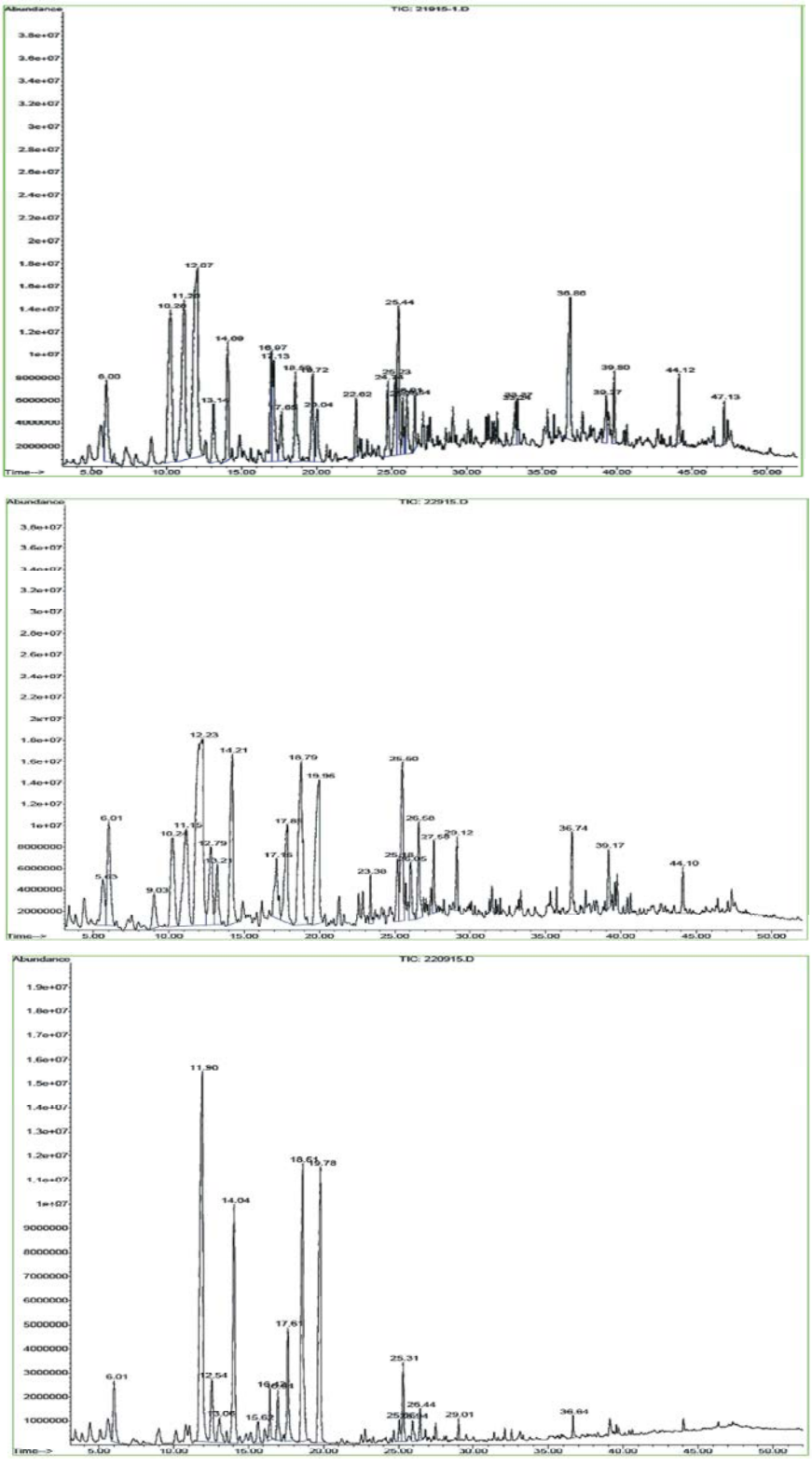

Fig. 3: GC-MS of volatile oil of basil herb at full blooming stage as affected by foliar application with amino acids and seaweed extract. (a) Control, (b) Amino acids at 1.5 ml/L and (c) seaweed extract at 1.5 ml/L

basil were Octadienal (19.75), Octadien (18.37%), trans-Linaloloxide (7.11%) and citral (8.30%). These results show increasing in area percentage compared with control plants also some amounts of Eucalyptol, Terpinen-4-ol, Limonene, Malaoxon, Caryophyllene oxide, fumaric acid and neric acid. On the other side, the plants spraying with seaweed extract at 1.5 ml/L show 17 compounds, the major constituents of basil cultivars were, Octadien (27.91%), citral (16.20%), Octadienal (16.04) and Terpinen-4-ol (12.6%) these results show increasing in area percentage compared with control plants also some amounts of cymenel, Cyclohexanol, Humulene, Malaoxon, Caryophyllene oxide and Butanoic acid.

This is in agreement with the studies of Megbo [53] found that the amount and composition of essential oils in holy basil, *Ocimum sanctum* L. was significantly influenced by the exogenous regulators of plant growth. The resulting oil chromatograms from the most effective samples from the field experiments were compared with control and the target peaks were confirmed by both retention time and mass spectra. The confirmed integrated peaks were used to determine the percentage of each chemical constituent in the essential oil from each sample.

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