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EFFECT OF HUMIC ACID AND ACETYL SALICYLIC ACID ON IMPROVING PRODUCTIVITY OF OREGANO (*ORIGANUM SYRIACUM* L.) PLANT IRRIGATED WITH SALINE WATER

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ABSTRACT: ***This study was conducted at North Sinai Research Station Farm, Desert Research Center, El-Sheikh Zwaid city during the two consecutive seasons of 2014 and 2015 to improve Origanum syriacum L. plant growth and productivity under saline water irrigation (about 3000 ppm) stress conditions. Humic acid (0, 2, 4 and 6 kg.fed^{-1}) were added with irrigation water. Different concentrations of acetyl salicylic acid (0, 500, 750 and 1000 mg.l^{-1}) were sprayed on plants. Experimental design was split plot design with three replicates, since humic acid concentrations were arranged in main plots, while acetyl salicylic acid levels were assigned in sub-plots. Obtained results showed that the highest values of vegetative growth parameters, volatile oil yield and chemical composition were gained with the interaction treatments of 750 or 1000 mg.l^{-1} acetyl salicylic acid combined with 6 kg.fed^{-1} humic acid without significant difference between both treatments. So that, our recommendation is to spray Origanum syriacum L. plants grown under saline water irrigation stress with 750 mg.l^{-1} acetyl salicylic acid with applying 6 kg.fed^{-1} humic acid to avoid the depressive effect of salinity on growth and productivity of Origanum syriacum L. plants.***

Key words: ***Saline water, acetyl salicylic acid, humic acid and Origanum syriacum L.***

INTRODUCTION

Origanum syriacum L. plant is a member of the oral family Lamiaceae and one of the most important medicinal plants of economic importance. This plant is a large, fertile grassy plant splinters, wooden, gray ribbed, covered with brown ophrys and small leaves, simple reverse gray-colored gray, and flowers are found in blue or pink clusters of plant height 50 cm and carries small capsule fruits with small crumpled seeds. The aromatic oil of the plant is found in oil glands scattered on the lower surface of the leaves. It is characterized by the smell of camphor and is used as a folk remedy because of its antiseptic properties and the beneficial effect on digestion. It is used in the treatment of gastrointestinal disorders and various parasitic diseases and is used as a popular remedy for bronchitis, loss of appetite, colitis and liver diseases. It is also used as a mildew, antiseptic, antiseptic, anticonvulsant and analgesic. Oil is used in the pharmaceutical industry (Elhage, 2000). The oil percentage is 1 - 2.5% and the main ingredient of oil is thymol (Amar and Abd El wahab, 2013).

Origanum syriacum L. cultivation is widespread in the Mediterranean region, particularly in North Sinai Governorate, Egypt. The problem of increasing the salinity of irrigation water in recent time is one of the most common problems affecting all plantations in the North Sinai Province, especially in plants which its production depends on the strength of their vegetative growth. These plants are clearly affected by increasing the salinity of irrigation water to the apparent deterioration of productivity. Concerned with tackling this urgent problem by scientific procedures that are inexpensive and applicable to all interested parties in order to preserve our important economic crops, especially our promising medicinal and aromatic plants, which are very reliable to promote agricultural investment in our province. The importance of the materials proposed to improve the tolerance of *Origanum syriacum* L. to salinity, included the use of acetyl salicylic acid which helps plants to resist the stress conditions resulting from the accumulation of salts in the soil (Poor *et al*, 2011), and improves the efficiency of root hairs to absorb nutrients (Shalaby and Razin, 1992). The addition of acetyl salicylic acid led to improved growth (Hamid *et al*., 2012), increased photodynamic (Bastam *et al*., 2013). Using Acetyl salicylic acid as spraying on olive seedlings increased the tolerance of salt-tolerant seedlings due to saline irrigation water in the rate of plant height, length and number of vegetative branches, and wet and dry weight of vegetative and root populations (AL-Taey, 2010).

Humic acid acts as a clavicle containing many organic compounds, amino acids and nutrients, especially potassium, which plays an important role in many biological processes within the plant (Said-Al Ahl *et al*., 2009 and Kava *et al*., 2005). Humic acid might show anti-stress effects under abiotic stress conditions such as unfavorable temperature, salinity, and pH. The major functional groups of humic substance include carboxyl, phenolic hydroxyl, alcoholic hydroxyl, ketone and quinoid (Russo and Berlyn, 1990). Humic substances are well known as stimulators of plant germination and growth (Dell'Amico *et al*., 1994). It was also reported that humic acid application positively affected the traits of plant grown in salinity condition (Türkmen *et al*., 2005). Increasing the humic levels resulted in a significant increase in all cowpea vegetative traits (El-Hefny, 2010).

The present work aimed to improve *Origanum syriacum* L. productivity of herb and volatile oil by using acetyl salicylic acid and humic acid under saline water irrigation, under North Sinai conditions.

MATERIALS AND METHODS

The present study was carried out on *Origanum syriacum* L. Fam. Lamiaceae (Labiatae) at North Sinai Research Station Farm, Desert Research Center, 30 Km East El-Arish City (North Sinai Governorate) during the two successive seasons of 2014 and 2015 to improve growth, productivity and oil production as well as chemical composition of *Origanum syriacum* L. plant by using humic acid and acetyl salicylic acid under saline water irrigation conditions in North Sinai region.

Plant material and procedure

Seedlings of *Origanum syriacum* L. were obtained from North Sinai Research Station, Desert Research Center, North Sinai Governorate. Homogenous seedlings of 12-15 cm height were transplanted in the field on 12th April 2014 and 18th April 2015 at distances of 50 cm between plants and 100 cm between rows (8400 plants/fed.). Drip irrigation system was applied in the whole experiment using drippers with discharge of 4 $l.h^{-1}$ for one hour every 3 days with saline well water (3000 ppm). Organic fertilizer (compost) was added at the rate of 15 m^3 per feddan during soil preparation. Chemical fertilization and other agricultural practices were done according the recommendations of

Ministry of Agriculture and Soil Reclimation.

Humic acid treatments

Four levels of humic acid (0, 2, 4 and 6 $kg.fed^{-1}$) were applied with irrigation water in the form of potassium humic acid. It was added three times. The first one was 15 days after transplanting date and repeated two times at 45 days intervals. It was obtained from the Seed Outlet at the Agricultural Research Center, Giza, Egypt, "Super Canada" produced by the Egyptian Canadian Company for Mobile Phone Trading and Agricultural Consulting in Egypt.

Acetyl salicylic acid treatments

Four levels of the acetyl salicylic acid (0, 500, 750 and 1000 $mg.l^{-1}$) were applied as a foliar application (three sprays per season, every ten days started after two weeks of transplanting). It was dissolved in weak water (0.2 mg/100 H_2O at 20° C). The acetyl salicylic acid was obtained from of Abo Ghaneima Co. for Fertilizer and Chemical Industries, Egypt.

Soil and water analyses

Some mechanical and chemical characteristics of the soil at the experimental site are tabulated in Table (1). The soil samples representing the experiment area was taken at 0-30 cm depth. Water irrigation was obtained from the irrigation wells water of North Sinai Station in El-Sheikh Zwaid, North Sinai. The water analysis is shown in Table (2).

Table (1): Some initial chemical and physical characteristics of experimental farm soil at 0-30 cm depth.

Chemical analysis													
Cations ($meq.l^{-1}$)				Anions ($meq.l^{-1}$)				EC ($d.Sm^{-1}$)	pH	Available micronutrients in soil (ppm)			
Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	Co_3^{--}	Hco_3^{-}	So_4^{--}			Fe	Zn	Cu	Mn
20.0	7.8	14.1	1.0	25.6	-	3.1	14.2	4.29	8.00	2.8	3.6	0.7	5.4

Mechanical analysis			
Clay	Silt	Sand	Texture calls
2.1 (%)	4.9 (%)	93.3 (%)	Sandy soil

Table (2): Some initial chemical and physical characteristics of irrigation water.

EC ($dS.m^{-1}$)	pH	Cations ($meq.l^{-1}$)				Anions ($meq.l^{-1}$)			
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{-}	HCO_3^{-}	Cl^{-}	SO_4^{-}
4.46	7.8	8.5	9.29	23.5	0.18	1.00	3.00	27.5	9.97

Experimental design and Statistical analysis

The layout of the experiment was completely randomized block design in split plot design with three replications. Humic acid concentrations were randomly arranged in the main plots, while acetyl salicylic acid concentrations were randomly assigned at sub-plots. All collected data were analyzed with analysis of variance (ANOVA) procedure using MSTAT-C statistical software package (Michigan state University, 1983). Differences between means were compared by using Duncan multiple range test at 0.05 (Duncan, 1955).

Observations and Measurements

Vegetative growth and herb yield

a. Plant height (cm).
b. Herb fresh weight/plant (gm).
c. Herb dry weight/plant (gm).
d. fresh and dry herb yields (kg/fed) were calculated based on fresh and dry weights of plant.

Oil yield characteristics

Oil yield per plant was calculated as follows:

$$\text{Oil yield per plant (ml)} = \frac{\text{Oil percentage X Herb dry weight}}{100}$$

Oil yield per feddan (L.) was calculated as follows:

$$\text{Oil yield per feddan (L.)} = \text{oil yield per plant} \times \text{number of plants/fed}$$

Gas chromatography – mass spectrometry (GC-MS) analysis

The chemical composition of essential oil samples were performed using Trace GC 1310-ISQ mass spectrometer (Thermo Scientific, Austin, TX, USA) with a direct capillary column TG–35MS (30 m x 0.25 mm x 0.25 µm film thickness). The column oven temperature was initially held at 55°C and then increased by 5°C /min to 300°C with hold 5 min. The injector temperature was kept at 250°C. Helium was used as a carrier gas at a constant flow rate of 1 ml/min. The solvent delay was 2 min and diluted samples of 1 µl were injected automatically using Autosampler AS3000 coupled with GC in the split mode. Mass spectra were collected at 70 eV ionization voltages over the range of m/z 50–650 in full scan mode. The ion source and transfer line temperatures were set at 200 and 300°C, respectively. The components were identified by comparison of their retention times and mass spectra with those of WILEY 09 and NIST 11 mass spectral database.

RESULTS AND DISCUSSION

Vegetative growth parameters

The interaction effect between different concentrations of acetyl salicylic acid and humic acid on some vegetative growth parameters of *Origanum syriacum* L. are presented in Table (3). All vegetative growth parameters (plant height, plant fresh and dry weights) were significantly increased when the maximum humic acid concentration (6 $kg.fed^{-1}$) was applied with high concentrations of acetyl salicylic acid (750 or 1000 $mg.l^{-1}$) during both seasons and at both cuts.

This result is similar to that reported by AL-Taey (2010) on olive seedlings; since he concluded that using salicylic acid (1000 $mg.l^{-1}$) as spray led to increase plant height. Also, Rivas-San and Plasencia (2011) suggested that the growth promoting effects of SA could be related to changes in the hormonal status or by improvement of photosynthesis, transpiration, and stomata conductance. This can ultimately enhance yield. In addition, Bayat *et al*. (2012) on *Calendula*

Table 3

Table 3

officinalis L. showed that foliar application of SA resulted in greater plant height, as well as El-Esawi *et al.* (2017) on *Rosmarinus officinalis* L. plants, showed that SA treatments significantly enhanced plant growth as well as fresh and dry weights.

Accordingly, Rao *et al.*, (1987) pointed that humic acid improves physical, chemical and biological conditions of soil. It breaks up clay and compacted soils, assists in transferring micronutrients from the soil to the plant, enhances water retention, increases seed germination rates, improves nutrient absorption, plant growth and penetration and stimulates the development of microflora populations. The direct effects on plant growth is due to the increase of cell chlorophyll content, the acceleration of the respiration process, hormonal growth responses, increasing substances penetration to plant membranes, affect the dry matter production and the uptake of nutrients by plants. Also, Türkmen *et al.* (2005) reported that the application of humic acid has a positive effect on plants that grow in salinity status.

Moreover, Said-Al Ahl *et al.* (2016) mentioned that, humic substances used for plant nutrition, enhance root, plant growth and seed yield. However, humic acid had significant impact on plant height, number of branches, dry weight and yield of basil. Humic acid increased root growth by increasing cell elongation or root cell membrane permeability therefore increased water and nutrients uptake by increasing root surface area, so improving plant growth, development and carbohydrates content.

Herb yield and oil characteristics

Data in Table 4 show significant effects for the interaction of applying humic acid with acetyl salicylic acid treatments on all traits of yield and its components in both seasons. The maximum values of these parameters were belonged to the interaction of the highest concentration (6 $kg.fed^{-1}$) of humic acid combined with high concentrations (750 or 1000 $mg.l^{-1}$) acetyl salicylic acid.

The positive effect of humic acid which demonstrated here has been described by Aiyafar *et al.* (2015) who investigated the effect of humic acid on yield, and yield components of black cumin (*Nigella sativa* L.). They concluded that application of humic acid increased the yield and yield components as well as essential oil percentage and essential oil yield.

The enhancing effect of acetyl salicylic acid on herb yield was previously observed by Refat *et al.* (2017) on *Helianthus annuus* L., who showed that SA treatment increased ultimately yield. Also, Rivas-San and Plasencia (2011) suggested that the growth promoting effects of SA could be related to changes in the hormonal status or by improvement photosynthesis, transpiration, and stomata conductance. This can ultimately enhances yield and plants fresh and dry weights.

Analysis of *Origanum syriacum* L. volatile oil components by GC-MS

Data in Table 5 show that the effect of the interaction treatment of 6$Kg.fed^{-1}$humic acid combined with 1000 $mg.l^{-1}$ acetyl salicylic acid on essential oil component compared with untreated plants (control). This interaction treatment had the superiority compared with all other investigated treatments regarding essential oil production. Essential oil GC-MS analysis shows that 21 compounds could be identified in this oil. The major components were thymol followed by γ-Terpinene, Terpinolene,

Table 4

Table 4

Table (5): Effect of 6 kg.fed^{-1} humic acid combined with 1000 mg.l^{-1} acetyl salicylic acid on *Origanum syriacum* L. essential oil component.

No.	Component	Composition	
		$S_{1000}H_6$	S_0H_0
1	α-Pinene	2.32	2.55
2	Sabinene	0.79	---
3	Camphene	0.14	0.19
4	β-Pinene	0.23	0.27
5	Myrcene	2.75	2.40
6	D-Limonene	0.11	---
7	Thymol	26.05	23.42
8	γ-Terpinene	15.89	14.74
9	α-Terpinene	11.36	11.25
10	Terpinene-$_4$-ol	---	4.50
11	Linalool	0.36	0.55
12	Borneol	0.18	---
13	p-Cymene	7.05	6.82
14	Cis-Sabinene hydrate	---	1.3
15	Trans-Sabinene hydrate	---	0.95
16	1, 8-Cineol	0.34	0.40
17	Terpinolene	12.35	10.27
18	Carvacrol	9.64	9.23
19	Carvone	0.27	0.39
20	Isoborneol	2.13	2.51
21	*β*-Caryophyllene ne	1.29	1.64
	Total	93.52	93.38

S_0: Without acetyl salicylic acid, S_{1000}: (1000 mg. l^{-1}) acetyl salicylic acid, H_0:Without humic acid, H_6: (6 Kg.fed^{-1}) humic acid

α-Terpinene, Carvacrol, p-Cymene, Myrcene, α-Pinene, Isoborneol and β-Caryophyllene. A glance on obtained data reveal that treating plants with acetyl salicylic acid (1000 mg.l^{-1}) and huimc acid (6 kg.fed^{-1}) could enhanced some main essential oil component percentages such as Thymol, γ-Terpinene, p-Cymene and Terpinolene. The noticeable observation that sabinene, D-limonene and Borneol compounds only detected when plants were treated with both investigated compounds, while, Terpinene-4-ol, Cis-Sabinene hydrate and Trans-Sabinene hydrate compounds were dissappered from essential oil obtained from plants treated with 1000 mg.l^{-1} acetyl salicylic acid and 6 kg.fed^{-1}huimc acid.

Consulting the above mentioned results shows that the most promising treatments were the combination between the highest concentration (6 kg. fed^{-1}) of humic acid and high concentrations (750 or 1000 mg.l^{-1}) of acetyl salicylic acid. These treatments gave the highest values of all investigated traits. From the economical point of view it is favorable to use the lower coast combination treatment (6 kg.fed^{-1} humic acid and 750 mg.l^{-1} acetyl salicylic acid).

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تأثير حمض الهيوميك وحمض السالسليك على تحسين إنتاجيه نبات الاوريجانو تحت ظروف الرى بمياه مالحة

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الملخص العربى

أجريت هذه التجربة على نبات الاوريجانو أحد نباتات العائلة الشفوية بمزرعة محطة بحوث شمال سيناء (الشيخ زويد) التابعة لمركز بحوث الصحراء ، خلال موسمين متعاقبين (2014 و 2015) بهدف تحسين نمو وإنتاجية نبات الاوريجانو النامى تحت ظروف اجهاد الرى بالماء المالح (حوالى3000 جزء فى المليون) وذلك باستخدام حامض الهيوميك وحامض السالسيلك حيث تم إضافه حمض الهيوميك مع مياه الرى بمعدل صفر، 2، 4، 6 كجم للفدان، أما حمض السالسيلك فقد تم إضافته رشاً على النباتات بتركيزات صفر و500و750 و1000 مللجم/ لتر. و قد صممت التجربه بنظام القطاعات كامله العشوائيه في قطع منشقه مره واحده يحتوي كلاً منها على ثلاث مكررات حيث وزعت معاملات حمض الهيوميك في القطع الرئيسية عشوائياً، ووزعت معاملات حمض السالسيلك عشوائياً في القطع تحت المنشقه. وقد أظهرت النتائج المتحصل عليها أن أعلى القيم لصفات النمو الخضري و محصول الزيت الطيار و المكونات الكيميائية له قد تحققت مع الرى بحمض الهيوميك بتركيز 6 كجم/فدان ورش هذه النباتات بحمض السالسيلك بتركيز 750 او 1000 ملجم / لتر بدون فرق معنوى بين كلتا المعاملتين. لذا فاننا نوصى برش نباتات الاوريجانو النامية تحت ظروف الرى بالماء المالح بحمض السالسيلك بتركيز 750 ملجم / لتر مع ريها بحمض الهيوميك بمعدل 6 كجم / فدان وذلك لتجنب التاثير المثبط للملوحة على نمو وإنتاجية نبات الاوريجانو .

الكلمات الإسترشادية: إنتاجية، نباتات الاوريجانو، حمض السالسيلك ، حامض الهيوميك، الري بالمياه المالحة.

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Table (3): Effect of interaction between humic acid and acetyl salicylic acid on vegetative growth parameters of *Origanum syriacum* L. during 2014 and 2015 seasons.

Treatment		First season 2014			Second season 2015		
Humic acid ($kg.fed^{-1}$)	Acetyl salicylic acid ($mg.l^{-1}$)	Plant height (cm)	Herb fresh weight /plant (g)	Herb dry weight /plant (g)	Plant height (cm)	Herb fresh weight /plant (g)	Herb dry weight /plant (g)
		First Cut					
0.0	0.0	27.73h	63.33l	21.11jk	28.19h	74.23k	24.74ij
	500	28.83g	73.89k	24.63j	29.49g	86.31j	28.77i
	750	30.57f	111.11j	37.04i	30.97fg	119.14i	39.71h
	1000	31.07e	120.00i	40.00h	31.31f	121.24hi	40.41g
2	0.0	31.33e	121.78hi	40.59gh	31.71ef	124.22h	41.41fg
	500	31.47e	124.78h	41.59g	31.77ef	131.31g	43.77f
	750	32.27de	136.44g	45.48fg	32.95e	142.21fg	47.40ef
	1000	32.80de	142.33f	47.44f	33.31de	149.13f	49.71e
4	0.0	32.91de	148.33ef	49.44ef	33.35de	152.16e	50.72de
	500	33.20d	149.78e	49.93e	33.51d	156.12de	52.04d
	750	34.10cd	154.31d	51.44d	34.17cd	159.11d	53.04cd
	1000	35.20c	161.56cd	53.85cd	36.01c	165.21cd	55.07c
6	0.0	40.55b	166.21c	55.40c	41.09b	169.34c	56.45bc
	500	41.43ab	175.11bc	58.37bc	41.81ab	177.24b	59.08b
	750	42.13ab	175.78b	58.59b	42.51ab	182.19ab	60.73ab
	1000	43.70a	181.00a	60.33a	44.63a	185.14a	61.71a

Means followed by the same letter(s) within each column are not significantly different at the 0.05 level, according to Duncan's multiple range test.

Table (3): Cont.

Treatment		First season 2014			Second season 2015		
Humic acid (kg.fed^{-1})	Acetyl salicylic acid(mg.l^{-1})	Plant height (cm)	Herb fresh weight /plant (g)	Herb dry weight /plant (g)	Plant height (cm)	Herb fresh weight /plant (g)	Herb dry weight /plant (g)
Second cut							
0.0	0.0	30.37g	78.42k	26.14j	30.93g	86.42k	28.81i
	500	31.07fg	88.39j	29.46i	31.35f	97.21j	32.40h
	750	31.85f	117.89i	39.30h	32.19ef	111.22ij	37.07gh
	1000	32.34ef	123.86hi	41.29gh	32.93ef	118.89i	39.63g
2	0.0	33.05e	127.28h	42.43g	33.59e	126.05h	42.02f
	500	33.77e	131.12gh	43.71fg	34.23de	132.78gh	44.26ef
	750	34.01de	135.28g	45.09f	34.49de	139.61g	46.54e
	1000	34.31d	149.55f	46.14ef	34.79de	153.05fg	51.02de
4	0.0	35.49cd	155.78e	51.93de	35.91d	154.72f	51.57de
	500	35.77cd	157.22de	52.41d	36.31cd	159.11ef	53.04d
	750	35.96cd	159.05d	53.02cd	36.51cd	159.89e	53.30cd
	1000	36.92c	161.89cd	53.96c	37.21c	162.55d	54.18c
6	0.0	41.80b	169.22c	56.41bc	41.97b	171.22cd	57.07bc
	500	42.43ab	173.12b	57.71b	42.93ab	179.52c	59.84b
	750	43.45ab	176.21ab	58.74ab	43.75ab	186.12b	62.04ab
	1000	45.05a	179.23a	59.74a	45.67a	192.31a	64.10a

Means followed by the same letter(s) within each column are not significantly different at the 0.05 level, according to Duncan's multiple range test.

Table (4): Effect of interaction between humic acid and acetyl salicylic acid on herb yield and oil production of *Origanum syriacum* L. in 2014 and 2015 seasons.

Treatment		First season 2014					Second season 2015				
Humic acid ($kg.fed^{-1}$)	Acetyl salicylic Acid ($mg.l^{-1}$)	Fresh herb yield ($kg.fed^{-1}$)	Dry herb yield ($kg.fed^{-1}$)	Essential oil (percentage)	Essential oil (ml)	Essential oil yield ($L.fed^{-1}$)	Fresh herb yield ($kg.fed^{-1}$)	Dry herb yield ($kg.fed^{-1}$)	Essential oil (percentage)	Essential oil (ml)	Essential oil yield ($L.fed^{-1}$)
						First cut					
0	0.0	532.00l	177.33jk	2.35i	0.50j	4.17i	623.53k	207.84ij	2.57h	0.74i	5.34i
	500	620.67k	206.89j	3.94hi	0.72i	6.08h	725.00j	241.67i	2.95gh	1.00h	7.13h
	750	933.33j	311.11i	3.03h	1.12hi	9.43gh	1000.78i	333.59h	2.27g	1.45gh	7.57gh
	1000	1008.00i	336.00h	3.20gh	1.28h	10.75g	1018.42hi	339.47g	3.62fg	1.55g	12.29g
2	0.0	1022.93hi	340.98gh	3.25gh	1.32gh	11.08fg	1043.45h	347.82fg	3.69f	1.81fg	12.83fg
	500	1048.13h	349.38g	3.47g	1.44g	12.12f	1103.00g	367.67f	3.73ef	1.91f	13.71f
	750	1146.13g	382.04fg	3.96fg	1.68fg	14.10ef	1194.56fg	398.19ef	3.81e	1.99ef	15.17ef
	1000	1195.60f	398.53f	3.76f	1.78f	14.98e	1252.69f	417.56e	3.90de	2.22e	16.28e
4	0.0	1246.00ef	415.33ef	4.27e	2.11e	17.73de	1278.14e	426.05de	4.05d	2.53d	17.25de
	500	1258.13e	419.38e	4.33de	2.16de	18.16d	1311.41de	437.14d	4.15cd	2.59d	18.14d
	750	1296.20d	432.07d	4.60e	2.37d	19.88cd	1336.52d	445.51cd	4.19c	2.70cd	18.67cd
	1000	1357.07cd	452.36cd	4.93c	2.65cd	22.30c	1387.76cd	462.59c	4.22bc	2.87c	19.52c
6	0.0	1396.16c	465.39c	5.13bc	2.84c	23.87bc	1422.46c	474.15bc	4.27b	3.14bc	20.25bc
	500	1470.93bc	490.31bc	5.40b	3.15b	26.48b	1488.82b	496.27b	4.35ab	3.24b	21.59b
	750	1476.53b	492.18b	5.47ab	3.21ab	26.92ab	1530.40ab	510.13ab	4.36ab	3.44ab	22.24ab
	1000	1520.40a	506.80a	5.51a	3.32a	27.92a	1555.18a	518.39a	4.43a	3.55a	22.96a

Means followed by the same letter(s) within each column are not significantly different at the 0.05 level, according to Duncan's multiple range test.

Table (4): Cont.

Treatment		First season 2014					Second season 2015				
Humic acid (kg.fed^{-1})	Acetyl salicylic Acid (mg.l^{-1})	Fresh herb yield (kg.fed^{-1})	Dry herb yield (kg.fed^{-1})	Essential oil (percentage)	Essential oil (ml)	Essential oil yield (L.fed^{-1})	Fresh herb yield (kg.fed^{-1})	Dry herb yield (kg.fed^{-1})	Essential oil (percentage)	Essential oil (ml)	Essential oil yield (L.fed^{-1})
Second cut											
0	0.0	658.73k	219.58j	2.84i	0.64i	6.24i	725.93k	241.98i	2.65i	0.76i	6.41j
	500	742.48j	247.49i	3.41h	0.85h	8.44h	816.56j	272.19h	3.49h	1.13h	9.50i
	750	990.28i	330.09h	3.68g	0.90gh	12.15gh	934.25ij	311.42gh	3.63g	1.35gh	11.30h
	1000	1040.42hi	346.81gh	3.75fg	1.46g	13.01g	998.68i	332.89g	3.70fg	1.47g	12.32gh
2	0.0	1069.15h	356.38g	4.26f	1.53fg	15.18fg	1058.82h	352.94f	3.76f	1.58fg	13.27g
	500	1101.41gh	367.14fg	4.36ef	1.63f	16.01f	1115.35gh	371.78ef	3.80ef	1.69f	14.16fg
	750	1136.35g	378.78f	4.41e	1.81ef	16.70ef	1172.72g	390.91e	3.84e	1.79ef	15.01f
	1000	1256.22f	418.74ef	4.45e	1.94e	18.63e	1285.62fg	428.54de	3.91de	1.99e	16.76ef
4	0.0	1308.55e	436.18de	4.88de	2.05de	21.29de	1299.65f	433.22de	3.99d	2.06de	17.29e
	500	1320.65de	440.22d	4.95d	2.16d	21.79d	1336.52ef	445.51d	4.04cd	2.14d	18.00d
	750	1336.02d	445.34cd	5.09cd	2.22cd	22.67cd	1343.08e	447.69cd	4.06cd	2.16cd	18.18d
	1000	1359.88cd	453.29c	5.32c	2.32c	24.12c	1365.42d	455.14c	4.74c	2.22c	18.66cd
6	0.0	1421.45c	473.82bc	5.57bc	2.41bc	26.39bc	1438.25cd	479.42bc	4.19bc	2.39bc	20.09c
	500	1454.21b	484.74b	5.61b	2.57b	27.19b	1507.97c	502.66b	4.24b	2.54b	21.31b
	750	1480.16ab	493.39ab	5.86ab	2.65ab	28.91ab	1563.41b	521.14ab	4.30ab	2.67ab	22.41ab
	1000	1505.53a	501.84a	5.94a	2.73a	29.81a	1615.40a	538.47a	4.89a	2.85a	23.96a

Means followed by the same letter(s) within each column are not significantly different at the 0.05 level, according to Duncan's multiple range test.