Journal Tikrit Univ. For Agri. Sci. Vol. (18) No.(1) – 2018
ISSN-1813-1646

Effect of Organic Fertilizer Addition and Spraying Seaweed Extract on Some Growth Characters, Yield and Active Ingredient of Arugula Plant (*Eruca sativa* Mill)

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Key words:
Organic fertilization, mushroom culture wastes, composites, Algamex, and Arugula plant.

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Received: 31/5/2017
Accepted: 13/6/2017

ABSTRACT

The experiment was conducted at the horticulture and garden landscape department field/college of Agriculture/ Tikrit University in Salah Alden area, at the growing season of 2016-2017, to study the effect of organic fertilizer (mushroom culture wastes composites), addition and spraying of seaweed extract (Algamex) on arugula plant (*Eurica sativa* Mill.) and effect of vegetative growth, yield, and active ingredient.

The experiment included 24 experimental units results of combination of experimental factors. The first factor was addition of mushroom culture wastes (composites) at a percentage of 10% calculated on experimental unit size, in addition to the control treatment (no addition). The second factor was spraying with seaweed extract with three levels in addition to the control treatment (no spraying), as followed: B1 sprayed with water only, B2 2.0 ml. liter^{-1} seaweed, B3 4 ml. liter^{-1}, and B4 6 ml. liter^{-1} with their combinations. The experiment planned and analyzed on Randomized Complete Block Design at three replications. The results were compared used Duncan's multi-variance at probability level of 0.05. The results were; the addition of mushroom culture waste was dominated in most of the study compared with control treatment (no addition). The spraying treatment of 6 ml. liter^{-1} was dominated to get the highest results of the plant height feature. The combination was significantly clear with 10% addition and spraying with 6 ml. liter^{-1} to give the highest values of studied features including plant height, leaf number, fresh weight, dray weight, leaf area, total yield as the means were 45.00 cm, 53.33 leaf. plant^{-1}, 213.10 gm. Plant^{-1}, 49.80 gm. Plant^{-1}, 113.40 cm^2, and 2.59 kg. experimental unit^{-1} respectively, compared with other treatments. The correlation results gave a positive correlation between the studies features. There was positive effect of the secondary production in the plant; as the combination of 0.0 composite + 4 ml. liter^{-1} gave a highest concentration of Resorcinol compound 0.14%. The treatment of 10% + 4 ml. liter^{-1} gave the highest value 0.042% of Catechol. The treatment of 10% + 0.00 gave the highest value 0.136% of Ascorbic acid.

تأثير إضافة السماد العضوي والرش بمستخلصات الأعشاب البحرية في بعض صفات النمو الخضري، الحاصل والمركبات الفعالة في نبات الجرجير ***Eruca sativa*** **Mill**

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الخلاصة

نفذت تجربة حقلية في احد الحقول التابعة لقسم البستنة وهندسة الحدائق / كلية الزراعة / جامعة تكريت خلال الموسم الزراعي 2016–2017 لدراسة تأثير التسميد العضوي (إضافة مخلفات وسط زراعة الفطر الكومبوست) والرش بمستخلص الأعشاب البحرية الجامكس على نبات الجرجير وتأثيرها على بعض الصفات الخضرية والحاصل والمواد الفعالة، تضمنت التجربة 24 وحدة تجريبية ناتجة من تداخل عاملي التجربة، العامل الأول هو إضافة مخلفات وسط زراعة الفطر (الكومبوست) بنسبة 10% محسوب على أساس حجم الوحدة التجريبية إضافة الى معاملة المقارنة (بدون إضافة). العامل الثاني هو الرش بمستخلص الأعشاب البحرية (الجامكس) بثلاث مستويات إضافة الى معاملة المقارنة وكالاتي: B1 (رشت بالماء فقط) ، B2 (2 مل.

الكلمات المفتاحية :
التسميد العضوي ، مخلفات وسط زراعة الفطر ، الكومبوست، الجامكس، الجرجير .

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لتر$^{-1}$ الجامكس) B3 (4 مل.لتر$^{-1}$ الجامكس) B4 (6 مل.لتر$^{-1}$ الجامكس) وتداخلاتهما نفذت التجربة بتصميم القطاعات العشوائية الكاملة RCBD وبثلاث مكررات، قورنت النتائج باختبار دنكن متعدد الحدود عند مستوى احتمال 0.05 وكانت النتائج كما يلي: تفوقت معاملة إضافة مخلفات وسط زراعة الفطر (كومبوست) في اغلب الصفات المدروسة متفوقةً على معاملة المقارنة ، اما الرش بمستخلص الأعشاب البحرية (الجامكس) فقد تفوقت المعاملة التي رشت بالمستوى 6 مل.لتر$^{-1}$ الجامكس في إعطاء اعلى القيم لأغلب الصفات المدروسة، التداخل كان معنوياً تفوقت فيه المعاملة 10% + 6 مل.لتر$^{-1}$ الجامكس في إعطاء اعلى القيم للصفات ارتفاع النبات ، عدد الأوراق ، الوزن الطري ، الوزن الجاف ، المساحة الورقية ، والحاصل الكلي بلغت متوسطاتها: 45.00 سم، 53.33 ورقة. نبات$^{-1}$، 213.10 غم. نبات$^{-1}$، 49.80 غم. نبات$^{-1}$، 113.40 سم2 و2.59 كغم. وحدة تجريبية$^{-1}$، على التوالي متفوقةً على باقي المعاملات ومعاملة المقارنة، من نتائج الارتباط نجد ان هناك علاقات ارتباط موجبة بين الصفات المدروسة، ونتج عن الدراسة تأثير إيجابي لعوامل الدراسة على مركبات الايض الثانوي حيث أعطت المعاملة صفر كومبوست + 4 مل.لتر$^{-1}$ الجامكس اعلى قيمة بلغت 0.14% لمركب Resorcinol وان المعاملة 10% كومبوست + 4 مل.لتر$^{-1}$ الجامكس أعطت اعلى قيمة بلغت 0.042 % لمركب Catechol وان المعاملة 10% كومبوست + صفر الجامكس أعطت اعلى قيمة بلغت 0.136 % لمركب Ascorbic acid .

INTRODUCTION

Arugula (*Eruca sativa* Mill.) plant one of the plants of Brassicaseae (Cruciferae) family. Arugula plant is a kind of standing plant reached about 30-60 cm in height with large and condensed leaves. The leaves are lobed with long petioles and chili taste. Its flowering is from mid of March to July. The flowers are small with white colors (Charkravaty, 1976). It is considered an important plant for its multiuse and multipurpose, Arugula contains vitamins A, B, and C, in addition to minerals such as Calcium, Sulfur, Iodide and others (Al-Digouy,1996). There are different medicinal uses and applications as it activates body against cancer, and it is antitumor, anti-enlarge of lymphatic glands. It helps digestion, filter the blood, and activates blood circulation, (Hila et. al., 2009). Younis (2005) reported that arugula oil reduced cholesterol and total fat percent in the body. Arugula also is used in some cosmetic products such as soup, shampoo, in addition to its application in biofuels and some flavors and appetites, (Mohammad and Rafiq, 2009). Roweha (1983), declared that arugula could be used to improve erectile dysfunction, reduce blood sugar, to treat some burns, skin infections, and hair fall. The arugula oil reported to improve some of the liver functions, improve semen's fertility, and sexual hormones, (Merza et. al., 2000).

The soils experimental are mostly gypsiferous soils that are characterized by low organic matter and contents with a deficiency of macro and micro nutrients due to the lack of gypsiferous soils with important nutrient minerals for plant growth (Al-Zubaidy, 1992). Generally, the chemical fertilizers are used when cultivate vegetables more than other agricultural crops because vegetables are cultivated more than one season and their short rotation. The chemical fertilizers cause many side effects on human health because of the nitrates accumulation especially with leafy vegetables, which is about 80% of cultivated vegetables in human consumption, compared to other sources of nitrates, (Brighton, 2001). In order to eliminate these problems, a new direction has been rise up to use organic fertilizers for cultivation and especially vegetables. The organic fertilizers are characterized by low contents of nitrates and oxalates, (Abu-Rayan, 2010). In addition to that, the organic fertilizers improve the physical and chemical features of soil and its nutrient contents to meet the plant growth needs. The organic fertilizers improve soil texture and increase water-holding capacity (Al-Hidad, 1998). Abdul Rahaman and Ramadan (2015) reported that the fertilization with poultry manure significantly increased the chlorophyll content of cabbage leaves compared to mushroom wastes fertilizer. While mushroom waste fertilizer got the highest oil

contents to give 0.056%. The chemical fertilizers substitute started using sea weed because of their contents of macro and micro nutrients and plant auxins, gibberellins, and cytokinins, (Blunden, 1991). The addition of sea weed increased the supply of micronutrients to the plant and increased the plant resistant to frost and reduced the chlorophyll breaking down, (Travena, 2007). Abdul Rahaman (2014) showed that spraying of radish plants with Alga 600 extract, significantly increased the plant height and total chlorophyll along with dry matter of leaves.

Due to the shortage of studies on arugula plant especially the production and active ingredient, so this study was planned to find out the response to the addition of composite and spraying of sea weed extract (Algamex), and their effect on arugula plant growth and some active ingredient.

MATERIALS AND METHODS

The experiment was performed at the horticulture field and garden landscaping department/ college of Agriculture/ Tikrit university on the cultiving season of 2016-2017. The land prepared by cultivation using cultivator followed by leveling and soil reducing particle size. The experiment planned with Randomized Complete Block Design (RCBD), with two combined factors. It was divided into three replications with distance between them of 70 cm. Each replicate contains experimental units in which they are plots with dimensions of 100 X 100 cm, and the distance between the plots was 60 cm in the same replicate. Each replicate included 8 plots of factors combination. The first factor was addition of mushroom wastes (Composites) at two levels; the ferst (0.0 addition) and the second level was 10% fertilizer of mushroom wastes calculated based on soil volume of experimental unit at a depth of 0-30 cm.

The second factor was spraying with seaweed extract (Algamex) at four concentrations:

1. Control treatment 0.00 ml. liter $^{-1}$, sprayed with water alone.
2. 2 ml. liter^{-1}
3. 4 ml. liter^{-1}
4. 6 ml. liter^{-1}

And their combinations, so the experiment included 24 experimental units (plot) based on combination of factors one and two distributed on three replicates:

(2 X 4X 3) = 24.

Table 1, explain some content and properties of mushroom wastes Composites and algamex seaweed.

mushroom wastes	
properties	SMC
C %	38.80
N %	2.61
Organic matter %	66.89
Phosphorous %	0.55
Organic nitrogen %	1.89
Iron %	0.92
Potassium %	1.03
Calcium %	6.16
Zinc ppm	136.41
Copper ppm	61.68
ph	8.05
N : P : K ratio	1.9 : 0.6 : 1.0

algamex	
content	w/w
Total nitrogen	0.3-0.6
Phosphorous	0.26-0.3
Potassium	3.3-5.1
Calcium	0.05-0.1
Iron ppm	46-75
Copper ppm	9-15
Zinc ppm	5-43
Organic matter w/w	13-16

The compound fertilizer was added (as recommended) at an amount of 200 kg. hectare $^{-1}$ (according to the manufacturer), for all the experimental units. The composite added to the experimental units as a

factor and mixed with the soil. On October 25, 2016. The seeds were sowed by broadcasting method at amount of 9.5 kg. hectare^{-1} (Hasan, 1989). The maintenance of the crop was as irrigation and weeding as needed. On 11 January, 2017, the second factor (spraying with seaweed extract) was added on the experimental units according to the plot distribution in the field by spraying on vegetative parts and repeated after two weeks on 26 January, 2017.

The measurements were done on three plants randomly selected from each experimental unit in march 2017, The measurements were on the following features:

1. Plant height (cm)
2. leaves Number of leaf. plant^{-1}
3. Leaves chlorophyll contents SPAD Unit by using SPAD device.
4. Fresh weight gm. plant^{-1} after collect the plants, cleaned them from dust and soil, and recorded the fresh weight with digital scale.
5. Dry weight gm. plant^{-1}. The plants were dried in the oven at 70^{o}C for 72 hours until stabilize the weight, and then recorded the weight.
6. Leaf area cm^2. It was done according to Ferreira and rasband (2012). By software for image analysis.
7. Total leaves yield kg. Experimental unit^{-1}, the yield was collected and weighed.
8. Active ingredients (Phenolic compounds) were calculated by taking ten leaves from each experimental unit, and the similar units in the replicates. The leaves were air dried until the weight stability, and then extraction and determination of phenolic compounds the method which it Is used by (Sulaiman, 2015). Phenolic compound were measurd by the method of (Harborne, 1973) using High performance liquid chromatography HPLC. The following phenolic compounds were determined: Recoresenol %, Catechol %, vanillin %, Salicalic %, and Ascorbic %. After the results were tabulated, the statistical analysis with SAS and the means were compared on Duncan multi variance at probability of 0.05.

RESULTS AND DISCUSSION

From Table 2, we can find that the treatment of composites addition caused a significant increase in the studied features. The plant height was the highest at 37.75 cm, number of leaves 30.75. Leaf. Plant^{-1}, the fresh weight was 163.15 gm. Plant^{-1}, the dry weight 37.14 gm. Plant^{-1}, leaf area was 79.11 cm^2, and total yield 1.83 kg. Experimental unit^{-1}. While the treatments with no addition of composites gave the lowest values. The spraying with seaweed at 6 ml. liter^{-1} gave the highest level of the studied features as the plant height 38.50 cm, leaf number 34.00 leaf. Plant^{-1}, chlorophyll 58.68 unit SPAD, fresh weight 166.98 gm. Plant^{-1} , dry weight 39.33 gm. Plant^{-1}, leaf area 84.68 cm^2, and the total yield 1.98 kg. Experimental unit $^{-1}$ dominated on other treatments.

The combination treatments between composites addition and spraying with seaweed, it can be seen that 10% + 6 ml. liter^{-1} combination significantly gave the highest plant height; 45.00 cm, leaf number 53.33 leaf. Plant $^{-1}$, chlorophyll unit SPAD 62.66, fresh weight 213.10 gm. Plant^{-1} , dry weight 49.80 gm. Plant^{-1}, leaf area 113.40 cm^2, and the total yield was 2.59 kg. Experimental unit $^{-1}$ compared with other treatments.

Table 2. Effect of organic fertilizer addition and spraying seaweed extract on some growth characters and yield of arugula plant.

features / Treatment	Plant height (cm)	leaves Number leaf.plant^{-1}	Chloro phyll SPAD	Fresh weight gm.plant^{-1}	Dry weight gm.plant^{-1}	Leaf area cm^2	Total leaves yield kg. Experimental unit^{-1}
0 % composites	28.75 b	11.58 b	54.75 a	88.502 b	22.97 b	45.426 b	1.194 b
10 % composites	37.75 a	30.75 a	56.80 a	163.153 a	37.14 a	79.110 a	1.833 a
0 ml. liter^{-1}	26.917 d	10.833 c	55.567 ab	75.142 d	18.618 c	39.01 c	1.059 c
2 ml. liter^{-1}	32.250 c	15.167 bc	52.567 b	116.715 c	27.489 b	55.66 bc	1.386 bc
4 ml. liter^{-1}	35.333 b	24.667 ab	56.283 ab	144.472 b	34.782 a	69.72 ab	1.622 b
6 ml. liter^{-1}	38.500 a	34.000 a	58.683 a	166.982 a	39.330 a	84.68 a	1.988 a
0 % + 0 ml. liter^{-1}	24.17 h	7.67 g	54.833 b	53.9 h	17.24 h	30.50 h	1.033 h
0 % + 2 ml. liter^{-1}	28.50 g	10.00 f	52.200 b	74.5 g	19.66 g	40.30 g	1.080 g
0 % + 4 ml. liter^{-1}	30.33 e	14.00 e	57.267 ab	104.8 e	26.13 e	55.00 e	1.279 e
0 % + 6 ml. liter^{-1}	32.00 d	14.67 d	54.700 b	120.9 d	28.86 d	55.90 d	1.386 d
10 % + 0 ml. liter^{-1}	29.67 f	14.00 e	56.300 b	96.4 f	20.00 f	47.50 f	1.086 f
10 % + 2 ml. liter^{-1}	36.00 c	20.33 c	52.933 b	159.0 c	35.32 c	71.00 c	1.693 c
10 % + 4 ml. liter^{-1}	40.33 b	35.33 b	55.300 b	184.1 b	43.44 b	84.50 b	1.966 b
10 % + 6 ml. liter^{-1}	45.00 a	53.33 a	62.667 a	213.1 a	49.80 a	113.40 a	2.590 a

The similar letters in the table means that was no significance between treatments at the probability of 0.05.

From Table 3, we can see a positive correlation between the experimental unit yield and each of plant height 0.901, leaf number 0.762, fresh weight 0.822, and dry weight 0.864.

Table 3. The correlation between studied features.

Features / Features	Plant height (cm)	leaves Number leaf.plant^{-1}	Chloro phyll SPAD	Fresh weight gm.plant^{-1}	Dry weight gm.plant^{-1}	Leaf area cm^2	Total leaves yield kg. Experimental unit^{-1}
Plant height (cm)	1.00						
leaves Number leaf.plant^{-1}	0.870	1.00					
Chlorophyll SPAD	0.474	0.614	1.00				
Fresh weight gm.plant^{-1}	0.954	0.890	0.427	1.00			
Dry weight gm.plant^{-1}	0.964	0.865	0.379	0.961	1.00		
Leaf area cm^2	0.936	0.864	0.409	0.887	0.951	1.00	
Total leaves yield kg. Experimental unit^{-1}	0.901	0.762	0.406	0.822	0.864	0.923	1.00

From the results of Figure 1. The treatment (0.00% composites + 4 ml. liter^{-1}) gave the highest values of Resorcinol compound it was 0.14%. While, Figure 2, shows that treatment (10% composites + 4 ml. liter^{-1}), gave the highest value of Catechol as it was 0.042%. The results in Figure 3. Treatment (0.00% composites + 6 ml. liter^{-1}) was the one that, got the highest values of Vanillin compound, it was 0.048%. From Figure 4. It can be seen that treatment (0.00% composites + 2 ml. liter^{-1}) affected in getting the highest result of Salicylic acid and it was 0.066%. Figure 5 shows the result of the highest value of Ascorbic acid; 0.130% in treatment (10% composites + 0.00 Algamex).

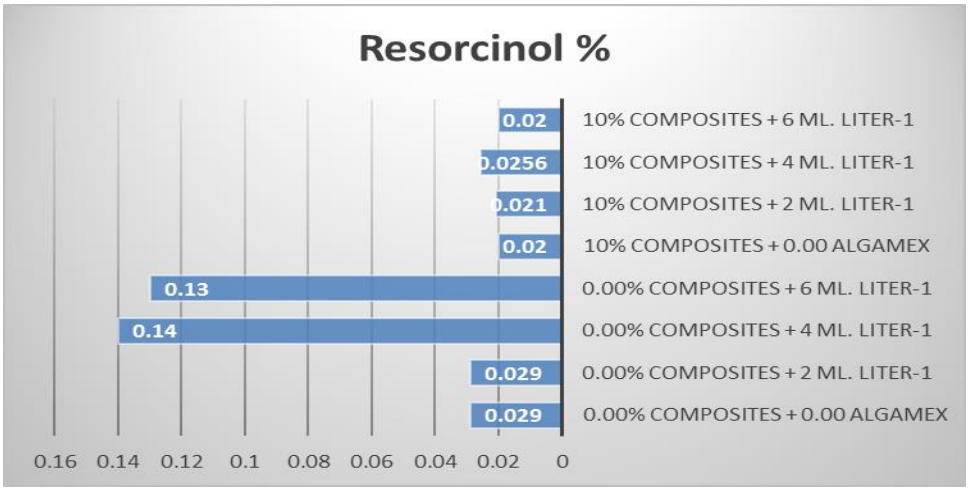

Figure (1) effect of combination between the composites and Algamex in the Resorcinol %

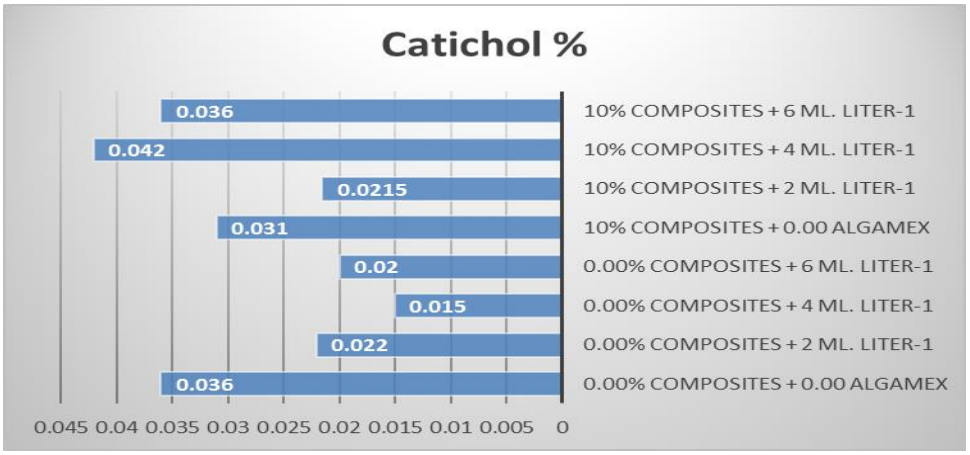

Figure (2) effect of combination between the composites and Algamex in the Catechol %

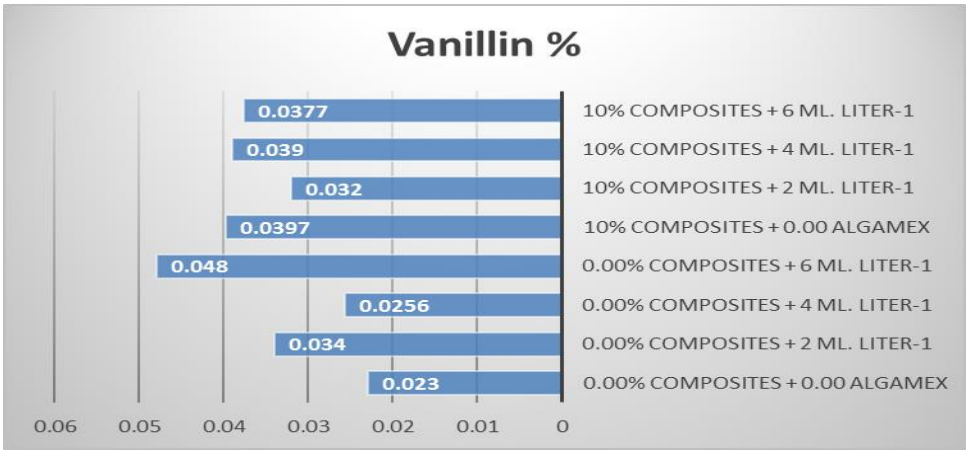

Figure (3) effect of combination between the composites and Algamex in the Vanillin %

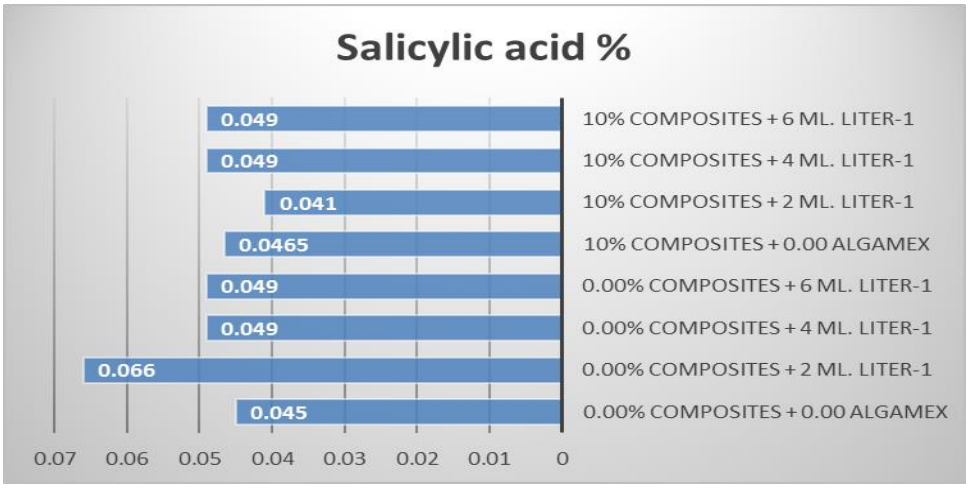

Figure (4) effect of combination between the composites and Algamex in the Salicylic acid %

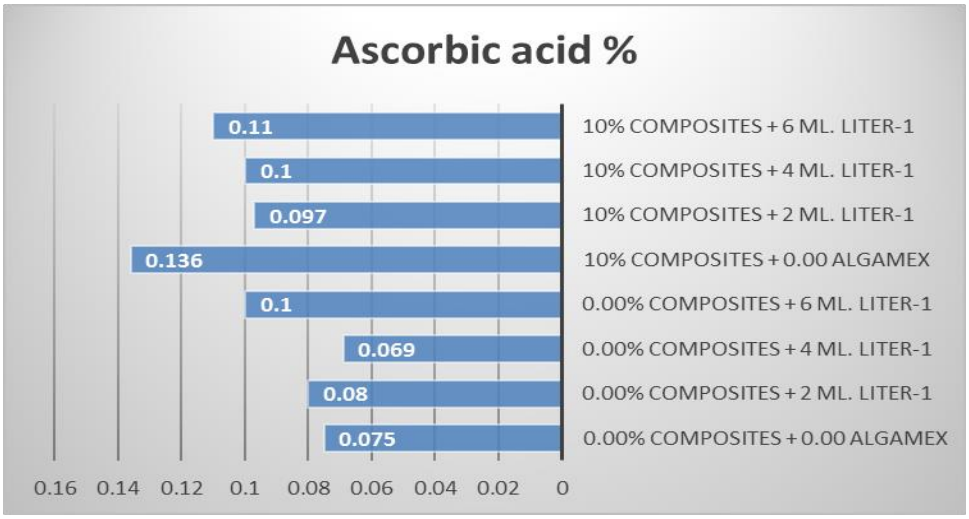

Figure (5) effect of combination between the composites and Algamex in the Ascorbic acid %

The significant increase in the vegetative growth features as plant height and leaf numbers may be due to the activation of plant growth. When the composites was added as it could cause some improvement of soil physical, chemical, and biotic properties, in addition to that, the composites might contain some minerals that are important in enhancement of fertilization of agricultural soils as nitrogen, phosphorous, and potassium, (Stewart et. al. 1998; Kutuk et.al. 1998).

The reason for the increase of studied properties values with the addition of composites may be to supply of organic matter around the root hair area in which it could lead absorption of the organic matter and increase the vegetative growth as plant height and leaf area, which enhances the transportation of metabolites of photosynthesis, (Aisha et.al. 2007). The minerals are ready after converting them to the forms that is ready to take by the plants, (Al-Zahawy, 2007). In addition to that the role of composites in improving the properties of soil such as chemical and physical and improve soil water holding capacity and increase the soil constituents of macronutrients, (Mackowaik, 2001).

These findings are in agreement with Abdul-Rahaman and Ramadan (2015) on their work with cabbage when they added chemical and organic fertilizers. As the composites increased the yield. Other studies reported that spraying with seaweed (Algamex), caused improvement of plant vegetative growth due to availability of macronutrients and micronutrients that are essential for plant growth in addition to some plant hormones such as cytokinins, auxins, gibberellins, and amino acid along with some carbohydrates, which increased after that vegetative growth characters and yield that will be increase secondary product secondary metabolism yield (Alexander and Csizinzky, 1994) and (Proceedings of sixth scientific conference, 2007)

As reported by Al-Alaf (2008), that the spraying with the seaweed extract which contains macro and micronutrients in addition to cytokinins, auxins, gibberellins, in which that those compounds affect the plant growth processes including photosynthesis, respiration, and metabolism, because these materials form some important amino acids for cell division and protein formation and some microelement like iron which it is important to activate oxidation enzyme and redaction is transfer electron in respiration proses and help to synthesis of chlorophyll and iron storage in chloroplast an photo ferreting which improve vegetative growth so leaves and it content of hormones as auxin, cytokinin which promotes physiological proses of plant that effect on vegetative growth (Al-Sahaf, 1989). The plant hormones of the seaweed extract could cause activation of DNA and RNA metabolism and improve the plant growth, (Abdool, 1987). Al-Zubaidy (2010), reported that the seaweed extract is rich of amino acid and could improve the growth. Al-Jubouri (2011) achieved an increase of vegetative growth including plant height and leaf number when he sprayed the black eye bean plant with the seaweed

Algamex, and converge on Thomas (1996) and Alzubaidy (2010) which content rich element like N, Mg, So4 and number of amino acids which improve qualitative and quantitative plant characters which converge on (Al-baiaty 2010).

The treatment with mushroom culture wastes (composites) and spraying with seaweed extract (Algamex), caused an increase in the plant contents of secondary metabolism may be due to the activation of physiological activities and its reflection on chemical contents of plant, (Chen and Aviad, 1990). The treatments encouraged to get more vegetative growth and increase the plant height and leaf area in which it was effected the performance of photosynthesis and increased the secondary compounds metabolism, (Al-Hilo and sloumy, 2013). the saleable organic in water include wide of components like sugars, proteins, amino acids, humus organic acid all these components participate directly or non-directly in development and growth plant either promote the growth by enzyme because it contents the element which plant need it and it effected in elements ability which was in soil or added to the soil and it improve the soil quantity (Fartosy, 2003), that converge on plaster (1997) and the result of Bohn and et. al (1985).

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