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Influence of Foliar and Soil Application of Humic Acid on Growth and Yield of Lettuce

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Abstract
The plastic-house experiment was carried out at University of Sulaimani, College of Agricultural Sciences during the growing season of 2016-2017 to determine the effect of soil and foliar application of humic acid on yield and yield components of Lettuce (*Lactuca sativa* L.var Romaine). Four humic acid doses (0) control, (2.5, 3.5 and 4.5) ml/L were sprayed, and soil application of humic acid in four levels, such as (0) control, (1.5, 2.5 and 3.5) ml/L added to the soil. Among the treatments level, highest total yield (47.863t/ha) was obtained with treatment T4 (1.5 ml/L soil application) followed by treatment T1 (2.5 ml/L foliar application). Foliar application of 4.5 ml/L humic acid (T3) recorded significantly highest plant height as compared with control treatment. In addition the highest values of (TSS) were obtained by soil application (T6) at rate 3.5 ml/L. The data showed that there were no significant differences in the amount of the N, P, K and nitrate in the lettuce product.
Keywords: Lettuce, Humic acid, Foliar application, Soil application, Sustainability.

1. Introduction

According to Food and Agriculture Organization (FAO) of the United Nations the definition of Organic agriculture 'is a unique production management system which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles and soil biological activity, and this is accomplished by using on-farm agronomic, biological and mechanical methods in exclusion of all synthetic off-farm inputs' (FAO, 2018). Developing ecological knowledge has led to increase people's awareness about food quality, as it has been revealed that traditional intensive agriculture can insert contaminants in the food chain. Purchasers have started to search for better quality of food that produced safely in environmentally friendly condition. Produce food from organic agriculture can be a method for obtaining the above required. Organic agriculture can result in increasing nutrition values and decreasing environmental impacts (Rembiałkowska, 2007). One of the applications of organic agriculture is utilizing organic fertilizers that have many forms which include animal sources, plants and mineral sources. Moreover, humic acid is one of the types of plant organic fertilizer that has a great role in plant nutrition and soil fertility; in addition, produce higher yields and healthier plant (Pettit, 2004). Humic acid is particularly used to decrease the negative effects of chemical fertilizers and could have beneficial effects on the nutrition of the plant (Martinez *et al.*, 1983). The commercial humic acids were found to improve growth, yield, production, quality and increased significantly in the accumulation of P, K, CA, Mg, Fe, Zn and Mn in the tissues of some vegetable crops (Padem and Ocal 1998 and Feibert *et al.,* 2001). Lettuce (Lactucasativa L.) belongs to the family Composite, it is the most popular salad crops in the world. It is popular for its delicate, crispy, texture. It is mainly a cold loving crop (Ryder, 1999). Lettuce is low in fat, sodium, and calories. It is an adequate source of iron, fiber, folate, and vitamin C. Lettuce can be grown under protected cultivation or in the open field (Filho, 2009). The concentration of nitrate in lettuce decreases when the bio fertilisers are used; particularly, nitrobien, biogien (Hosseny and Ahmad, 2009). This work was carried out to study the effect of humic acid on the growth, yield and chemical contents of head lettuce plants.

2. Methods

Lettuce was grown in a plastic house which sites at College of Agricultural Sciences, University of Sulaimani in 2016–2017. The soil characteristics evaluated included physical and chemical as shown in Table (1). The experimental area was tilled, levelled, plotted and mulched by a black polyethylene in August 2016; furthermore, drip irrigation was established. There were 3 blocks which consist of 7 plots that has 6 plants each, the plots divided into 3 rows and 2 columns with length 1.2M and 30 cm space between plants. However, the distance between the blocks was 1M and 0.5M between plots within the units. A total of 126 Lettuce seedlings was transplanted in November 2016 and the design of experiments was a Randomized Complete Block (RCBD) with three replications of 18 Lettuce plants and the means compared according to Dunken at 0.05 level. Humic acid was applied at doses (0) control, (2.5, 3.5 and 4.5) ml/L were sprayed until wet plants completely, while (1.5, 2.5 and 3.5) ml/L added to the soil. Data collection was initiated in March 2017 of vegetative growth and reproductive parameters including plant height, unfolded leaf number, dry weight **% [**100 g fresh (folded leaves) in each plot were taken then washed with tap water and oven dried at 70 ^{O}C, then weighted by using sensitive

balance], head fresh weight (gm.plant^{-1}), total yield (ton.ha^{-1}) and chemical characteristics (leaf chlorophyll intensity was measured using digital monitor chlorophyll meter (%) (SPAD 502 PLUS), Total Soluble Solids (TSS %) of (folded leaves),total nitrogen (%), phosphorus (%), potassium (%)and Nitrate contents (%).

Table1. The main physical and chemical properties of the experiment location soil

Soil properties*	Units	The values
Sand	g.kg^{-1}	435.70
Silt		244.50
Clay		319.80
Texture		Sandy clay loam
EC	d.ms^{-1}	1.03
PH		7.87
Organic matter	g.kg^{-1}	28.90
Total nitrogen		10.20
Available phosphorus		0.03
Soluble potassium		0.08

* Data were analysed in the Central Laboratories of College of Agriculture, University of Baghdad.

3. Results and Discussion

Table 2. Effect of foliar and soil application of humic acid on number of unfolded Lettuce leaves, plant high, chlorophyll, and T.S.S.

Category		No. of unfolded leaves	Plant Height (cm)	Chlorophyll (%)	T.S.S. (%)
Concentrations (ml/L)	Treatments				
0	T0 (control)	20.667**a**	30.667**b**	3.900**a**	48.000**ab**
2.5	T1 (foliar)	19.000**a**	34.000**a**	3.967**a**	48.200**ab**
3.5	T2 (foliar)	19.667**a**	33.000**ab**	4.000**a**	44.800**b**
4.5	T3 (foliar)	21.333**a**	34.667**a**	3.733**a**	47.033**ab**
1.5	T4 (soil)	21.000**a**	34.000**a**	4.000**a**	45.000**ab**
2.5	T5 (soil)	19.000**a**	33.667**a**	3.967**a**	47.033**ab**
3.5	T6 (soil)	21.333**a**	33.667**a**	3.567**a**	48.933**a**

3.1. Unfolded leaves of lettuce and Plant High (cm)

Table (2) shows that there were no significant differences between the treatments in unfolded leaves. While, there were slight significant differences in plant high as effected by HA, compare to control (T0). Besides, T3 has the highest height, which is (34.667 cm). This result is proved by Tüfenkçi *et al.* (2006) study, whilst it disagrees with the result of unfolded leaves.

3.2. Chlorophyll and T.S.S. (%)

There are no significant differences among the treatments in the amount of chlorophyll content as it is shown in Table (2). Nevertheless, Mirdad (2016) found that raising levels of humic acid by 100 or 1000 mg/l led to increase photosynthetic activity because of improvement of mesophyll conductance and chlorophyll content. Furthermore, there were significant difference between T2 and T6 compare to the other treatments in the content of T.S.S which is T6 has the greatest percentage (48.933%) while T2 has the lowest percentage (44.800%).

Table 3. Yield characteristics of the lettuce plant treated with HA by different concentrations

Category		Head fresh weight (gm)	Head dry weight (%)	Total Yield (ton.ha^{-1})
Concentration (ml/L)	treatments			
0	T0 (control)	558.597**ab**	5.840**a**	37.227**b**
2.5	T1(foliar)	624.437**ab**	5.518**a**	41.617**ab**
3.5	T2 (foliar)	514.373**b**	5.482**a**	34.283**b**
4.5	T3 (foliar)	552.560**ab**	3.980**b**	36.830**b**
1.5	T4 (Soil)	718.040**a**	4.918**ab**	47.863**a**
2.5	T5 (Soil)	549.797**ab**	5.773**a**	36.643**b**
3.5	T6 (Soil)	542.227**ab**	4.988**ab**	36.140**b**

3.3. Head Fresh weight

The Table (3) illustrates that there are no significant differences among these treatments (T0, T1, T3, T5 and T6), while there are significant differences between treatments T2 and T4. Moreover, treatment (2) has lowest weight (514.373gm); however, treatment (4) has the highest weight (718.040gm). Cimrin and Yilmaz confirmed that

using HA and phosphorus together at a rate (300 and 120) kg/ha respectively was appropriate for the lettuce head fresh weight (2005).

3.4. Head dry weight

Table (3) shows that there are significant differences in head dry weight. In addition, T3 has the lowest dry weight (3.980%), while the greatest dry weight was given by control (T0). The result was disagreement with Shahein and Algharib (2015) investigation; however, in their research combine (NPK+HCF+HBS) while in this research merely used HA. Similar results were investigated by Taha *et al*., 2016, unless they used (humic and fulvic acids). Since, it is explained by Tüfenkçi *et al.* (2006) that owing to a comparative short growing season of lettuce the advantages of utilizing humic acid have been limited.

3.5. Total Yield

The influence of HA on total yield of lettuce plants are shown in Table (3). Where the total yield of T4 has the best yield representing (47.863 ton/h) compared to the other treatments. Whilst, treatment T2 representing the lowest yield, which is (34.283 ton/h). Although there has been relatively little research on the effect of HA into a total yield of lettuce, Salehi *et al*. (2013) discovered that HA with vitamins had not considerable consequence on total yield of lettuce which is agreed with the result of this research.

Table 4. Effect of HA on chemical content of head lettuce plant

Category		N (%)	P (%)	K (%)	No_3 (%)
Concentrations (ml/L)	Treatments				
0	T0 (control)	1.903**a**	0.310**a**	0.427**a**	0.160**a**
2.5	T1(foliar)	1.827**a**	0.303**a**	0.430**a**	0.140**a**
3.5	T2 (foliar)	1.873**a**	0.330**a**	0.443**a**	0.173**a**
4.5	T3 (foliar)	1.880**a**	0.347**a**	0.460**a**	0.153**a**
1.5	T4 (Soil)	2.004**a**	0.329**a**	0.463**a**	0.152**a**
2.5	T5 (Soil)	1.900**a**	0.340**a**	0.453**a**	0.160**a**
3.5	T6 (Soil)	1.790**a**	0.347**a**	0.427**a**	0.167**a**

3.6. The Contents of Nitrogen, Phosphor and Potassium (%):

Table (4) indicates that HA had not effect on the concentration of N, P and K in the lettuce product. However, these results are in contrast with those obtained by (Fawzy, 2010 and Taha *et al.*, 2016).

3.7. Content of Nitrate (No_3)

There are no significant differences amongst the treatments (Table 4). T1 resulted the lowest nitrate (0.140%); additionally, similar results were investigated by (Fawzy, 2010 and Shahein and Algharib, 2015) which gave the low concentration of nitrate when HA applied to the lettuce plants.

4. Conclusion

Foliar and soil application of humic acids has a significant effect on growth and yield of Lettuce, mainly the great result is obtained by soil application. Besides, T4 (1.5 ml/L) gave the highest fresh weight and yield production. Although, soil application has significant influence on growth and yield of lettuce, further research is required for the effect of the combination of foliar and soil application of HA on Lettuce.

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