J. Plant Production, Mansoura Univ., Vol. 9(9): 739 - 741, 2018

Growth and Yield of Broccoli (*Brassica oleracea* L. Var. Corato) as affected by humic acid application

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ABSTRACT

The present study was conducted during the 2016-2017 at University of Sulaimani, College of Agricultural Sciences. This investigation aimed to study the effect of humic acid (foliar application) with three levels; 2.5, 3.5 and 4.5 ml/L and three levels of (soil application) ; 1.5, 2.5 and 3.5 ml/L, compared with the control (spray with water only) on growth and yield components of broccoli (*Brassica oleracea* L. var. corato). After 2 weeks from transplanting, the humic acid was added four times to the plants. The experimental design was used is Random Complete Block Design (RCBD), with three replicates was applied and the means compared according to Dunken at 0.05 level. The obtained results showed that soil application in the rate of (1.5 ml/L) achieved the highest results of Plant height (53 cm), fresh weight of main head (403.5 gm) and total yield (50 ton/ha). On the other hand, the highest value of the main head diameter was obtained by foliar application of 2.5 ml/L. In addition, the highest value of TSS was recorded when humic acid as a foliar spray at a rate of 3.5 ml/L, while the amount of NPK were not significantly affected by applications of different doses of humic acid. These results imply that soil application of humic acid at the rate of 1.5 ml/L could be recommended to use in the agricultural field for producing optimum yields.

Keywords: Broccoli, Humic acid, Foliar application, Soil application, Sustainability.

INTRODUCTION

Broccoli (Brassica Oleracea Var. *Corato*) belongs to Brassicacea family which consist of a number of cole vegetable crops such as cauliflower and cabbage. Broccoli is important for human health as contain antioxidant substances that prevent cancer; besides, it has numerous nutritional due to containing vitamins (E, A, B1, B2, B5 and B6) and minerals (Fe, Zn, Ca and Mg) (Abou El-Magd, *et al.*, 2006). Organic fertiliser application enhances these nutrients (Ouda and Mahadeen, 2008). Plant nutrients are essential part of sustainable agriculture. Crop production increase depends mainly on fertilizer types (Chen, 2006). Especially organic fertiliser which is defined by which is defined by King County (2004) as"(Natural organic) fertilizers provide nutrients in small amounts over an extended period of time—just the way your plants need them". Organic agriculture is eco-friendly system owing to minimising tillage and reducing herbicides, pesticides and chemical fertilisers. It has an important role in sustaining and improving the ecosystems health of various organisms from the smallest in the soil to the human (Dubey and shukla, 2014), also it has certain positive effects on social and economical conditions besides the environment. Hence it is considered as a basic dimension of sustainable development (Morgera *et al.,* 2012 and Dubey and shukla, 2014). Using organic fertiliser is the best method to decrease pollution and high cost of chemical fertiliser (Hosseny and Ahmad, 2009). Sustainable agriculture causes the decrease of contamination of food and thus enhancing improvement of the quality of food. Chemical farming on contrary has negative impacts on human health and environment (Islam *et al.*, 2017). Foliar nutrition represents the application of soluble fertilizers directly through the leaf, Consequently They are absorb directly by plants in limited quantities. Effect of foliar fertilizer is assessed on the basis of absorption and availability of elements, reduction of phytotoxicity, deficit, impact of physiological processes over the yield and quality of culture (Petrov *et al*. 2014). Wojciechowska *et al.* (2005) report that foliar feeding significantly decreased nitrate contents in broccoli heads compared to non-feeding plants. Humic acid stimulaties shoot and root growth but its effect is more prominent on the roots. Sabzevari and Khazaei (2009) stated that humic acid increased root content and improved root system. Furthermore, humic acid causes the increase of nutrient absorption by plants such as N, P, K, Ca and Mg.The main aim of the present study was to evaluate the effects of soil and or foliar application of humic acid on growth and yield of broccoli.

MATERIALS AND METHODS

A plastic-house experiment was carried out at the field of Horticulture, college of Agricultural Sciences, Bakrajo, University of Sulaimani, Iraqi Kurdistan Region during the growing season 2016/2017. Some physical and chemical characteristics of the soil are demonstrated in Table 1. Humic acid Fertilizer had been used at seven doses: control (0), Foliar (2.5, 3.5,and 4.5) ML\L as well as soil (1.5, 2.5, and 3.5)ML\L. Random Complete Block (RCBD), with three replicates was applied and the means compared according to Dunken at 0.05 level. The soil was well prepared by tillage, levelling and then plotting. Each plot consisted of 2 rows (1.2* 0.4) M. Distances between plants within a plot and plots were (0.50*1.0) M respectively. Trickl (drip) irrigation was used and the soil covered with black polyethylene mulch. Seedlings were transplanted on November 1, 2016.

Table 1. The main physical and chemical properties of the experiment location soil.

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

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

Two weeks later, the humic acid was applied and repeated four times on 15 dayes interval. At harvest, plant height and mean number of leaves plant for three plants with in each plot were measured, also leaf samples were taken for the purpose of chlorophyll intensity deterimination using a digital monitor chlorophyll meter (SPAD 502 PLUS). Means of main heads diameter were taken with Vernier caliper using three heads grown on 10-12 cm diameter stalk. Moreover, number of lateral head initiated on the secondary branches were taken. Fresh weight means of both main and

lateral heads for each plant were recorded. For the purpose of dry weights the main head samples were kept in an electrical oven at 70°C until constant weight, then the dry weight percentage of main heads was calculated as follows: main dry weight % = main head dry weight/ main head fresh weight * 100. Total yield comprises weight of both main and lateral heads and then converted into ton/ha. Some chemical characteristics such as Total Soluble Solids (TSS %), Total Nitrogen %, phosphorus %, potassium % and Fe % of mean head were determined.

RESULTS AND DISCUSSION

Vegetative Growth

Table 2 shows that humic acid soil application (T4) gave the highest plant hight (53 cm) which was not different significantly from most other treatments, while no significant differences were found among all the treatment in respect number of leaves/plant. However, T4 resulted in highest number of lateral heads/plant which dominated significantly the majority of the other treatments. Nevertheless, T1 was superior significantly to the majority of other treatments with respect to main head diameter. This result agrees with Ouda and Mahadeen (2008) who comprehended that the number of heads increased when organic and chemical fertilisers were applied. In addition the results agree with Selim and Mosa (2012) who found that broccoli head diameter increased with the application of humic acid. Fahrmand *et.al,* (2014) indicated that humic acid stimulated growth and consequently yield through metabolic processes such as; cell respiration, photosynthesis, protein synthesis, water and nutrient uptake, enzyme activities. Chen and Aviad (1990) showed that foliar application can improve the growth of root and shoot. Nevertheless, non-organic fertilizers have impacts on health and environment (Bare, 2011). All obtained data were statistically analysed according to the procedure outlined by Snedecor and Cochram (1967).The means were compared using Duncan's multiple range test as published by Duncan (1955).

Table 2. Effect of HA on vegetative growth of broccoli.

Treatments	Concentrations (ml/L)	Plant height (Cm)	Number hf leaves	Number of lateral head	Main head diameter (Cm)
T0(control)	0	49.667ab	43.000a	14.667bc	149.293ab
T1 (foliar)	2.5	48.333ab	44.333a	13.333bc	207.397a
T2 (foliar)	3.5	46.000b	46.667a	16.000abc	111.280b
T3 (foliar)	4.5	49.333ab	47.667a	11.333c	124.380b
T4 (Soil)	1.5	53.000a	51.667a	22.667a	101.153b
T5 (Soil)	2.5	51.000ab	52.333a	18.333ab	157.600ab
T6 (Soil)	3.5	48.333ab	47.000a	16.333abc	109.313b

T.S.S and Chlorophyll intensity

Table (3) illustrates that T2 resulted in greatest amount of T.S.S. (9.433%) which was different significantly from the majority of other treatment. On the other hand, T3 gave the highest chlorophyll content (74.633) which did not differ significantly from most treatments except T6. The result agrees with Karakurt *et al.,* (2009) who discovered that foliar and soil application of humic acid at 20ml/L recorded the greatest content of chlorophyll in pepper. The investigation of Yildirim (2007) proved that the foliar and soil Humic acid application led to rise total soluble solids (TSS) in tomato plant.

Table 3. T.S.S. and Chlorophyll intensity of broccoli treated with Humic acid in different concentrations.

Treatments	Concentrations (ml/L)	T.S.S.	Chlorophyll
T0 (control)	0	7.667c	69.867ab
T1 (foliar)	2.5	8.000bc	71.367ab
T2 (foliar)	3.5	9.433a	70.433ab
T3 (foliar)	4.5	7.900bc	74.633a
T4 (Soil)	1.5	7.400c	71.633ab
T5 (Soil)	2.5	8.767ab	70.133ab
T6 (Soil)	3.5	7.633c	68.300b

Yield and its Characteristics

The data in Table (4) presents that T4 recorded the highest fresh weight of main head (403.507 gm/plant), fresh weight of lateral head (596.645 gm/plant) as well as total yield (50.008 ton/ha) which were superior significantly to most other treatments. Furthermore, T5 gave the highest dry weight of main head (7.100%) which dominated significantly the majority of other treatments. The result is incontrast with Magd *et al.* (2009) who found that dry and fresh weights of broccoli were greatly higher in fertigation method than soil application. On contrary, the result agrees with Yildirim (2007) who demonstrated that 20 ml/l humic acid resulted in better yield and growth in tomato. Mokhtari *et al.* (2008) found that humic acid can increases the absorption of some nutrients such as nitrogen, potassium, calcium, magnesium and phosphorus by plants and those coused the yield increase. Ghosh *et al.* (1981) mentioned that some fertilizers such as humic acid can directly cause the positive effects on plant growth, as they stimulate both shoot and root growth; however, the effect is more prominent on the roots.

Table 4. Yield characteristics of broccoli, which treated with HA.

Treatments	Concentrations (ml/L)	Fresh weight of main head (gm)	Dry weight of main head (%)	Weight of lateral head (gm)	Total yield (ton/ha)
T0 (control)	0	384.140a	5.808bc	291.597c	32.896bcd
T1 (foliar)	2.5	347.450ab	6.762ab	303.683c	32.557bcd
T2 (foliar)	3.5	343.567ab	5.195c	353.220bc	34.839bc
T3 (foliar)	4.5	270.133b	5.795bc	197.973c	23.405d
T4 (Soil)	1.5	403.507a	5.908abc	596.645a	50.008a
T5 (Soil)	2.5	318.390ab	7.100a	473.220ab	39.581b
T6 (Soil)	3.5	278.920b	6.667ab	243.765c	26.134cd

Chemical Contents

N, P, K contents were not affected significantly by HA application (Table 5). Nevertheless, soil or foliar application of HA recorded the decrease in Fe content. Though insignificantly except T3 application that resulted in significant decrease compared to the control; while, no significant difference was found between T3 and the rest of the treatments. The result agrees with Haghighi *et al.* (2010) who pointed out that humic acid decreased the uptake of Fe in the plants (cucumber, melon and bent-grass). They also found that 1000 mg kg^{-1} rof humic acid raised both macro- and micro- nutrient contents of plant organs. Khaled and Fawzy (2011) confermed that foliar and soil applications of humic acid raised nutrient uptake. Nevertheless, high levels of humic acid reduced nutrient contents and stop the growth of plants (Türkmen *et al.*, 2004).

Table 5. Effect of chemical characteristics of broccoli by humic acid.

Treatments	Concentrations (ml/L)	Nitrogen content (%)	Phosphor content (%)	Potassium content (%)	Fe content (%)
T0 (control)	0	1.903a	0.310a	0.427a	0.720a
T1 (foliar)	2.5	1.827a	0.303a	0.430a	0.680ab
T2 (foliar)	3.5	1.873a	0.330a	0.443a	0.680ab
T3 (foliar)	4.5	1.880a	0.347a	0.460a	0.660b
T4 (Soil)	1.5	2.004a	0.329a	0.463a	0.677ab
T5 (Soil)	2.5	1.900a	0.340a	0.453a	0.677ab
T6 (Soil)	3.5	1.790a	0.347a	0.447a	0.680ab

CONCLUSION

Foliar and soil application of humic acids has a great influence on growth and yield of broccoli, especially soil application which led to high production of broccoli. It can be concluded that soil application of humic acid, particularly the application at the rate of 1.5 ml/L stimulated some vegetative growth characters of broccoli plants and improved fresh weight of main head and total yield.

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تاثير حامض الهيوميك على النمو والحاصل للبروكولي (*Brassica oleracea* L. var. corato)

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أجريت هذه الدراسة خلال عام 2016-2017 في جامعة السليمانية ، كلية العلوم الزراعية. يهدف هذا البحث إلى دراسة تأثير حامض الهيوميك (رش الورقي) مع ثلاثة مستويات. 2.5 و 3.5 و 4.5 مل / لتر وثلاثة مستويات (اضافه الى التربة) 1.5 و 2.5 و 3.5 مل / لتر، مقارنة بالكنترول (رش بالماء فقط) على النمو والحاصل للبروكلي (*Brassica Oleracea* L. Var. Corato). تمت زراعة البذور في شهر اكتوبر و في شهر نوفمبر نقلت الشتلات الى الحقل المستديم في البيوت المحميه. بعد أسبوعين من الزرع ، تمت إضافة حامض الهيوميك أربع مرات إلى النباتات. واستخدم التصميم العشوائي الكامل لهذه التجربه. وأظهرت النتائج أن اضافة الهيوميك للتربة بمعدل (1.5 مل / لتر) حقق أعلى النتائج من ارتفاع النبات (53 سم)، الوزن الطازج للرأس الرئيسي (403.5 جم) والحاصل الإجمالي (50 طن / هكتار). من ناحية أخرى ، تم الحصول على أعلى قيمة لقطر الرأس الرئيسي بالرش الورقي 2.5 مل / لتر. وبالإضافة إلى ذلك، تم تسجيل أعلى قيمة TSS عندما تم أضافة حامض الهيوميك بالرش الورقية بمعدل 3.5 مل / لتر، في حين أن كمية NPK لم تتأثر بشكل كبير من خلال تطبيق جرعات مختلفة من حامض الهيوميك. هذه النتائج تشير إلى أن اضافة حامض الهيوميك للتربة بمعدل 1.5 مل / لتر يمكن أن ينصح باستخدامها في المجال الزراعي لإنتاج الحاصل الأمثل.