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Full Length Article

Response of Onion (*Allium cepa*) Crop to Foliar Application of Humic Acid under Rain-Fed Conditions

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Abstract

Humic acid is an organic chemical contains many elements which increase the availability of nutrient elements by holding them on mineral surfaces and consequently affect plant growth and yield positively. This experiment was carried out to see the effect of spraying humic acid at various concentrations (0, 500, 750 and 1000 mg L^{-1}) and frequency (G1: at 21days after transplanting, G2: two times sprays of Humic acid at 21 and 35 DAT andG3: three times sprays of Humic acid at 21, 35 and 45) on growth of onion (*Allium cepa* L. Giza 20). A field experiments were carried out during the two seasons of 2014/2015 and 2015/2016. Foliar application of Humic acid significantly increased all growth characters (i.e. Number of leaves, leaf length, leaf diameter, neck diameter , fresh weight of leaves, root length and number, bulb length and diameter and fresh weight of plants) compared to untreated control plants. Among different times of Humic acid applications, Triple spray of humic acid (G3) was better than double (G2) or single spray (G1) in terms of having significantly higher number of leaves, leaf length, leaf diameter, neck diameter, fresh weight of leaves, root length and number, bulb length and diameter and fresh weight of plants. It is concluded that spraying onion with humic acid at 1000 mg L^{-1} resulted in higher growth and yield. © 2018 Friends Science Publishers

Keywords: Spraying time; Bulb; Chemical; Doses; Organic; Yield

Introduction

Onion plant (*Allium cepa* L.) is the second most popular vegetable crops of the *Alliacea family* (Singh and Bahadur, 2007) grown under wide range of climatic conditions with a world production of about 90 million tones (FAOSTAT, 2015). It is a widespread crop with various functions to people. Onion plants are excellent sources of carbohydrates, protein, minerals, antioxidant vitamin and has preservative values in addition to its medicinal values (Padmini *et al*., 2007; Tyagi and Yadav, 2007; Barzegar *et al*., 2008; Mahanthesh *et al*., 2008). The local demand for onion far exceeds local production in Jordan. Increasing productivity of onion is possible genetically through introducing of high yielding varieties and by cultural practice through application of fertilizer (Nasreen *et al.*, 2007), plant protection, plant growth regulators and by increasing organic and inorganic sources of nutrients.

Planting rotation, various plough techniques, green fertilizer application and animal fertilizer application are various techniques for improving the organic contents of soils. In addition to these practices, utilization of organic-mineral fertilizers in agriculture has increased in recent years (Doran *et al*., 2003). Natural substances like humic acid produced by the decay of organic materials (Schiavon *et al*., 2010; Primo *et al*., 2011; Selladurai and Purakayastha, 2016; Chen *et al*., 2017) can be utilized for increasing yield.

Humic acid is a product contains many elements which improve the soil fertility and increase the availability of nutrient elements by holding them on mineral surfaces and consequently affect plant growth and yield (Neri *et al*., 2002; El-Desuki, 2004; Akinci *et al*., 2009). Humic acid affects chemical properties of soil (Ohta *et al*., 2004) and enhanced nutrient uptake and yield of some crops (Rajpar *et al*., 2011). Humic substances considered as plant biostimulants (Calvo *et al*., 2014) due to its effect in promoting plant growth through enhancing root growth and nutrient uptake (Canellas *et al*., 2002; Nardi *et al*., 2002; Zandonadi *et al*., 2007; Baldotto *et al*., 2009; Oliveira Aguiar *et al*., 2009; Rosa *et al*., 2009; Gulser *et al*., 2010; Ortiz *et al*., 2010; Bernardes *et al*., 2011; Daur and Bakhashwain, 2013) and its role in plant physiology through

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increasing photosynthesis (Baldotto *et al*., 2009; Ertani *et al*., 2011), net photosynthesis (Canellas *et al*., 2002), cell respiration and protein synthesis (Nardi *et al*., 2002), enzyme activities (Allison, 2006; Nardi *et al*., 2007) and leaf water retention (Fu Jiu, 1995). Application of humic acid significantly increased photosynthetic pigments, vegetative growth, the nutritive value and assist in the transport and absorption of nutrients (Chen *et al*., 2004; Baldotto *et al*., 2009) due to the formation of complexes and chelates, which leads to increase yield in several plants (Ulukan, 2008; El-Hefn, 2010; Mahmoud and Hafez, 2010; El-Sayed Hameda *et al*., 2011). Sugars (Lima *et al*., 2011), carbohydrates (Aminifard *et al*., 2012) and starch (Canellas *et al*., 2002; Nardi *et al*., 2007; Ertani *et al*., 2011) were found to be increased after spraying the crops with humic acid. Water use efficiency in the sandy soil has been found to increase as a result of humic substances. This may be attributed to the swelling and retention of water by the amended soil (Suganya and Sivasamy, 2006; Pereira *et al*., 2010; Khaled and Fawy, 2011).

Foliar application of humic acids is based on plants requirement in general and critical stages of growth in particular. Previous studies indicates that an appropriate concentration humic acid affects the growth and yield of plants while under rainfed conditions, very little work has been done in onion crop and therefore, an attempt has been made to study the effect of different concentrations of humic acid applied at different stages on growth and development of onion crop.

Despite the fact that the use of humic acid is not a new idea for increasing onion production and other crops in the world, the rates of humic acid needed are less clearly established in Jordan that represent a rain-fed conditions, therefore, the aim of this study was to determine the effects of humic acid foliar spray at different growth stages on growth and development of onion crop under rain-fed conditions of Jordan.

Materials and Methods

A field experiments were conducted at farmer's field near Marou village (34○ 40' N latitude and 32○37' E longitude with an elevation of 500 m), which is 100 Km north of Amman, Jordan.

The research work was carried out during two successive seasons 2014/2015 and 2015/2016 production period with a local market onion cultivar Giza 20 which was available in the local market and is the dominant variety produced in the area, at the agricultural research and experiment station area. The soil was silty clay soil texture (Table 1). The mean seasonal rainfalls for the duration of the experiment (2014/2015 to 2015/2016) was: 402 mm and 383 mm, respectively (Table 2). The seeds were cultivated in the nursery at the 1st October of each cropping season and were transplanted to rows in the fields at the 10th of December. The plot size was 4 × 4 m.

Table 1: Selected properties of the soil

pH	7.7
OM%	0.68
Nitrogen	0.07
CEC (cmol kg-I)	28.4
K (mg Kg -1)	410
P (mg Kg -1)	10.4
EC (dS m-I)	0.26
C/N ratio	11.8
Sand%	8
Silt%	48
Clay%	44

Table 2: Rainfall distribution during the experimental period

Months	Growing season /Precipitation (mm)	
	2014/2015	2015/2016
December	44	23
January	145	273
February	124	18
March	21	58
April	68	11

The experiment has two factors laid out in Randomized Complete Block Design (RCBD) with three replications. The first factor consisted of four foliar doses of humic acid (0,500, 750 and 1000 mg L^{-1}) and the second factor consisted of three humic spray treatments viz., one time spray of humic acid (at 21 days after transplanting (DAT) (G1), two times sprays of humic acid (at 21 and 35 DAT) (G2) and three times sprays of humic acid (at 21, 35 and 45 (DAT) (G3). To test the significance of variation in the data obtained, factorial randomized block design was adopted.

During crop production, cultural practices including weeding, insect pest and disease control and hoeing were completed. As a basal fertilizer, nitrogen (120 mg/kg as NH4NO3), phosphorus (90 mg/kg), potassium (120 mg/kg as KH2PO4), and zinc (0.7 mg/kg as ZnSO4) were applied to the pots before planting.

Measurements on the following growth parameters and bulb characters were recorded 150 days after transplanting (DAP) from ten selected plants. Number of leaves per plant, Plant height was measured using ruler from the soil surface to the top of the longest leaf. Neck diameter was measured at the narrowest point using caliper. Leaf length was recorded with ruler from the tip of the leaf to bulb and diameter was recorded with caliper. Length and diameter of mature bulb was measured using caliper. Fresh weight of plant was recorded as the weight of the bulb, above ground parts as well as leaves and roots. Root number was counted and root length was measured from the tip of root to the base of bulb. The data were statistically analyzed for each season and then combined analysis of the two seasons was carried out using ANOVA and least significant deference test (LSD) using SAS statistical software (SAS, 2002).

Results

Foliar applications of humic acid has often recommended as a method to improve crop production in various crops by controlling physiological processes. This experiment was conducted to determine the effects of humic acid rates and frequency on growth and yield of onion. The effect of humic acid on growth and yield parameters from the two seasons of 2014/2015 and 2015/2016 were pooled together and analyzed. Analysis of variance indicated that the reaction of onion toward diverse levels of humic acid rates and frequency for vegetative and yield components were statistically significant ($P<0.05$) (Table 3).

Vegetative Growth Characters

Effect of foliar treatments with humic acid on vegetative growth of onion is shown in Fig. 1A-E. Humic acid significantly influenced vegetative growth by increasing number of leaves, leaf length, leaf diameter, neck diameter and fresh weight of leaves by 88.7%, 82.8%, 115.6%, 120% and 139.1%, respectively at 1000 mg L^{-1} corresponding to untreated crops. The maximum number of leaves was recorded as 11.7 with the spray of humic acid @ 1000 mg L^{-1}. Similar trend were also noticed with other vegetative parameters. Significant variation in vegetative growth was found among the frequency of humic acid applications. Foliar spray (G3) had significantly higher vegetative growth. Results indicated that a triple application of humic acid was significantly higher than single application (Fig. 2A–E). The highest values of leaves number (10.5), leaf length (57.4 cm), leaf diameter (5.4 cm), neck diameter (8.3 cm) and fresh weight of leaves (95.1g) was observed in triple spray of humic acid, while the lowest values were observed in single spray. The increase in number of leaves was ~1.16 (G2) and ~1.33 (G3) fold, respectively.

Root Parameters

Humic acid application significantly affects root parameters (number and length) per plant in compression with control (Fig. 1F and G). A Higher level (1000 mg L^{-1}) increased the root growth compared with the lower levels. The highest recorded value of length (14.3 cm) and number (60.8) of roots per plants was obtained with 1000 mg L^{-1} which was significantly greater than values at low dose of humic acid. The increase in number of roots and root length were ~2.25 and ~1.88 fold, respectively.

Root number and length varied significantly among different times of humic acid applications. The highest number of roots were obtained from triple spray (59.3) followed by double (46.9) whereas the lowest number (30) was observed in single (Fig. 2F). Similar trend was obtained for root length (Fig. 2G). Root length and root number increased by 88.2% and 125.2% as a result of triple spray of humic acid corresponding to single spray.

Yield and Quality of Bulbs

Bulb characteristics of onion were significantly affected under humic acid application Fig. 1 H–J. Application of humic acid increased onion yield and quality of bulbs more than control plants. In all cases, the increments in bulb diameter, bulb length and fresh weight of plant were often highly significant in comparison with untreated control plants. High concentration of humic acid (1000 mg L^{-1}) increased bulb diameter (68%), bulb length (84%) and fresh weight of plant (63%) as compared to control. The results showed that humic acid application improved bub characteristics of onion. Significant variation in bulb characteristics at all growth stages were found among different times of spray. Triple spray of humic acid (G3) increased yield and improved quality of bulbs compared to double (G2) and single spray (G1). The highest fresh weight of plant (148.9 g), length of bulb (8.2 cm) and bulb diameter (18.cm) were obtained by triple spray of humic acid, which were significantly greater than values after single spray. The increases in bulb length and bulb diameter were ~1.2 and ~1.15 fold, respectively.

Discussion

The application of humic acid as foliar application can improve onion crop in response to treatments with low and medium concentration. This study showed that the use of humic acid up to 1000 mg L^{-1} influenced the vegetative growth and production of onion mainly in high concentration. In general, fresh weight of plant increased in response to humic acid over the control. This could be attributed to the increase in the vegetative growth (Number of leaves, leaf length, leaf diameter, neck diameter, fresh weight of leaves). Increasing vegetative growth of onion with humic acid could improve photosynthetic activity of this crop. Spraying plants with humic acid caused significant increase in photosynthesis (Bettoni *et al*., 2014) and total soluble sugars (Nardi *et al*., 2007; Ertani *et al*., 2011; Parandian and Samavat, 2012). Humic acid have been shown to stimulate plant growth and yield by acting on mechanisms involved in physiological respiration by acting as an activator, photosynthesis, protein synthesis, water and nutrient uptake, cationic exchange capacity, enzyme activities and antioxidant metabolism (Chen and Aviad, 1990; Chunhua *et al*., 1998; Fahramad *et al*., 2004; Pereira *et al*., 2010; Klein *et al*., 2014). Rapid increase in cell division and cell elongation in the meristematic region were found in plants spread with humic acid resulted in improving plant growth (Katkat *et al*., 2009; Bettoni *et al*., 2012).

Number of roots and root length of onion plants were also increased as a result of foliar applications of humic acid. Stimulated root growth in onion could increase nutrient absorption as a result of increasing surface area of the root. The positive effect of humic acid on the growth of root system (root length and root number) was also shown by other crops grown at different conditions

Table 3: Analyses of variance for fresh weight of plant, number of leaves per plant, plant height, leaf length, neck diameter, bulb diameter, bulb length, leaf diameter, number of roots, root length and fresh weight of leaf for onion crops in response to rate and frequency of humic acid foliar applications

Source of variation	Fresh weight of plant (g)	Number of leaves per plant	Plant height (cm)	Leaf length (cm)	Neck diameter (cm)	Bulb diameter (cm)	Bulb length (cm)	Leaf diameter (cm)	Number of roots	Root length (cm)	Fresh weight of leaf(g)
Application Rate (R)	16996.6 **	97.5 **	3278.5 **	3137.2 **	99.91 **	235 **	60.4 **	44.32 **	378.46 **	17.4 **	786.9 **
Frequency of application (F)	390.7 **	40 **	155.3 **	193.3 **	10.54 **	36.14 **	11.1 **	2.19 **	5218.6 **	205.66 **	15663.6 **
R*F	24.6 NS	0.05 NS	7.6 NS	4.19 NS	0.09 NS	0.33 NS	0.12 NS	0.03 NS	25.3 NS	1.31 NS	67.9 NS
Replication	207.7 *	0.72 NS	13.5 NS	1.43 NS	0.31 NS	0.61 NS	0.71 NS	0.04 NS	2.1 NS	3.97 NS	61.1 NS
Error	61.6	0.77	23	14.68	0.54	0.53	1.53	0.14	17.4	2.59	48.4
C.V (%)	5.42	9.6	8.48	7.03	9.7	4.2	16.4	7.46	9.18	14.2	9.5

*, **, NS indicate significant difference at 5%, 1% probability level, and no significantly, respectively

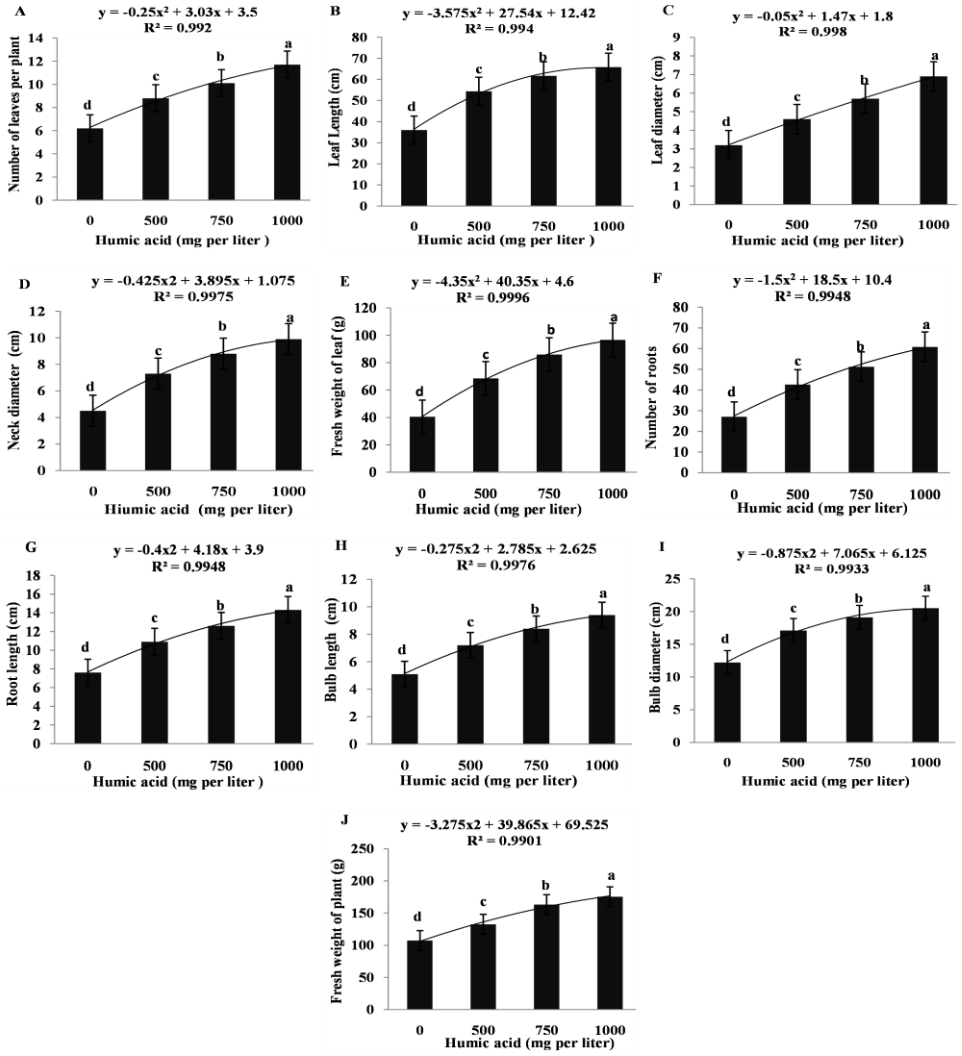

Fig. 1: Growth parameters of onion as affected by humic acid at different concentrations

(Atiyeh *et al.*, 2002). The effect of humic acid on the growth of roots (125.2% increase in number of roots) were greater than shoots (88.7% increase in number of leaves) indicating that greater recourse distribution toward the roots (Nardi *et al.*, 2002; Nikbakht *et al.*, 2008). Root dry mass increased by more than three times with the application of humic substances in bean plants treated with humic substances (Rosa *et al.*, 2009). Chen and Aviad (1990) attributed the growth promotion of humic acid to the enhanced uptake of micronutrients.

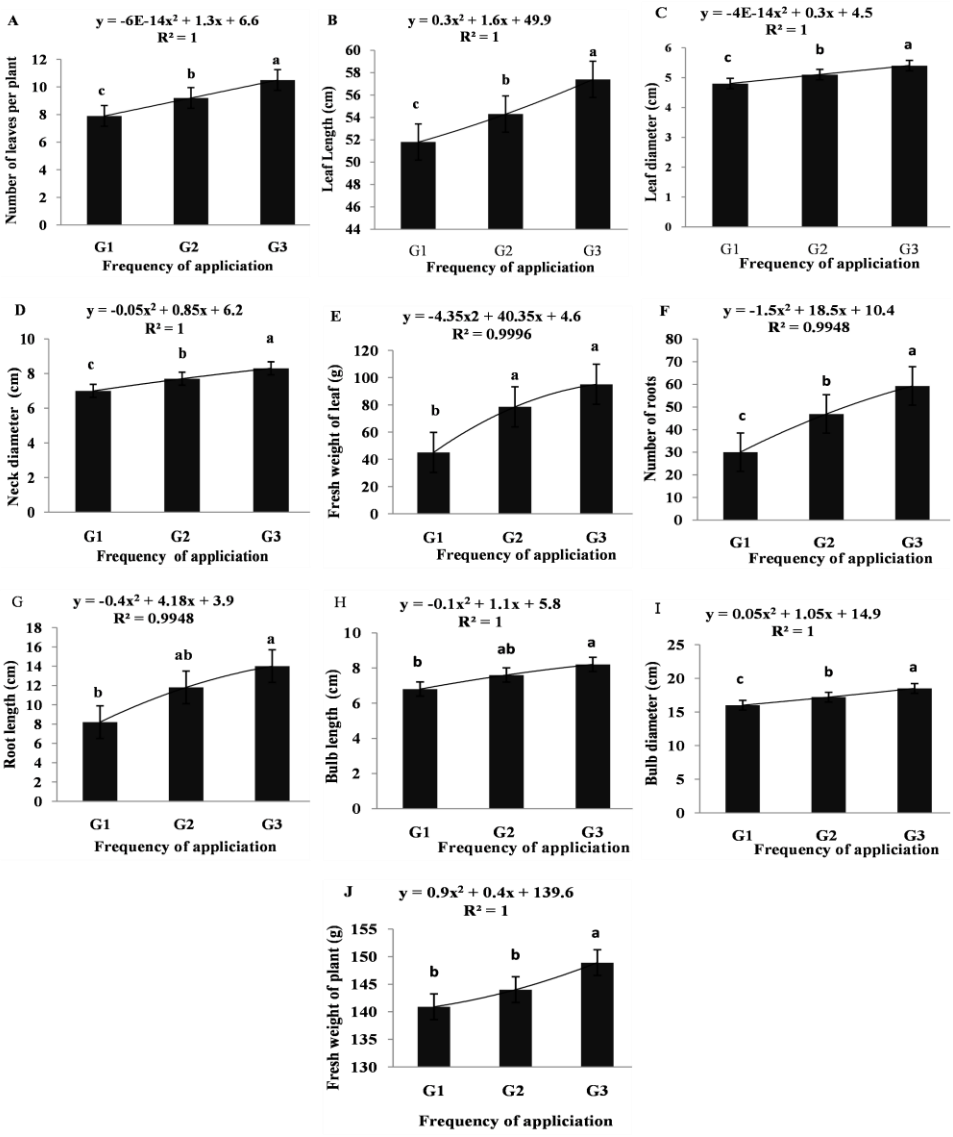

Fig. 2: Growth parameters of onion as affected by humic acid at different growth stages

Promotion in the nutrients uptake with the application of HA has been reported by various researchers (Chen and Aviad, 1990; David *et al*., 1994; Adani *et al*., 1998; Sharif *et al*., 2002). Humic acid increased the uptake of N, P, K, Mg and Ca over the control (Nikbakht *et al*., 2008).

Conclusion

Humic acid can be easily applied to onion plants in the field. Foliar application of humic acid significantly increased all growth characters (i.e. Number of leaves, leaf length, leaf diameter, neck diameter, fresh weight of leaves, root length and number, bulb length and diameter and fresh weight of plants) compared to untreated control plants. Among different times of humic acid applications, Triple spray of humic acid (G3) was better than double (G2) or single spray (G1) in terms of having significantly higher number of leaves, leaf length, leaf diameter, neck diameter, fresh weight of leaves, root length and number, bulb length and diameter and fresh weight of plants.

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