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Effect of Foliar Application with Potassium Humate on Growth and Uptake of some Nutrients by Wheat and Broad Bean Plants

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A COMPLETELY randomized green house experiment with five replicates for each treatment was conducted during 2006 to evaluate the effect of potassium humate (KH) as foliar spray by concentrations of 50, 75, and 100 μg g^{-1} at different stages of growth i.e. one spray after 21 days and two sprays after 21 and 45 days from planting on plant growth and uptake of some nutrients by wheat and broad bean plants.

The dry matter yield of wheat and broad bean plants (after 80 days from plantation) was significantly increased with increasing the concentration and number of sprays of KH; excluding broad bean at one spray, where the increment was insignificant. The content and uptake of N, P and K by both plants significantly increased with increasing KH concentration and number of spray excluding phosphorus at one spray. The same was true with micronutrients (Fe, Mn, Zn, and Cu).

Generally, the highest values of dry matter yield, macro- and micronutrients content and uptake by the studied plants were recorded at the rate of 100 μg g^{-1} KH with two sprays followed by only one spray with the same concentration of KH.

Humic acid (HA) is one of the most important components of bio-liquid complex. Because of its molecular structure, it provides numerous benefits to crop production. It helps break up clay and compacted soils, assists in transferring micronutrients from the soil to the plant, enhances water retention, increases seed germination rates, improves water, air, and roots penetration, and stimulates development of microflora population in soils. Humic acid is not a fertilizer, but as considered as a compliment to fertilizer (Mackowiak *et al.*, 2001).

Singaravel *et al.* (1993) found that the seed yield of sesame plants increased with increasing the addition rate of HA from 0 to 40 kg/ha sprayed on the soil surface. Fagbenro & Agboola (1993) indicated that HA was beneficial to the growth and nutrient uptake of teak seedlings. They found that plant monthly

rates, height, and total dry matter yield significantly increased over the control. Abd El- Aal (1994) reported that the dry matter yield of barley plants grown on sandy and calcareous soils was significantly increased with increasing the addition rate of HA from 450 to 900 mg/kg soil. Deffune *et al.* (1995) stated that growth of wheat seedlings was increased by spraying low concentration of HA. Ayuso *et al.* (1996) studied the stimulation of barley growth and nutrient absorption by humic substances originated from various materials. They found that the low doses (less than 10 mg C l^{-1}) favored plant growth, macro- and micronutrients absorption; while high doses (above 10 mg C l^{-1}) inhibited them. Nardi *et al.* (1999) attributed the beneficial effect of HA on plant growth to its acting as plant growth hormones, since it had a gibberellins like activity and suggested that humic fractions exhibited an auxin like activity exhibiting higher amount of phenolic and a considerable amount of carboxylic groups showed the best metabolic effect. Aydn *et al.* (1999) – in a pot experiment – studied the effect of K H (0, 1.5, 3.0, and 4.5 kg ha^{-1}) applied to the soil or foliage on maize and sunflowers plants. They found that the increasing of K H application rates generally increased dry matter and N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu contents of both plants. They also reported that the increase of ion uptake by plant with soil application of K H was more than its application to the plant as foliar spray.

Humic acid essentially helps the movement of micronutrients form soil to plant. Hermann *et al.* (2000) stated that the positive effect of HA and organic fertilization on the yield capacity of soil consists of many components. First, these components concern nutrient supply to plants. Second, physical soil properties are affected resulting in differences in root penetration, gas exchange and water supply. Also, Mackowiak *et al.* (2001) reported that the benefit role of HA in agricultural systems is its ability to complex metal ions; HA can form aqueous complexes with micronutrients, though not to be the same extent as many synthetic chelating agents; since HA binds to soil colloidal surfaces, it is not easily leached and soil HA promotes micronutrients sorption on soil minerals. Metwally *et al.* (1976) demonstrated that the addition of humic acid to Nile suspended matter amended with $CaCO_3$ increased Fe, Zn, and Cu uptake by barely plant.

The objective of this investigation is to evaluate the effect of humic acid in the form of KH (humic acid 80 %, total K 10 – 12 %, other materials 8 – 10 %, and water solubility more than 98 % and produced during coal mining) at different concentrations and number of sprays on plant growth and some nutrients status in wheat (*Triticum aestivum* L.) and broad bean (*Vicia faba* L.) plants.

Material and Methods

A completely randomized green house experiment with five replicates for each treatment was conducted during winter season of 2006. Pots were packed by five kilograms clay loam soil portion (soil sample was collected from

Mosturod area, Kalubiya Governorate, Table 1). Twenty wheat seeds, Sakha 8 and five seeds of broad bean, variety Giza 2 were planted in each pot at 10 November of 2006. Pots were irrigated twice a week to adjust their moisture content at field capacity. After 10 days, seedlings were thinned to ten and three per pot of wheat and broad bean, respectively. Plants were fertilized according to the general recommendations by Ministry of Agriculture.

Potassium humate solution was sprayed at rates of 50, 75, and 100 μg g^{-1} and number of sprays (only one after 21 days, and other two sprays after 21 and 45 days from planting). After 80 days from planting representative portions of plant samples were wet digested using $HClO_4$ and H_2SO_4. Total N was determined by micro – Kjeldahl technique. Total P by ascorbic acid method and total K by flame – photometre. The micronutrients (Fe, Mn, Zn, and Cu) were determined by Inductively Coupled Plasma Spectrometer (ICP) plasma 400 (Cottenie *et al.*, 1982). Data were statistically analyzed (Snedecor & Cochran, 1980).

TABLE 1. Some chemical properties of the soil.

pH	EC ds m^{-1}	Soluble ions meq 100 g^{-1} soil								OM %	$CaCO_3$ %
		Ca	Mg	Na	K	CO_3	HCO_3	Cl	SO_4		
7.8	0.56	0.72	0.58	1.06	0.48	--	0.20	1.45	1.19	1.04	2.61

Results and Discussion

Wheat

a. Effect of KH on dry matter yield

Data presented in Table 2 show the dry matter yield of wheat plants as affected by KH addition at different concentrations and spray numbers. The results showed that the dry matter yield was significantly increased with increasing the concentration and number of sprays KH compared with the control. The highest values of dry matter yield (37.60 and 46.26 g pot^{-1}) were obtained at rate of 100 μg g^{-1} under one and two sprays, respectively. These results could be explained according to the findings of McCarthy *et al.* (1990) who reported that the beneficial effect of HA on plant growth related to its role, since it acts as plant growth hormones. These results agreed with those obtained by Metwally *et al.* (1976) and Salib (2002) who found that the grain and straw yields of wheat plants were increased by 60.52 and 44.34 %, respectively due to spraying the plant with 60 g HA fed^{-1}.

b. Effect of KH on N, P and K content and uptake

Generally, data in Table 2 showed also that the N, P and K content and uptake were increased with increasing the concentration and spray numbers of KH compared with those of the control treatment. The highest values of N, P and K content and uptake were recorded at rate of 100 μg g^{-1} under two sprays of KH, where the respective values of N, P and K content reached 1.35, 1.05 and 1.27 times that of the control treatment. Under the same concentration and

compared with the non sprayed plants, the values of N, P and K uptake were 2.1, 1.6 and 2.0 times. The results indicated that KH had beneficial effect on the absorption of different nutrients by plant. These results are in agreement with those of Cooper & Chunhua (1998) and Sellamuthu & Govindaswamy (2005).

c. Effect of KH on micronutrients (Fe, Mn, Zn, and Cu) content and uptake

The results of Table 2 revealed that the micronutrients content and uptake of wheat plant significantly increased due to the increase of KH concentration and numbers of sprays. The obtained values of Fe, Mn, Zn, and Cu content at rate of 100 ppm under one spray were 392, 42.23, 53.70 and 25.27 μg g^{-1}; while these values under two sprays were 418, 48.70, 58.30 and 26.03 μg g^{-1}, respectively. Also, the values which obtained from the other treatments were found to in between.

Concerning the Fe, Mn, Zn, and Cu uptake(μ g/plant), data showed that the highest values were recorded at 100 ppm of KH under two sprays followed by 100 ppm under one spray treatment compared with the control. Aydn *et al.* (1999) studied the effect of humic acid application on yield and nutrient uptake by sunflower and corn. They found that increasing KH application rates generally increased dry matter and N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu contents of both plants; also, KH application generally increased nutrient uptake by the plants. While, Nandakumar *et al.* (2004) stated that the HA at 10 kg ha^{-1} as soil application with 0.1 % as foliar spray (twice) + 0.3 % as root dip were the best treatments for improving soil nutrient availability.

Broad bean

a. Effect of KH on dry matter yield

Data in Table 3 indicated that the application of KH had a significant effect on the dry matter yield at all concentrations and the highest values of dry matter yield were obtained at 100 ppm of KH under two sprays compared with other treatments. The increase of dry matter yield at one spray was insignificant. Also, data showed that the highest values of dry matter yield were 18.13 and 21.77 g pot^{-1} for 100 μg g^{-1} KH under one and two sprays, respectively. The relative increase in dry matter for the above-mentioned treatments is 22.5 and 47.1 %, in sequence. These results are in agreement with those obtained by McCarthy *et al.* (1990) and Salib (2002).

b. Effect of KH on macronutrients content and uptake

The presented results in Table 3 indicated that the N, P and K content and uptake significantly increased with increasing KH concentration and number of sprays at all treatments excluding N content under one spray. Also, the highest values of N, P and K content and uptake were recorded at 100 μg g^{-1} of KH compared with other treatments. The values of N, P and K content at the rate of 100 μg g^{-1} under one or two sprays treatments of KH were higher than that of the control treatment by 9.4, 29.0 and 15.7 % or 29.8, 28.7, and 16.5 %, respectively. In addition, the obtained values of N, P and K content of broad bean with other concentrations of KH represent an intermediate case.

TABLE 2. Dry matter yield, N , P and K and some micronutrients (Fe, Mn, Zn and Cu) content and uptake by wheat plants as affected by KH application.*

concentration of KH solution	D.M	N		P		K		Fe		Mn		Zn		Cu	
	g/pot	Content %	Uptake mg/plant	Content %	Uptake mg/plant	Content %	Uptake mg/plant	Content µg g^{-1}	Uptake µ g/plant	Content µg g^{-1}	Uptake µ g/plant	Content µg g^{-1}	Uptake µ g/plant	Content µg g^{-1}	Uptake µ g/plant
One spray after 21 days from planting															
Control	29.93	2.61	78.12	0.42	12.60	2.36	70.63	331	990.7	27.73	83.0	35.30	105.6	18.43	55.2
50 µg g^{-1}	32.10	2.45	78.62	0.41	13.16	2.36	75.43	342	1095.7	30.93	99.3	39.23	125.9	23.87	76.6
75 µg g^{-1}	35.80	2.72	97.43	0.44	15.75	2.35	86.99	351	1257.6	36.57	130.9	46.93	168.0	23.67	84.7
100 µg g^{-1}	37.60	2.98	111.81	0.45	16.92	2.43	91.00	392	1473.9	42.23	158.8	53.70	201.9	25.27	95.0
LSD at 5%	4.61	0.93	10.19	NS	NS	2.42	12.83	13.10	166.66	6.23	20.85	1.60	20.39	6.76	19.91
Two sprays after 21 and 45 days from planting															
50 µg g^{-1}	34.40	2.64	90.82	0.43	14.80	2.53	87.03	397	1305.8	36.17	124.4	46.40	159.6	25.10	86.3
75 µg g^{-1}	38.20	3.30	126.10	0.44	16.81	2.87	109.63	408	1557.4	41.13	157.1	53.93	206.0	26.10	99.7
100 µg g^{-1}	46.26	3.53	163.30	0.44	20.35	2.99	138.32	418	1933.7	48.70	225.3	58.30	269.7	26.03	120.4
LSD at 5%	8.17	0.84	15.35	NS	5.24	1.36	21.48	25.72	25.00	2.72	31.17	2.28	4.61	7.75	2.82

*- after 80 days from planting.
NS - not significant.

Also, the data revealed that the mentioned trend of N, P and K content was observed for N, P and K uptake, where the highest values of N, P and K uptake were obtained at rate of 100 µg g^{-1} under two sprays (191, 195 and 171%); while at the same concentration under one spray, the values of N, P and K uptake were (134, 170 and 142%) compared with the control (100%), respectively. This increase in N, P and K content and uptake may be attributed to the improving role of KH on auxins content; in which auxins are involved in the chelating of iron for the plant, improving growth, heaving nutrient intensity of the plant, especially the development of the root system of the plant. These results confirmed with those of data obtained by El-Ghanam & El-Ghazoli (2003) who reported that the N, P and K content and uptake was increased with increasing concentration of HA by faba bean plants.

c- Effect of KH on micronutrients content and uptake

The results in Table 3 revealed that the micronutrients content and uptake of broad bean significantly increased due to the increase of KH concentration and number of sprays. The highest values of Fe, Mn, Zn and Cu content and uptake were obtained by spraying the plant with100 µg g^{-1} KH solution twice followed by one spray at the same concentration. The values of Fe, Mn, Zn and Cu content at rate of 100 µg g^{-1} under two sprays were higher than that of the control treatment by 17.7, 22.2, 30.4 and 40.2 %. The respective values under one spray were 16.5, 18.2, 21.8 and 25.5 %. Concerning the micronutrients uptake, data revealed that the mentioned trend of N, P and K uptake was noticed for micronutrients. The highest values of Fe, Mn, Zn and Cu uptake were observed for the 100 µg g^{-1} of KH under two sprays treatment; followed by the same concentration when sprayed only once. These results are in agreement with those of Aydn *et al.* (1999) and Nandakumar *et al.* (2004).

Generally, this increase in dry matter yield of plants, nutrients content and uptake due to foliar application of KH may be attributed mainly to the beneficial roles of KH components. The first, humic acid (80 %), which combine with sunlight and photosynthesis to produce metabolic energy, then include the biochemical manufacture of complex organic material, especially carbohydrates from CO_2, water, nutrients, and inorganic salts, along with sunlight energy for chlorophyll production. The second is the role of potassium (10 – 12 %) in plant growth and nutrition, which play a significant role in carbohydrate metabolism and translocation in plant.

TABLE 3. Dry matter yield, N, P and K and some micronutrients (Fe, Mn, Zn, and Cu) content and uptake by broad bean plants as affected by KH application *

concentration of KH solution	D.M	N		P		K		Fe		Mn		Zn		Cu	
	g/pot	Content %	Uptake mg/plant	Content %	Uptake mg/plant	Content %	Uptake mg/plant	Content $\mu g\ g^{-1}$	Uptake μ g/plant	Content $\mu g\ g^{-1}$	Uptake μ g/plant	Content $\mu g\ g^{-1}$	Uptake μ g/plant	Content $\mu g\ g^{-1}$	Uptake μ g/plant
One spray after 21 days from planting															
Control	14.80	3.93	193.88	0.31	15.29	3.63	179.10	412	2032	47.30	233.30	43.13	213.0	18.40	90.77
50 $\mu g\ g^{-1}$	17.27	4.17	240.10	0.32	18.42	3.83	221.48	458	2636	49.27	284.00	45.40	261.0	20.77	120.0
75 $\mu g\ g^{-1}$	17.30	4.27	246.24	0.37	21.34	4.10	236.43	469	2705	52.60	303.00	48.70	281.0	22.43	129.0
100 $\mu g\ g^{-1}$	18.13	4.30	259.86	0.41	26.00	4.20	253.82	480	2901	55.90	338.00	52.53	317.0	23.10	140.0
LSD at 5%	NS	NS	64.45	0.11	6.92	0.44	9.37	12.42	5.55	2.62	7.33	4.34	47.26	2.30	23.78
Two sprays after 21 and 45 days from planting															
50 $\mu g\ g^{-1}$	17.63	4.30	252.69	0.34	19.98	4.03	236.82	467	2744	51.70	304	47.86	281	22.27	131.14
75 $\mu g\ g^{-1}$	20.13	4.56	305.97	0.38	25.50	4.13	277.12	476	3194	56.70	380	54.50	366	24.60	165.30
100 $\mu g\ g^{-1}$	21.77	5.10	370.1	0.43	29.75	4.23	306.95	485	3517	57.80	419	56.20	408	25.80	187.30
LSD at 5%	3.23	0.48	68.64	0.055	6.39	0.54	49.83	12.58	49.25	2.36	13.13	8.33	78.60	2.96	28.00

* - after 80 days from planting.
NS - not significant

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تأثير الرش بهيومات البوتاسيوم على نمو القمح والفول البلدي وامتصاص بعض العناصر المغذية

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أقيمت تجربة أصص بنظام تام العشوائية ذو خمسة مكررات لكل معاملة خلال الموسم الشتوي ٢٠٠٦ لدراسة تأثير رش هيومات البوتاسيوم مرة واحدة على المجموع الخضري للنبات بعد ٢١ يوم من الإنبات أو مرتين بعد ٢١، ٤٥ يوم من الإنبات وذلك بتركيزات مختلفة (٥٠، ٧٥، ١٠٠ ميكرو جرام/ جرام) على نمو نباتي القمح ، الفول البلدي وكذا محتوى النبات وامتصاصه لبعض العناصر المغذية.

أدى رش النبات بهيومات البوتاسيوم إلى زيادة معنوية فى إنتاج المادة الجافة لنباتي الفول والقمح تحت جميع المعاملات فيما عدا الرش لمرة واحدة لنبات الفول، حيث كانت الزيادة غير معنوية. كما أدى الرش بهيومات البوتاسيوم إلى زيادة معنوية فى محتوى وامتصاص النبات لعناصر النيتروجين، الفوسفور، البوتاسيوم تحت جميع المعاملات . كما لوحظ زيادة معنوية فى محتوى وامتصاص النبات للعناصر الصغرى (الحديد، المنجنيز، الزنك، النحاس) وكان هذا واضحا فى جميع المعاملات سواء من ناحية تركيز محلول الرش أو عدد الرشات.

وبصفه عامه يؤدى رش النباتات بهيومات البوتاسيوم إلى زيادة إنتاج المادة الجافة وامتصاص العناصر المغذية تحت الدراسة لنباتي الفول والقمح بزيادة تركيز هيومات البوتاسيوم وعدد الرشات، حيث كانت أفضل النتائج عند إضافة هيومات البوتاسيوم رشا بتركيز ١٠٠ ميكرو جرام/ جرام سواء كان الرش لمرة واحدة أو مرتين .