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EFFECT OF HUMIC ACID, EFFECTIVE MICROORGANISMS (EM) AND MAGNESIUM ON POTATOES IN CLAYEY SOIL

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ABSTRACT

This investigation was carried out during the two fall seasons of 2004/2005 and 2005/2006 on potato cv. Spunta at Baramoon Experimental Farm, Dakahlia Governorate. The current study aimed to identify the integrated effect of humic acid, effective microorganisms (EM) and magnesium used as individual and/or combined treatments on vegetative growth, yield and its components and contents of NPK in leaves and tubers as well as dry matter and nitrate content in tubers.

Results showed that the vegetative growth parameters, i.e., plant height, number of main stems/plant, foliage fresh and dry weight/plant, at 75 days after planting, likewise, total yield, tuber number and tuber dry matter at harvest time, as well as NPK contents in the leaves at 75 days after planting and in tubers at harvest gave the highest values with the combined treatment which received humic acid, effective microorganisms (EM) and magnesium, while, the highest chlorophyll content at 75 days after planting was noticed with magnesium foliar spray. The lowest value of nitrate content in tubers was recorded from untreated plant .

The beneficial effect of humic acid combined with EM and magnesium, might be due to releaseing the available nutrient and promoting the development of chlorophyll , and in turn reflected positively yield and its components.

INTRODUCTION

Potatoes are grown worldwide under a wider range of altitude, and climatic condition than any other major crop. Humic acids a profound effect not only on the biological activity and soil structure, but also on the plant its self. This is due to their positive effect on the increment in plant nutrients and their availability to the growing plants (El-Fakharani,1999 and Marks *et al*. 1997) they also, indicated that fertilization with bio-humus from processed cattle manure applied at 3000, 4000 and 5000 liter/ha had positive effect on potato yield. Seyedbagheri and Torell (2001) found that applied humic acid at 84 kg/ha increased potato yield, increased soil fertility, improved tilth and facilitates aeration and water penetration, they also, found that the highest yields of the grown crops were obtained, when humus content in the soil was 2.3 – 2.5%.

On the other hand, Atienza and Aquino (1996) noticed that there was a significant increase in yield of potato by using EM and Bokashi organic fertilizer either singly or combined and likewise Largosa and Balaki (1998) observed that larger tuber were produced in plots treated with Bokashi + EM.

Mahendran and Chandramani (1998) found that the application of the recommended NPK rate to soil inoculated with *Azospirillum* and *phosphobacteria* gave the highest tuber yield of potato.Also, Ghoneim and Abdel-Razik (1999) found that inoculation of potato tuber with biofertilizers (Hale x 2) had significant total yield, N, P, Ca and starch of potato tuber cv.

Alpha. Kumar *et al.* (2001) found that fertilization of potato cv. Kurfri Ashoka with 100% N,P and tuber treatment with *Azotobacter* + *phosphobacteria* increased plant height, number of leaves and total yield. Abou Hussein *et al.* (2002 a and b) mentioned that biofertilizer that were added to the soil or inoculated with tuber, increased the vegetative growth characters, percentage of nutrients in potato leaves, dry matter content, total carbohydrates and total yield per plant. Indiresh *et al.* (2003) indicate that inoculation of potato with both *Azotobacter chroococcum*e and *Psudomonas striata* showed significantly effect on tuber, tuber weight per plant, total tuber yield and marketable tuber yield of potato. Kushwah and Banafar (2003) reported that application of potato with 150 kg N + 80 kg P_2O_5/ha with inoculation of phosphate solubilizing bacteria increased yield tubers. Yadav *et al.* (2003) found that inoculation with *Azotobacter* increased tuber yield potato by 5-24% in the presence of N over unioculated without N. Anwar (2005) found that application of 100% mineral NPK + 1kg nitropein and 1kg phosphorein + spraying with 1% K_2SO_4 was the superior treatment for yield and its components.

Kiss (1989) found that application of 22 kg Mg/ha increased tuber yields. Shanmugasundaram and Nanjan (1992) mentioned that foliar application of Mg (1% $MgSO_4$) gave increased potato yields of 13.43 to 14.12 t/ha. Allison *et al.* (2001) show that significant increases resulting from use of Mg fertilizers, the optimum Mg application rate was <50 kg/ha. Slavov *et al.* (2001) found that applied of MgO (14.57%) had positive effect on yield and quality of potato as well as increased dry matter. Swierezwska and Sztuder (2001) indicate that foliar application of magnesium fertilizer at 5% $MgSO_4.7H_2O$ solution at rate of 300 dm^3/ha increases crop yield. Civic (2002) found that NPK with 2.5, 5 or 7.5% Mg tuber yield 27.23 – 29 t/ha compared with 24.5 t/ha for NPK only also, Mg applied increased vitamin C. Kavvadias *et al.* (2002) found that 360: 150 : 250 kg NPK + 100 kg Mg/ha gave the highest tuber yield. Civic (2003) indicated that tuber yield increased from 53.87 to 56 t/ha with 17.5 kg MgO. Rogozinska *et al*. (2004) found that higher magnesium concentration in potato tubers was correlated stronger to accumulate vitamin C and protein at (45 kg Mg/ha).

This current work aims to study the integrated effect of humic acids and effective micro-organisms (EM) in combination with magnesium on potatoes in ayey soil.

MATERIAL AND METHODS

This study was conducted during the two fall seasons of 2005/2006 and 2006/2007 at the experimental farm of the Baramoon Station, Dakahlia Governorate. Tuber seed of potato (*Solanum tuberosum* L.) cv. Spunta was used. The whole seed tubers were planted, on 7 and 10 of October in the first and seconded seasons, respectively,and harvested at 105 days from planting in the two seasons. Each plot area was 13.5 m^2 comprising of three rows 0.75 m width and 6 m length and tubers were planted on 25 cm spacing . Some physical and chemical properties of the experimental soil are presented in Table 1.

Table 1.Some physical and chemical properties of the experimental soil.

Parameters		Values	Parameters		Values
EC dS/m		0.79	Mechanical analysis	C. sand	2.9
pH 1:2.5		7.8		F. sand	19.1
SP %		66		Silt	26.8
Available cations	Ca^{++}	2.23		Clay	51.2
	Mg^{++}	1.31		Texture	Clayey
	Na^{+}	0.74	OM%		2.72
	K^{+}	0.06	$CaCO_3$%		3.48
Available anions	$CO_3^{=}$	0	Available nutrients		
	HCO_3^{-}	1.88	N%		53
	Cl^{-}	0.93	P%		3.7
	$SO_4^{=}$	1.53	K%		365

The experimental design

The treatments were arranged in a randomized complete block design with three replicates.

Treatments

1- Control.
2- Humic acid (0.5%) according to Zhang *et al.* (2003).
3- EM (diluted 1 : 100) was used as biofertilizer according to Largosa and Balaki (1998).
4- Magnesium (0.5%) according to Allison *et al.* (2001).
5- Humic acid + EM.
6- Humic acid + Mg.
7- EM + Mg.
8- Humic acid + EM. + Mg.

EM is a biological solution produced in vats from cultivation of over 80 varieties of micro-organisms belonging to different families, i.e., photosynthetic bacteria, yeasts, lactic acid bacteria and fungi . These microorganisms included both aerobic and amaerobic species (Higa, 1994). It was obtained from Environment Affair Management.Humic acid in a solid form (HA 85%) as K-humate was obtained from union for Agriculture Development Com. Magnesium sulfate fertilizer (20% MgO-7H_2O) was obtained from Chemicals El-Gomhouria Co.

Nitrogen fertilizer as ammonium nitrate (33.5% N) was added at the rate of 180 kg N/fed at three equal portions at 3, 5 and 7 weeks after planting, calcium superphosphate (15.5% P_2O_5) was added at 75 kg P_2O_5/fed once during the soil preparation and potassium sulphate (48% K_2O) at rate of 96 kg K_2O/fed in two times one half with first addition of N fertilizer and second half with the third addition of N fertilizer.

Before addition, both humic at 0.5% and EM diluted 1:100 were added beside potato plant with 100 ml/plant from each type at 32, 46 and 60 days after planting, while magnesium sulphate was added at dose of 0.5% as foliar spraying at 7 and 9 weeks after planting.

Data collected

1.Vegetative growth parameters

A random sample of five plants was taken at 75 days after planting (DAP) for determination of vegetative growth, i.e., plant height, number of main stems/plant, foliage fresh and dry weight . Chlorophyll content was measured by a Minolta SPAD unit chlorophyll meter (Yadaua, 1986). Chlorophyll measuring were taken on the fifth leaf from the plant apex .

2. Yield and its components

Total tuber yield/fed , number of tubers / plant and tuber weight / plant were determined at harvest time, i.e.,105 days after planting.

3.Tuber quality

At harvest, random samples of tubers were dried at 70 ^{o}C till constant weight for dry matter measuring and nitrate tubers (dry weight basis) was estimated as reported by Singh (1988).

4.Chemical contents

Nitrogen, phosphorus and potassium were determined in the fourth leaf from the plant apex at 75 days after planting (DAP) and in tubers at harvest time. Nitrogen was determined by the microkjeldahl method as mentioned by Hesse (1971). Phosphorus was determined colorimetrically at a wavelength of 660nm using stannous chloride reduced molybedohosphoric blue color method as described by Jackson (1967). Potassium was determined using Gallen flame photometer as described by Jackson (1967).

Soil analysis

Soil mechanical and chemical analyses were determined according to Black (1965) and Jackson (1967).

Statistical analysis

Data were statistically analyzed and means were compared by using LSD test as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1.Vegetative growth parameters

Data presented in Table (2) indicated that application of humic acid, EM and magnesium either in a single form or mixed together to potato plants had significant effect on vegetative growth parameters expressed as plant height, chlorophyll content, foliage fresh and dry weight, in both seasons. The highest estimates were obtained with combination of humic acid plus EM and Mg compared to untreated (control). These results could be due to the role of humic acid which enhance photosynthetic process, stimulate root growth and development of chlorophyll and proliferation of desirable micro-organisms in soil (Liu *et al.,* 1998). The benefits of EM compound are stated by Abou-Hussein *et al.* (2002a) and Anwar (2005) who mentioned that it increases microorganisms living in the soil and help plant growth by increasing the number and biological activity of desired microorganisms in the root environment and its ability to release plant growth promoters, activate absorption and efficiency of nutrients as well as the metabolism processes and improved root growth and functions.

2

Also, the increased vegetative growth of potato resulted from foliar spray with magnesium may be attributed to its role as the central atom of the chlorophyll molecule, converts light energy into chemical energy and is essential for photosynthesis (Clecko *et al*., 2000; Allison *et al.,* 2001).

Table 3. Effect of humic acid, EM and Mg on total tuber yield, tuber number and tuber weight/plant in the two fall seasons 2005/2006 and 2006/2007.

Treatments	Total Tuber Yield t/fed		Tuber No./Plant		Tuber weight/plant (g)	
	2005	2006	2005	2006	2005	2006
Control	9.87	9.45	3.16	3.05	428.67	415.00
Humic acid	10.02	9.63	3.55	3.50	459.00	438.33
EM	9.82	9.46	3.30	3.25	436.67	427.33
Mg	9.70	9.41	3.19	3.20	437.00	422.67
Humic acid +EM	10.51	10.29	3.82	3.72	488.33	482.00
Humic acid + Mg	10.31	10.18	3.60	3.58	506.67	460.33
EM + Mg	10.18	10.06	3.53	3.47	471.67	447.67
Humic acid+Em+Mg	11.04	10.56	4.22	3.95	568.00	531.67
LSD 5%	**0.193**	**0.153**	**0.141**	**0.172**	**11.734**	**15.323**

2.Yield and its components

Data in Table (3) revealed that the individual treatments and/or combination with humic acid, effective EM and magnesium on total yield and its components, i.e., total tuber yield, tuber number and weight/plant, were significantly increased in both seasons. The highest values of total tuber yield were produced by treatment received humic acid, EM and magnesium together, since it increased their values by 11.85% and 11.75% compared with control in both seasons, respectively. The results illustrated by Chen and Aviad (1990) demonstrated that humic materials increase the permeability of plant membranes promote the uptake of nutrients, increase soil moisture holding capacity, improved soil, reduce impacts of disease and stimulate plant growth (higher biomass production) by accelerating net photosynthesis consequently tuber development Zhang *et al.* (2003). The influence of multi-biofertilizer (EM) may be due to increasing microorganisms in the soil, which convert the unavailable forms of nutrients elements to available forms. As well as producing growth promoting substances which increase the plant growth, so that the tuber weight and tuber size increased, which consequently increased the total yield. Similar results were found by Abou-Hussein *et al.* (2002a and b), Singh *et al.* (2002), Indirsh *et al.* (2003) and Anwar (2005), they reported that potato inoculated with suspension of biofertilizer gave the greatest total tuber yield. The enhancing effect of magnesium element may be attributed to it aids in the formation of many compounds, such as sugars, proteins, it regulates the uptake of other plant nutrients, especially phosphorus, and it is involved in the translocation and metabolism of carbohydrates (Fallett *et al.,* 1988).

3.Tuber quality (dry matter and nitrate contents)

Data presented in Table (4) show that the used treatments, individually or together, significantly increased content of dry matter and nitrate in the tubers in the two seasons. The maximum values of dry matter and nitrate in tubers were obtained when the plants were supplied with humic acid, EM and magnesium in combination while the minimum values were obtained in the tubers of control in both seasons. These results may be due to increase of availability of elements in rooting zone, consequently increasing their absorption by plant and translocated them to the storage parts (tubers) as reported by Salib (2002) who worked on humic acid, EM and micronutrients .

Table 4. Effect of humic acid, EM and Mg on contents the tubers dry matter and NO_3 in the two fall seasons 2005/2006 and 2006/2007.

Treatments	Tuber NO_3 (ppm)		Tuber dry matter(%)	
	2005	2006	2005	2006
Control	28.00	30.33	19.40	21.16
Humic acid 100 ml/plant	38.67	46.00	19.97	22.03
EM 100 ml/plant	36.33	41.00	19.76	21.89
Mg 0.5%	33.33	36.33	19.59	21.66
Humic acid +EM	58.00	66.33	20.32	22.38
Humic acid + Mg	52.33	55.33	20.20	22.21
EM + Mg	44.00	47.33	20.14	22.17
Humic acid+Em+Mg	66.33	71.67	20.42	22.43
LSD 5%	**3.706**	**4.013**	**0.071**	**0.134**

4.Mineral content

It is clear from the data in Table (5) that the addition of humic acid, EM and magnesium had significant effect on macronutrient (NPK) in leaves at 75 days after planting (DAP) and the tubers at harvest time in both seasons. However, the highest percentage of total nitrogen, phosphorus and potassium in the leaves and tuber were obtained in plants supplied with the combined treatment of humic acid, EM and magnesium compared with control in the two seasons. These results may suggest that humic acid stimulate root growth and enable better uptake of nutrients (Liu *et al.*, 1998) ; Zhang *et al.*, 2003). Adding EM as biofertilizers play fundamental role in N_2 fixiation and converting P or K form to be soluble ready for plant nutrition making the uptake of nutrients by plants more easy. The results are in harmony with those reported by Zaghloul (2002), Abou-Hussein *et al.* (2002a and b) and Anwer (2005). As to the role of magnesium, it regulates the uptake of other nutrients, especially phosphorus (Allison *et al.*, 2001).

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تأثير حمض الهيوميك والمخصب الحيوي EM والمغنسيوم على نبات البطاطس في الأراضي الطينية

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تـم تنفيـذ تجـربتين حقليتـين خـلال موسـمين نيليـين ٢٠٠٤/٢٠٠٥ و ٢٠٠٥/٢٠٠٦ علـى محصـول البطـاطس صـنف سبونتا فـي مزرعـة بحـوث البسـاتين بـالبرامون، محافظـة الدقهليـة. وتهـدف هذه الدراسـة إلـى استبيان مدى التأثير المتكامل لحمض الهيوميك وفعالية المخصب الحيوي EM وعنصر المغنسيوم (كإضـافات منفـردة أو مشـتركة) علـى الصـفات الخضـرية والمحصـول ومكوناتـه وكـذلك محتـوى النيتـروجين والفوسـفور والبوتاسيوم في الأوراق والدرنات بالإضافة إلى مستوى المادة الجافة والنترات في الدرنات.

وتشير النتائج إلى أن القياسات الخضرية (طول النبـات، عدد السيقان الرئيسية /نبـات، الـوزن الطـازج والجـاف/ نبـات) عنـد ٧٥ يـوم بعـد الزراعـة، وكـذلك المحصـول الكلـي، عـدد الـدرنات ووزن الـدرنات/النبات ومحتوى المادة الجافة في الدرنات عند الحصاد، بالإضافة إلـى محتوى النيتروجين والفوسفور والبوتاسيوم في الأوراق عند ٧٥ يوم بعد الزراعة والدرنات عند الحصـاد قد أعطت أعلى قيم مـع المعاملـة المشتركة بحمض الهيوميـك + المخصـب الحيـوي EM + عنصـر المغنسـيوم بينمـا أعلـى محتـوى للكلورفيـل عنـد ٧٥ يـوم مـن الزراعـة تـم الحصـول عليـه مـع الـرش بالمغنسـيوم منفرداً، ومـن ناحيـة أخـرى فـإن أقل محتـوى للنتـرات فـي الدرنات قد تم تسجيله فى درنات النباتات الغير معاملة.

أيضـا التأثير المفيد لإ ضا فة حمض الهيوميك والمخصب الحيوي EM وعنصـر المغنسيوم معـا قد يكون راجعا إلى زيادة وزيادة القدرة على ميسرة المغذيات وتحفيز تكون الكلوروفيل والذي ينعكس إيجابياً علـى محصول ومكوناته.

Table 2. Effect of humic acid, EM and Mg on plant vegetative growth parameters at 75 days after planting in the two fall seasons 2005/2006 and 2006/2007.

Treatments	Plant height (cm)		Number of main stems/plant		Chlorophyll Content (SPAD)		Foliage fresh weight/plant (g)		Foliage dry weight/plant (g)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Control	53.10	50.25	2.08	2.14	27.34	26.37	45.90	44.45	309.42	290.81
Humic acid	54.66	53.02	2.17	2.26	31.09	29.89	47.37	46.00	335.15	325.10
EM	53.92	53.15	2.23	2.20	28.72	28.20	44.87	44.53	326.38	318.40
Mg	53.78	52.23	2.25	2.24	28.25	27.22	55.88	55.02	320.97	316.67
Humic acid +EM	56.40	54.66	2.32	2.33	34.28	33.24	48.88	49.99	357.83	350.60
Humic acid + Mg	55.18	54.44	2.44	2.41	33.30	32.36	54.86	53.59	346.98	342.38
EM + Mg	54.27	52.58	2.51	2.48	32.21	31.48	52.73	51.93	341.22	335.69
Humic acid+EM + Mg	61.27	58.44	2.63	2.58	36.47	35.60	54.47	54.89	367.76	360.76
LSD 5%	**1.882**	**1.867**	**0.122**	**0.194**	**1.351**	**1.258**	**2.145**	**1.722**	**6.375**	**7.949**

Table 5. Effect of humic acid, EM and Mg on contents the leaves and tubers N, P and K% in the two fall seasons 2005/2006 and 2006/2007.

Treatments	Tuber N%		Tuber P%		Tuber K%		LeavesN%		Leaves P%		LeavesK%	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Control	1.39	1.51	0.243	0.263	1.57	1.70	2.30	2.49	0.207	0.223	2.39	2.64
Humic acid	1.58	1.78	0.293	0.317	1.99	2.14	2.59	2.88	0.253	0.285	2.68	2.97
EM	1.53	1.67	0.272	0.300	1.90	2.12	2.47	2.72	0.242	0.272	2.61	2.85
Mg	1.47	1.64	0.261	0.293	1.66	1.83	2.39	2.65	0.237	0.259	2.50	2.78
Humic acid +EM	1.90	2.02	0.349	0.382	2.73	2.95	2.94	3.30	0.283	0.307	3.09	3.34
Humic acid + Mg	1.78	1.88	0.339	0.377	2.37	2.55	2.85	3.17	0.275	0.296	2.94	3.21
EM + Mg	1.67	1.84	0.312	0.342	2.20	2.50	2.65	2.87	0.264	0.294	2.85	3.17
Humic acid+Em+Mg	2.00	2.21	0.360	0.388	2.58	3.16	3.02	3.41	0.295	0.320	3.26	3.54
LSD 5%	**0.062**	**0.044**	**0.007**	**0.005**	**0.286**	**0.056**	**0.084**	**0.054**	**0.008**	**0.005**	**0.063**	**0.049**