J. Agric. Sci. Mansoura Univ., 30 (10): 6167 - 6182, 2005

EFFECT OF MINERAL AND BIO-PHOSPHATE FERTILIZATION AND FOLIAR APPLICATION OF MICRONUTRIENTS ON SWEET POTATO "*Ipomoea batatas*, L."

2- CHEMICAL COMPOSITION OF LEAVES AND CURED TUBER ROOTS.

Hassan, M.A.[1]; S.K. El-Seifi[1]; F.A. Omar[1] and U.M Saif El-Deen[2]
1- Dept. of Hort., Fac. of Agric., Suez Canal Univ. Ismailia, Egypt.
2- Vegetable Res. Dept., Hort. Res. Inst., Agric Res. Center. Giza, Egypt.

ABSTRACT

Two field trials were carried out in 2002 and 2003 seasons on sweet potato cv. Abeese, at El-Bramoon Agric. Farm of El-Mansoura Hort. Res. Station. The research aimed at studying the effect of foliar nutrition with a mixture of Fe, Mn and Zn, each at 100 ppm, vascular arbuscular mycorrhiza (VAM) and Phosphorein, as bio-phosphorus fertilizer, and mineral phosphate fertilizer at 0, 30, 45 and 60 kg P_2O_5/fed., on chemical composition of leaves and nutritional status of cured roots of sweet potato. Results indicated that foliar application of micronutrients significantly increased N contents of leaves and cured roots, P contents of cured roots and K contents of leaves, in both seasons. Also Fe, Zn and Mn contents of both leaves and tuber roots significantly increased in response to foliar spray with micronutrients. Using P_2O_5 at 60 kg/fed. as mineral fertilizer, or VAM, as bio-fertilizer resulted in best significant increases in N, P, K, Fe, Zn, and Mn, in leaves and cured roots, in both seasons.

Organic composition, i.e., total carbohydrates, reducing, non-reducing, total carotenes and dry matter, of cured sweet potato roots were significantly increased as a result of treating plants with either micronutrients, or mineral phosphorus fertilizer at 30, 45 or 60 kg P_2O_5/ fed., or by VAM or Phosphorein as bio-phosphate fertilizer.

Positive interactions among micronutrients, mineral P-rates and bio-phosphorus fertilizer, on chemical composition of leaves and cured roots were detected.

INTRODUCTION

Sweet potato is a popular vegetable crop in Egypt. It has been cultivated for food and starch manufacture, while the foliage parts are used in animal feeding.

Micronutrients are essential elements for plant growth and development. They are involved in many metabolic functions such as transport of carbohydrates, regulation of meristematic activity, photosynthesis, respiration, energy production and protein metabolism. Such function would contribute to mineral and organic composition of plant organs. (Srivastva and Gupta, 1991).

Phosphorus has benefical effect on the activation of photosynthesis and metabolic processes in plants. It is also an essential component of many organic compounds, such as phosphoprotein, phospholipids, nucleic acid and nucleotides (Marchner, 1995). Phosphate-dissolving bacteria (Phosphorein) and fungus (mycorrhiza) have the capability to mobilize phosphate, micronutrients and phytohormones such as gibberellins, auxins and cytokinins, in addition of promoting root development and thereby enhance nutrient uptake (Marschner, 1995). Considerable investigations have been focused on the effect of micronutrients and mineral and bio-phosphate fertilizer on growth and yield of sweet potatoes (El-Shimi, 1996; Alphonso *et al*, 2002 and El-Morsy *et al.*, 2002) but few researches have been carried out on chemical composition of vegetative growth and nutritional status of tuber roots as affected by the application of micronutrients and mineral and bio-phosphate fertilization. However, Srivastva and Gupta (1996) reported that micronutrients have a positive effect on organic composition of plant organs through their essential roles in many important metabolic functions. On the other hand, Marschner (1995) pointed out that organic composition of plants may be affected by phosphorus because of its role as an essential component of many organic compounds. He also added that VA mycorrhiza fungi are capable to contribute some hormones and supply plants with P elements and certain micronutrients, that would contribute positively to organic composition of plant organs.

Therefore, the object of this study was to determine the effect of foliar nutrition with micronutrients, and mineral and bio-phosphate fertilization on chemical composition of vegetative growth and cured tuber roots of sweet potato cv. Abeese.

MATERIALS AND METHODS

Two field experiments were carried out at El-Bramoom Agricultural Research farm of El-Mansoura Horticultural Research station, during the two successive summer seasons of 2002 and 2003. The experiments were designed to investigate the effects of some micronutrients, mineral and bio-phosphate fertilizer treatments and their interactions, on chemical composition of vegetative growth, and tuber roots of sweet potato (*Ipomoea batatas*, L.) cv. Abeese, under clay-loam soil conditions. Physical and chemical properties of experimental soil are presented in Table (1).

Table (1): Some physical and chemical properties of the experimental soil

Parameter	Sand %	Silt %	Clay %	Texture	pH	$CaCO_3$	EC (ds/m)	Organic matter %	Available elements (ppm)					
									N	P	K	Zn	Mn	Fe
Value	25.8	33.7	40.5	Clay loam	8.11	4.55	1.12	1.95	47.2	11.9	379.0	1.35	11.51	8.62

Each experiment was designed as split-split-plot with 4 replicates. The micronutrient mixture (Fe, Zn and Mn) placed in the main plots, which subsequently divided into 4 sub plots, each contained one of the phosphate rates, while biofertilizer treatments were assigned to the sub-sub plots.

Each sub sub plot area was 17.5 m^2 and contained 5 rows; each was 5m in length and 0.7m in width. The experiment included 24 treatments which were the possible combinations of 2 micronutrient levels (0.0 and 100 ppm of chelated Fe, Zn and Mn mixture), 4 P_2O_5 rates (0, 30, 45 and 60 kg/fed.), and 3 biofertilizer treatments, i.e., control, phosphorein and Vesicular Arbuscular Mycorrhizae (VAM). The mixture of chelated micronutrients was applied to plants as foliar spray at 30, 45 and 60 days after transplanting. Calcium superphosphate (15.5%) was used as a source of phosphate (P_2O_5), which was used at 4 different rates, e.g. 0, 30, 45 and 60 kg/fed., at planting time. Phosphorein inoculum which contains active bacteria (*Bacillus megatherium* var. *phosphaticum*) was mixed with wet soft dust at (1:10 ratio). It was applied to the root absorption zone of plants, 30 days after transplanting, at the rate of 3 kg/fed, just before irrigation. As for VAM, forty grams of inoculum were added to root absorption zone of each plant, 30 days after transplanting, before irrigation.

Sweet potato stem cuttings, about 20 cm length, were transplanted on the third top of slope ridges, at 25 cm apart, in the second week of April of both seasons of the study. Growing plants were fertilized with 200 kg/fed ammonium sulfate, (20.5% N) and 200 kg/fed. potassium sulfate (48% K_2O). The added amounts were equally divided and applied after planting and 45 days after transplanting.

Recorded Data:

Chemical constituents:

a- Element concentrations

Samples of plant leaves (100 days after transplanting) and cured tuber roots were taken to determine total nitrogen (%), phosphorus (%) and potassium (%), following methods described by A.O.A.C. (1990), John, (1970) and Brown and Lilleland (1946), respectively. Fe, Zn and Mn were measured using atomic absorption spectrophotometer (Chapman and Partt, 1961).

b- Organic compositions:

Samples of cured sweet potato tubers were picked up at random to determine total carbohydrate contents according to the method of Michel *et al.*(1956), reducing and non-reducing sugar (%) according to the method of Dubois *et al.*(1956) and total carotene content, following the method described by Booth (1958). Dry matter percentage was determined by drying 100 gm fresh tuber roots at 70 C^o for 48 h, until constant weight is obtained.

All recorded data were statistically analyzed by Analysis of Variance and least significance differences (LSD) was used to separate means, as described by Gomez and Gomez (1984).

RESULTS AND DICUSSION

Chemical constituents:

a- Mineral concentrations:

Data in Table (2) clearly illustrate that micronutrients significantly increased the N concentration of both leaves and tuber roots of sweet potato plants, in the two seasons. P concentration was significantly improved, in both seasons, in tuber roots only, while the concentration of K significantly increased only in leaves in both seasons.

Table (2): Macronutrient contents of sweet potato leaves and tuber roots as affected by micronutrients, P_2O_5 rates and biofertilizers, during 2002 and 2003 seasons.

Characters	Leaves						Tuber roots					
	N %		P %		K %		N %		P %		K %	
Treatments	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
a- Effect of micronutrients												
Without	3.88	4.10	0.521	0.442	2.64	2.79	1.20	1.18	0.202	1.87	1.74	1.98
With	4.41	4.66	0.532	0.458	2.7	2.88	1.28	1.34	0.215	0.194	1.91	2.20
SD (5%)	0.02	0.01	N.S	N.S	0.01	0.03	0.03	0.01	0.004	0.002	N.S	N.S
b- Effect of P-rates												
Control	3.58	3.73	0.431	0.404	2.29	2.12	1.01	1.05	0.168	0.147	1.41	1.52
30 kg P_2O_5/fed	3.91	4.20	0.498	0.443	2.50	2.55	1.11	1.18	0.201	0.187	1.61	1.96
45 kg P_2O_5/fed	4.36	4.64	0.562	0.464	2.83	3.14	1.36	1.38	0.227	0.206	2.03	2.30
60 kg P_2O_5/fed	4.74	4.96	0.616	0.487	3.06	3.53	1.47	1.45	0.238	0.223	2.24	2.57
LSD (5%)	0.06	0.08	0.016	0.011	0.05	0.03	0.02	0.02	0.002	0.003	0.15	0.07
c- Effect of biofertilizers												
Control	3.86	4.21	0.495	0.378	2.45	2.63	1.14	1.19	0.189	0.174	1.65	1.87
VAM[1]	4.36	4.59	0.563	0.521	2.93	3.06	1.37	1.36	0.230	0.212	2.04	2.33
Phosphorein	4.22	4.35	0.521	0.449	2.66	2.81	1.20	1.24	0.206	0.186	1.79	2.07
LSD (5%)	0.03	0.09	0.021	0.011	0.04	0.05	0.03	0.03	0.003	0.003	0.22	0.17

1 VAM = vascular arbuscular mycorrhiza

Data in Table (2) also clarified that leaf and tuber macronutrients, i.e., N, P and K were significantly increased to the maximum as the applied p-rates increased from 0 to 60 kg P_2O_5/fed., in both seasons of study.

As for the effect of biofertilizers on chemical constituents of leaves and tuber roots of sweet potato, data in Table (2) show that macronutrients, i.e., N, P and K were significantly increased by using biofertilizers as compared with the uninoculated ones, with VAM inoculation being significantly the most effective, in both seasons, while Phosphorein did not significantly affect the concentration of K in tuber roots, in the first season.

Data presented in Table (3) show that micronutrients, i.e., Fe, Zn and Mn of sweet potato leaves and tuber roots were significantly increased, in both seasons, in response to foliar spray of micronutrients, compared with control.

Data in Table (3) also show that concentrations of micronutrients of sweet potato leaves and tubers were generally increased by increasing the rate of applied P_2O_5 from 0 to 60 kg/fed., in both seasons, with the attention that plants fertilized with 60 kg P_2O_5/fed gave the highest Fe, Zn and Mn concentrations, compared with control treatment of plants.

Data in Table (3) reveal that inoculation of sweet potato with biofertilizers led to significant increases in the concentration of Fe, Zn and Mn in leaves and tuber roots of sweet potato, in both seasons, compared with control. Inoculation with VAM-fungi gave the highest values of all micronutrients. In fact, biofertilizer application may stimulate nutrients availability and uptake by plants (Fayez *et al.*, 1985)

Table (3): Micronutrient contents of sweet potato leaves and tuber roots as affected by micronutrients, P_2O_5 rates and biofertilizers during 2002 and 2003 seasons.

Characters	Leaves						Tuber roots					
	Fe (ppm)		Zn (ppm)		Mn (ppm)		Fe (ppm)		Zn (ppm)		Mn (ppm)	
Treatments	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
a- Effect of micronutrients												
Without	254	270	52	59	108	96	168	178	20	21	64	61
With	310	335	61	72	123	117	178	190	24	25	75	71
LSD (5%)	6.5	7.8	1.9	0.5	1.40	2.30	0.30	0.90	0.3	2.6	0.4	1.0
b- Effect of P-rates												
Control	243	264	42	50	86	82	145	152	14	17	49	47
30 kg P_2O_5/fed	264	298	53	60	108	99	165	173	17	22	67	62
45 kg P_2O_5/fed	299	320	63	72	129	114	184	198	25	25	78	74
60 kg P_2O_5/fed	325	329	68	80	140	131	198	211	30	27	84	80
LSD (5%)	3.3	3.4	2.0	1.18	1.4	1.7	1.8	1.5	1.3	0.8	0.9	0.8
c- Effect of biofertilizers												
Control	257	277	48	58	101	93	153	164	18	19	60	56
VAM[1]	310	326	65	74	134	124	194	202	26	28	80	76
Phosphorein	280	305	56	64	112	103	172	185	21	22	68	65
LSD (5%)	3.6	4.5	2.2	2.6	2.9	4.6	0.17	3.17	3.41	1.72	2.51	2.11

1- VAM = vascular arbuscular mycorrhiza.

These increases in elemental constituents of leaves and tuber roots of sweet potato may be due to the effect of micronutrients on stimulating biological activities, i.e., enzyme activity, rate of translocation of photosynthetic products and increased nutrient uptake through roots after foliar fertilization (Follett *et al*, 1981). The obtained results are in accordance with those of Radwan and Tawfik (2004), who found that spraying potato plants with micronutrients significantly, increased N, P, K, Fe, Zn and Mn concentrations in different plant parts.

As for the positive effect of phosphorus, the obtained results are in harmony with those of Abdel-Fattah and Abdel-hamed (1997) declared that increasing P-rate, added to sweet potato plants tended to increase N, P, K, Fe, Zn and Mn contents in both tuber roots and aerial parts of plants.

Regarding the stimulative effect of biofertilizers, it has been reported that biofertilizer application may stimulate nutrients availability and uptake by plants (Fayez *et al*., 1985). These results were similar with those of Hauka *et al.* (1996) who found a significant positive effect on soil available P after inoculation with *Bacillus megaterium*. The solubilization effect of these bacteria has an important role in providing plants with available Fe, Mn and Zn. El-Morsy *et al.* (2002), on sweet potato, found that N, P and K concentrations markedly increased in foliage and tubers of plants inoculated with VAM-fungi.

Concerning the effect of interaction of micronutrients x P-rates on chemical constituents of sweet potato plants, data in Table (4) show that the interaction significantly increased on the concentrations of N and P of leaves and tuber roots, in both season, but did not affect K concentration of leaves or tuber roots, in both seasons.

Table (4): Macronutrients content of sweet potato leaves and tuber roots as affected by the interaction of micronutrients × P_2O_5 rates, during 2002 and 2003 seasons.

Characters		Leaves						Tuber roots					
		N %		P %		K %		N %		P %		K %	
Treatments		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Micro.[1]	P-rates	Effect of micronutrients x P-rates											
Without	Control	3.32	3.44	0.425	0.383	2.23	2.03	0.99	0.99	0.155	0.137	1.32	1.44
	30 kg P_2O_5/fed	3.60	3.84	0.484	0.431	2.48	2.45	1.07	1.11	0.191	0.185	1.48	1.85
	45 kg P_2O_5/fed	4.06	4.34	0.557	0.462	2.79	3.05	1.32	1.62	0.223	0.200	1.98	2.15
	60 kg P_2O_5/fed	4.61	4.80	0.619	0.491	3.06	3.60	1.44	1.37	0.238	0.223	2.19	2.48
With	Control	3.92	4.02	0.436	0.425	2.35	2.22	1.05	1.11	0.180	0.156	1.51	1.60
	30 kg P_2O_5/fed	4.21	4.57	0.513	0.454	2.53	2.65	1.16	1.25	0.210	0.188	1.74	2.07
	45 kg P_2O_5/fed	4.66	4.95	0.565	0.466	2.89	3.22	1.40	1.49	0.230	0.208	2.09	2.45
	60 kg P_2O_5/fed	4.87	5.12	0.612	0.484	3.05	3.44	1.50	1.52	0.237	0.222	2.29	2.66
LSD (5%)		0.09	0.12	0.019	0.016	N.S	N.S	0.03	0.004	0.004	0.005	N.S	N.S

1- Micro. = micronutrients.

Table (5): Micronutrients content of sweet potato leaves and tuber roots as affected by the interaction of micronutrients × P_2O_5-rates, during 2002 and 2003 seasons.

Characters		Leaves						Tuber roots					
		Fe (ppm)		Zn (ppm)		Mn (ppm)		Fe (ppm)		Zn (ppm)		Mn (ppm)	
Treatments		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Micro.[1]	P-rates	Effect of Micronutrients x P-rates											
Without	Control	210	233	35	41	73	70	143	147	12	16	44	41
	30 kg P_2O_5/fed	223	267	48	52	99	87	164	166	15	19	59	56
	45 kg P_2O_5/fed	274	286	59	66	123	103	177	193	23	23	72	69
	60 kg P_2O_5/fed	300	297	66	77	137	125	189	205	28	26	80	78
With	Control	275	295	49	59	100	95	148	158	16	19	53	52
	30 kg P_2O_5/fed	293	329	58	68	117	111	167	179	20	24	75	69
	45 kg P_2O_5/fed	324	354	66	78	135	124	191	204	28	27	84	79
	60 kg P_2O_5/fed	362	362	70	84	143	137	207	218	32	29	88	83
LSD (5%)		0.7	9.01	N.S	N.S	1.96	2.43	2.53	N.S	N.S	N.S	1.29	1.47

1- Micro. = micronutrients.

The effect of interaction of micronutrients x P-rates on micronutrients concentration of sweet potato leaves and tubers is presented in Table (5). The interaction had a positive significant effect on the concentration of Fe and Mn, of leaves and tuber roots, in both seasons. However, it did not significantly affect Zn concentration in leaves and tuber roots, during the two seasons, or tuber Fe content, in the second season only. The interaction of micronutrients x p-rates at 60 kg P_2O_5/fed was superior for enhancing N, P, Fe and Mn in leaves and tuber roots. Obtained results agreed with those of (Al-Garawany *et al.* (1997).

Data presented Table (6) show the effects of interaction of micronutrients x biofertilizers on macronutrient concentrations of sweet potato leaves. This interaction did not significantly affect K or N contents of tuber roots, or K contents N of leaves, in both seasons, while it reflected a significant effect on P contents of leaves and roots, and N content of leaves in both seasons.

Regarding the interaction effects of micronutrients x biofertilizers on micronutrient concentrations of sweet potato leaves and tuber roots, data in Table (7) show that the interaction had significant effects on Fe content of leaves, in both seasons. However, this interaction had no significant effects on Zn and Mn contents of leaves and tuber roots, in both seasons, while Fe content of leaves was not significantly affected by the interaction, in both seasons.

In general, element contents of leaves and tuber roots of sweet potato were higher with the interaction of micronutrients x VAM fungi, followed by the interaction of micronutrients x phosphorein, then that of control plants. The obtained results are in harmony with those of Sabik *et al.* (2001) on faba bean, who found that N, P, Zn, Fe and Mn increased significantly in seed and straw by inoculation with VAM fungi, in the presence of micronutrients.

Table (6): Macronutrient content of sweet potato leaves and tuber roots as affected by the interaction of micronutrients× biofertilizers, during 2002 and 2003 seasons.

Characters		Leaves						Tuber roots					
		N %		P %		K %		N %		P %		K %	
Treatments		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Micro.[1]	Bio.	Effect of Micronutrients x biofertilizers											
Without	Control	3.62	3.88	0.506	0.379	2.43	2.58	1.10	1.14	0.183	0172	1.61	1.79
	VAM[2]	4.09	4.38	0.547	0.505	2.87	2.98	1.33	1.26	0.226	0.208	1.94	2.19
	Phos.[3]	3.91	4.05	0.511	0.442	2.63	2.79	1.17	1.16	0.197	0.181	1.68	1.97
With	Control	4.10	4.54	0.484	0.377	2.48	2.68	1.20	1.25	0.194	1.176	1.69	1.95
	VAM	4.62	4.79	0.580	0.538	2.93	3.15	1.41	1.46	0.234	0.216	2.13	2.48
	Phos.	4.52	4.66	0.532	0.457	2.69	2.90	1.24	1.32	0.216	0.191	1.90	2.16
LSD (5%)		0.07	0.12	0.029	0.015	N.S	N.S	N.S	N.S	0.004	0.005	N.S	N.S

1- Micro. = micronutrients 2-VAM = vascular arbuscular mycorrhiza.
3-Phos.= Phosphorien

Table (7): Micronutrient content of sweet potato leaves and tuber roots as affected by the interaction of micronutrients × biofertilizers, during 2002 and 2003 seasons.

Characters		Leaves						Tuber roots					
		Fe (ppm) (ppm)		Zn (ppm) (ppm)		Mn (ppm)		Fe (ppm) (ppm)		Zn (ppm) (ppm)		Mn (ppm) (ppm)	
Treatments		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Micro.[1]	Bio.	Effect of Micronutrients x biofertilizers											
Without	Control	228	252	44	51	94	83	149	156	16	18	55	52
	VAM[2]	282	286	60	68	126	114	188	196	24	26	74	71
	Phos.[3]	254	273	52	57	103	91	167	181	19	20	63	59
With	Control	286	303	53	66	108	102	158	173	20	20	64	60
	VAM	339	365	70	80	142	134	200	208	29	30	87	82
	Phos.	307	337	60	70	121	114	177	188	23	24	73	71
LSD (5%)		N.S	N.S	N.S	N.S	N.S	N.S	3.31	4.48	N.S	N.S	N.S	N.S

1- Micro. =micronutrients **2- VAM =vascular arbuscular mycorrhiza.**
3-Phos.= Phosphorien

Concerning the interaction effect of P-rates x biofertilizers on mineral composition of leaves of sweet potato plants, data in Table (8) indicate that increasing P-rates from 0 to 60 kg P_2O_5/fed. in the presence of VAM fungi or phosphorein caused a significant increase in N contents of leaves and roots, but did not affect K contents of leaves and roots, in both seasons. Meanwhile, P content of leaves were significantly increased, in the first seasons only, where as P content in tuber roots significantly increased in the two seasons of the study.

Table (8): Macronutrient content of sweet potato leaves and tuber roots as affected by the interaction of P_2O_5 rates × biofertilizers, during 2002 and 2003 seasons.

Characters		Leaves						Tuber roots					
Treatments		N %		P %		K %		N %		P %		K %	
P-rates	Bio.	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Control	Control	3.37	3.59	0.379	0.332	2.05	1.84	0.95	1.00	0.140	0.114	1.24	1.34
	VAM[1]	3.72	3.87	0.479	0.479	2.49	2.34	1.07	1.09	0.187	0.177	1.57	1.74
	Phos.	3.63	3.73	0.434	0.403	2.34	2.20	1.01	1.06	0.176	0.15	1.44	1.79
30 kg P_2O_5/fed	Control	3.57	3.93	0.456	0.372	2.28	2.35	1.05	1.07	0.176	0.164	1.38	1.69
	VAM	4.18	4.47	0.539	0.515	2.72	2.81	1.20	1.30	0.231	0.212	1.95	2.79
	Phos.	3.97	4.20	0.501	0.442	2.51	2.49	1.10	1.18	0.195	0.186	1.51	1.89
45 kg P_2O_5/fed	Control	3.95	4.41	0.523	0.394	2.57	2.92	1.22	1.30	0.209	0.192	1.86	1.98
	VAM	4.64	4.90	0.599	0.541	3.14	3.43	1.56	1.51	0.249	0.226	2.30	2.59
	Phos.	4.84	4.62	0.563	0.458	2.77	3.06	1.31	1.32	0.222	0.200	1.95	2.73
60 kg P_2O_5/fed	Control	4.54	4.91	0.621	0.416	2.90	3.43	1.36	1.42	0.229	0.227	2.11	2.46
	VAM	4.89	5.11	0.638	0.552	3.25	3.65	1.66	1.53	0.253	0.233	2.35	2.69
	Phos.	4.78	4.85	0.589	0.495	3.02	3.50	1.41	1.40	0.232	0.209	2.27	257
LSD (5%)		0.08	0.15	0.041	N.S	N.S	N.S	0.06	0.07	0.006	0.007	N.S	N.S

1- VAM =Vvascular Arbuscular Mycorrhiza

Data in Table (9) show that Fe concentration in leaves and tuber roots of sweet potato plants were significantly increased as p-rates increased from 0 to 60 kg P_2O_5/fed. in the presence of VAM or phosphorein, compared with control, while Zn concentration in leaves and tuber roots insignificantly increased, in both seasons. Data also point out that the interaction of P_2O_5 × biofertilizer significantly increased Mn concentration of leaves, in both seasons, but did not affect Mn concentration in tuber roots, in both seasons. These results agreed with those of Floyd *et al.* (1988) who declared that phosphate nutrition was the dominant factor in soil that affect soil fertility and yields of sweet potato. They also added that phosphorus was significantly affected by endogenous mycorrhizal infection and increasing infection was associated with increases in yield and uptake of elements.

Table (9): Micronutrient content of sweet potato leaves and tuber roots as affected by the nteraction of P_2O_5-rates × biofertilizers, during 2002 and 2003 seasons.

Characters		Leaves						Tuber roots					
Treatments		Fe (ppm)		Zn (ppm)		Mn (ppm)		Fe (ppm)		Zn (ppm)		Mn (ppm)	
P-rates	Biofertilizers	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Control	Control	220	239	36	44	74	72	124	128	11	14	40	38
	VAM[1]	265	283	48	56	98	92	169	179	18	22	60	55
	Phos.[2]	243	269	43	50	87	83	144	150	13	17	46	47
30 kg P_2O_5/fed	Control	239	271	44	53	92	86	144	145	13	17	56	52
	VAM	290	324	62	70	125	114	189	197	23	26	78	74
	Phos.	262	299	52	58	108	96	164	176	16	21	67	62
45 kg P_2O_5/fed	Control	266	239	54	63	113	97	163	185	20	20	69	64
	VAM	332	344	74	81	152	136	206	211	31	30	89	86
	Phos.	297	322	61	71	123	109	184	200	26	25	77	73
60 kg P_2O_5/fed	Control	302	307	60	73	125	117	183	200	28	23	74	70
	VAM	354	352	77	91	162	154	213	221	34	33	95	92
	Phos.	318	330	67	76	133	123	198	213	30	26	83	80
LSD (5%)		7.2	7.8	N.S	N.S	5.8	9.2	6.25	6.87	N.S	N.S	N.S	N.S

1- VAM =Vvascular Arbuscular Mycorrhiza 2- Phos.= Phosphorien

Data presented in Table (10) show the interaction effect among micronutrients, P-rates and biofertilizers on macronutrients of leaves and tuber roots of sweet potato plants. Obtained results revealed significant increases in leaf N content, in both seasons, while P and K were insignificantly affected by the above mentioned interaction, in both seasons. No significant effects were found, in both seasons, on concentrations of N and K in tuber roots as a result of the interaction among micronutrients, P-rates and biofertilizers. However, P was significantly increased in tuber roots as a result of the interaction of micronutrients, 45 or 60 kg P_2O_5/fed. in the presence of VAM or phosphorein, respectively. The highest values of macronutrients were obtained when plants sprayed with micronutrients, supplied with 45 or 60 kg P_2O_5/fed in the presence of VAM-fungi in both seasons. There were no significant differences between leaf N content in plants sprayed with micronutrients in the presence of VAM-fungi at 45 or 60 kg P_2O_5/fed. Also, there was no significant differences in P content in tuber root in plants sprayed with micronutrients in the presence of VAM fungi at 45 or 60 kg P_2O_5/fed.

As for the effect of the interaction of the three tested factors on micronutrient contents of leaves and tuber roots, obtained results in Table (11) revealed significant increases in Fe content of leaves and tuber roots, in both seasons, however, Zn and Mn contents were insignificantly affected by the above mentioned interaction, in both seasons. The highest values of micronutrient were obtained when plants sprayed with micronutrients, and supplied with 60 kg P_2O_5, in the presence of VAM-fungi, in both seasons

Table (10): Macronutrient content of sweet potato leaves and tuber roots as affected by the interaction of micronutrients, P_2O_5 rates and biofertilizers, during 2002 and 2003 seasons.

Characters			Leaves						Tuber roots					
Treatments			N %		P %		K %		N %		P %		K %	
Micro[3]	P-rates	Bio.[1]	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Wihout	Control	Cont[2]	3.12	3.29	0.385	0.319	1.99	1.7	0.9	0.96	0.132	0.102	1.16	1.29
		VAM[4]	3.35	3.63	0.462	0.451	2.44	2.27	1.02	1.01	0.171	0.169	1.45	1.62
		Phos[5]	3.21	3.41	0.429	0.381	2.27	2.13	0.98	1.00	0.162	0.141	1.35	1.43
	30 kg P_2O_5/fed	Cont.	3.26	3.51	0.451	0.355	2.26	2.31	0.99	1.03	0.162	0.165	1.32	1.65
		VAM	3.90	4.22	0.517	0.495	2.68	2.65	1.17	1.22	0.230	0.209	1.76	2.09
		Phos.	3.65	3.79	0.484	0.443	2.50	2.40	1.06	1.09	0.181	0.180	1.36	1.80
	45 kg P_2O_5/fed	Cont.	3.70	4.04	0.528	0.403	2.54	2.83	1.19	1.19	0.206	0.187	1.84	1.84
		VAM	4.35	4.68	0.583	0.532	3.11	3.33	1.49	1.39	0.250	0.222	2.24	2.42
		Phos.	4.13	4.29	0.561	0.451	2.72	3.00	1.28	1.21	0.214	0.198	1.87	2.20
	60 kg P_2O_5/fed	Cont.	4.40	4.69	0.660	0.440	2.91	3.52	1.32	1.36	0.233	0.235	2.10	2.38
		VAM	4.78	5.01	0.627	0.542	3.24	3.67	1.64	1.43	0.253	0.231	2.33	2.60
		Phos.	4.65	4.70	0.572	0.491	3.03	3.63	1.38	1.33	0.229	0.205	2.15	2.46
With	Control	Cont.	3.63	3.90	0.374	0.344	2.11	1.97	1.00	1.03	0.148	0.126	1.31	1.40
		VAM	4.09	4.11	0.495	0.506	2.53	2.41	1.11	1.18	0.203	0.185	1.68	1.87
		Phos.	4.05	4.06	0.440	0.425	2.42	2.27	1.05	1.13	0.190	0.159	1.53	1.54
	30 kg P_2O_5/fed	Cont.	3.88	4.35	0.462	0.388	2.31	2.39	1.11	1.10	0.190	0.162	1.43	1.73
		VAM	4.47	4.73	0.561	0.535	2.75	2.97	1.23	1.38	0.232	0.214	2.13	2.50
		Phos.	4.30	4.62	0.517	0.440	2.52	2.58	1.14	1.26	0.209	0.192	1.65	1.98
	45 kg P_2O_5/fed	Cont.	4.21	4.78	0.517	0.385	2.61	3.02	1.25	1.41	0.214	0.196	1.88	2.13
		VAM	4.94	5.13	0.616	0.550	3.17	3.52	1.62	1.63	0.248	0.230	2.36	2.75
		Phos.	4.84	4.95	0.564	0.465	2.82	3.12	1.34	1.43	0.229	0.203	2.03	2.46
	60 kg P_2O_5/fed	Cont.	4.69	5.14	0.583	0.392	2.89	3.33	1.39	1.46	0.225	0.219	2.12	2.53
		VAM	5.04	5.21	0.649	0.561	3.25	3.63	1.68	1.64	0.253	0.235	2.37	2.79
		Phos.	4.91	5.01	0.605	0.498	3.00	3.36	1.44	1.46	0.234	0.212	2.39	2.67
LSD (5%)			0.11	0.17	N.S	N.S	N.S	N.S	N.S	N.S	0.009	0.008	N.S	N.S

1- Bio. = biofertilizers 2- Cont.= control 3- Micro. = micronutrients
4- VAM = vascular arbuscular mycorrhiza 5- Phos.= phosphorein

As for the effect of the interaction of the three tested factors on micronutrient contents of leaves and tuber roots, obtained results in Table (11) revealed significant increases in Fe content of leaves and tuber roots, in both seasons, however, Zn and Mn contents were insignificantly affected by the above mentioned interaction, in both seasons. The highest values of micronutrient were obtained when plants sprayed with micronutrients, and supplied with 60 kg P_2O_5, in the presence of VAM-fungi, in both seasons.

Organic compositions of cured roots:

Foliar spray with micronutrients increased total carbohydrates, reducing and non reducing sugars, total carotene content as well as dry matter of cured roots of sweet potato plants (Table 12). The positive effect of micronutrients on organic composition of fresh cured roots may be due to their involvement in one or more of important biological functions such as synthesis of chlorophyll, electron transport system, oxidation-reduction reactions, protein synthesis and degradation and to their function as Co-enzyme of several important enzymes (Tisdale *et al.*, 1985). The obtained results agreed with those of Radwan and Tawfik (2004).

Table (11): Micronutrient content of sweet potato leaves and tuber roots as affected by the nteraction of micronutrients, P_2O5 rates and biofertilizers, during 2002 and 2003 seasons.

Characters			Leaves						Tuber roots					
Treatments			Fe (ppm)		Zn (ppm)		Mn (ppm)		Fe (ppm)		Zn (ppm)		Mn (ppm)	
Micro[3]	P-rates	Bio.[1]	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Without	Control	Cont.[2]	192	210	30	33	63	60	123	122	10	13	37	33
		VAM[4]	231	251	41	49	84	81	162	171	17	19	54	50
		Phos.[5]	207	238	36	41	72	69	144	148	12	15	42	41
	30 kg P_2O_5/fed	Cont.	211	248	39	44	85	77	146	134	12	16	51	47
		VAM	261	284	85	63	116	101	183	194	20	24	69	68
		Phos.	230	270	47	50	98	84	162	172	14	19	59	55
	45 kg P_2O_5/fed	Cont.	238	269	50	59	108	89	159	177	18	19	64	60
		VAM	302	301	69	73	146	123	199	206	28	29	83	81
		Phos.	281	288	60	66	117	99	174	198	24	22	71	67
	60 kg P_2O_5/fed	Cont.	270	284	59	69	123	109	169	192	26	23	70	70
		VAM	334	309	74	90	160	151	210	215	32	33	91	88
		Phos.	296	298	65	72	128	115	190	208	27	24	80	76
With	Control	Cont.	247	269	43	54	86	84	125	134	13	14	44	43
		VAM	299	315	56	63	112	104	175	188	20	24	67	61
		Phos.	280	301	50	59	102	97	144	152	15	19	50	54
	30 kg P_2O_5/fed	Cont.	267	295	50	62	100	96	142	157	15	19	62	58
		VAM	319	364	67	77	134	128	165	201	25	29	88	80
		Phos.	294	329	58	66	118	109	194	181	19	23	75	69
	45 kg P_2O_5/fed	Cont.	295	318	58	69	119	105	167	194	22	22	74	69
		VAM	363	388	79	89	158	149	213	216	35	32	95	91
		Phos.	314	356	63	76	129	120	194	181	28	27	83	79
	60 kg P_2O_5/fed	Cont.	335	330	62	77	127	125	198	194	30	24	79	71
		VAM	375	396	81	93	164	157	217	216	36	34	99	96
		Phos.	341	362	69	81	138	131	207	202	34	28	86	84
LSD (5%)			13.1	14.3	N.S	N.S	N.S	N.S	8.8	10.3	N.S	N.S	N.S	N.S

1- Bio. = biofertilizers 2- Cont.= control 3-Micro. = micronutrients
4- VAM = vascular arbuscular mycorrhiza 5- Phos.= phosphorein

It is clear from data in Table (12) that all organic composition including total carbohydrates, reducing and non reducing sugars, total carotene contents as well as dry matter of cured tubers of sweet potato were significantly increased by increasing P-rates from 0 to 60 kg P_2O_5/fed. Results may be attributed to the promoting effect of phosphate on nitrogen metabolism, soluble carbohydrates synthesis and photosynthetic rate. In addition phosphorus is known to be an essential component for energy transfer compounds, the genetic information system, cell membrane and phosphoprotiens (Marschner, 1995).

Data in Table (12) show that biofertilizers, including VAM fungi or phosphorein increased dry matter, total carbohydrates, reducing and non-reducing sugars and total carotene contents of cured tuber roots, in both seasons of study. VAM fungi gave the highest values of all organic composition in cured roots, followed by phosphorein. The favourable effect of VAM-fungi on organic composition of sweet potato may be due to their role on improving mineral nutrition uptake, especially Mn and Fe (Mosse, 1973). In addition, VAM fungi increase CO_2 fixation and improve the photosynthetic efficiency (Sivaprasad and Rai, 1985). These results are in agreement with those of Alphonse *et al.* (2001) and El-Morsy *et al.* (2002) who found that inoculation of sweet potato with biofertilizers significantly increased total carbohydrates, total sugars and total carotene content of cured tuber roots.

Table (12): Organic composition of sweet potato cured roots as affected by micronutrients, P_2O_5 rates and biofertilizers, during 2002 and 2003 seasons.

Characters / Treatments	Dry matter (%)		Total carbohydrates (%)		Reducing sugars (%)		Non-reducing sugars (%)		Total carotene (mg/g d.w.)	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
a- Effect of micronutrients										
Without	23.07	25.99	68.93	46.90	6.59	6.20	3.03	2.46	0.63	0.82
With	25.28	28.77	72.18	67.46	6.80	6.44	3.17	2.70	0.70	0.87
LSD (5%)	0.15	0.92	0.31	0.07	0.09	0.05	0.01	0.02	0.01	0.01
b- Effect of P-rates										
Control	21.91	24.63	63.58	58.84	6.00	5.74	2.33	1.95	0.47	0.59
30 kg P_2O_5/fed	23.35	26.79	69.28	64.16	6.56	6.17	2.97	2.39	0.63	0.82
45 kg P_2O_5/fed	25.04	28.56	73.69	69.35	6.92	6.54	3.44	2.85	0.74	0.95
60 kg P_2O_5/fed	26.45	29.53	75.68	72.38	7.32	6.85	3.33	3.15	0.81	1.02
LSD (5%)	0.19	0.07	0.12	0.11	0.10	0.03	0.03	0.03	0.01	0.02
c- Efect of biofertilizers										
Control	22.92	24.81	67.69	62.56	6.42	5.97	2.87	2.42	0.60	0.79
VAM[1]	25.60	30.22	73.44	70.02	6.98	6.77	3.38	2.74	0.73	0.90
Phosphorein	24.04	27.09	70.62	65.96	6.70	6.23	3.07	2.59	0.65	0.84
LSD (5%)	0.19	0.05	0.16	0.30	0.14	0.09	0.05	0.04	0.04	0.02

1- VAM = vascular arbuscular mycorrhiza.

Data in Table (13) indicate that all organic composition, in cured roots, was significantly increased by the interaction of micronutrients and P-rates, except of reducing sugars. Significantly the highest values of dry matter, total carbohydrates, reducing and non reducing sugars and total carotene content, of cured roots, were obtained as a result of the interaction of micronutrients with 60 kg P_2O_5/fed.

Table (13): Organic composition of sweet potato cured roots as affected by the interaction of micronutrients × P_2O_5 rates, during 2002 and 2003 seasons.

Characters / Treatments		Dry matter (%)		Total carbohydrates (%)		Reducing sugars (%)		Non-reducing sugars (%)		Total carotene (mg/g d.w.)	
		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Micro.[1]	P-rates	**Effect of micronutrients x P-rates**									
Without	Control	20.58	22.89	61.27	57.48	5.90	5.64	2.24	1.88	0.43	0.54
	30 kg P_2O_5/fed	21.97	25.06	67.95	62.95	6.39	6.04	2.91	2.20	0.58	0.79
	45 kg P_2O_5/fed	23.93	27.21	72.45	67.69	6.88	6.43	3.38	2.64	0.70	0.93
	60 kg P_2O_5/fed	25.91	28.79	74.81	71.48	7.21	6.72	3.61	3.11	0.79	1.01
With	Control	23.42	26.37	65.90	60.21	6.10	5.83	2.42	2.02	0.52	0.63
	30 kg P_2O_5/fed	24.72	28.53	71.36	65.37	6.74	6.30	3.04	2.57	0.67	0.85
	45 kg P_2O_5/fed	26.15	29.91	74.94	71.01	6.96	6.65	3.49	3.05	0.78	0.97
	60 kg P_2O_5/fed	26.99	30.27	76.54	73.27	7.42	6.99	3.74	3.18	0.82	1.04
LSD (5%)		0.27	0.09	0.17	0.19	N.S	N.S	0.07	0.05	0.04	0.03

- Micro. = micronutrients.

These results are in agreement with those of El-Zohery (2003) on garlic plants.

Regarding the interaction effect of micronutrients x biofertilizers, data in Table (14) indicate that dry matter and total carbohydrates were significantly affected by the interaction, in both seasons. However, reducing and non-reducing sugars as well as total carotene content were not significantly influenced by this interaction.

The highest and significant increase in dry matter and total carbohydrates resulted from the interaction of micronutrients with VAM-fungi.

Table (14): Organic composition of sweet potato cured roots as affected by the interaction of micronutrients × biofertilizers during 2002 and 2003 seasons.

Characters		Dry matter (%)		Total carbohydrates (%)		Reducing sugars (%)		Non-reducing sugars (%)		Total carotene (mg/g d.w.)	
Treatments		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Micro.[1]	Biofertilizers	Effect of micronutrients x biofertilizers									
Without	Control	21.74	23.24	66.54	61.31	6.37	5.87	2.79	2.29	0.57	0.76
	VAM	24.74	28.52	71.13	68.39	6.83	6.61	3.32	2.62	0.69	0.88
	Phosphorein	22.81	26.21	69.32	64.99	6.58	6.14	2.99	2.45	0.61	0.81
With	Control	24.09	26.39	68.88	63.81	6.46	6.06	2.93	2.54	0.64	0.82
	VAM[2]	26.46	31.93	75.75	71.64	7.12	6.94	3.44	2.86	0.76	0.93
	Phosphorein	25.27	27.99	71.91	66.94	6.83	6.32	3.12	2.72	0.69	0.87
LSD (5%)		0.27	0.06	0.23	0.42	N.S	N.S	N.S	N.S	N.S	N.S

1- Micro. = micronutrients 2- VAM = vascular arbuscular mycorrhiza.

Concerning the interaction effect of P-rates x biofertilizers on organic composition of cured tuber roots, data in Table (15) indicate that increasing the applied P-rates from 0 to 60 kg P_2O_5/fed in the presence of VAM or Phosphorein, caused significant increases in dry matter, total carbohydrates and reducing sugars of cured roots.

Table (15): Organic composition of sweet potato cured roots as affected by the interaction of P_2O_5 rates × biofertilizers during 2002 and 2003 seasons.

Characters / Treatments		Dry matter (%)		Total carbohydrates (%)		Reducing sugars (%)		Non- reducing sugars (%)		Total carotene (mg/g d.w.)	
P-rates	Biofertilizers	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Control	Control	20.95	22.11	62.17	56.28	5.78	5.49	2.12	1.83	0.42	0.53
	VAM[1]	23.06	27.04	65.02	61.06	6.22	6.00	2.56	2.08	0.55	0.65
	Phosphorein	21.72	24.74	63.56	59.18	5.99	5.71	2.30	1.92	0.46	0.59
30 kg P_2O_5/fed	Control	21.97	24.14	65.78	6..30	6.25	5.81	2.75	2.19	0.56	0.74
	VAM	24.79	29.51	72.32	67.84	6.86	6.67	3.23	2.57	0.69	0.89
	Phosphorein	23.28	26.74	69.74	64.34	6.58	6.04	2.95	2.40	0.62	0.82
45 kg P_2O_5/fed	Control	23.62	25.92	70.92	65.24	6.62	6.13	3.15	2.64	0.68	0.90
	VAM	26.83	31.56	76.76	74.16	7.14	7.07	3.79	3.03	0.80	1.00
	Phosphorein	24.68	28.19	73.40	68.65	7.00	6.42	3.37	2.87	0.73	0.94
60 kg P_2O_5/fed	Control	25.15	27.59	71.94	68.42	7.02	6.45	3.45	3.01	0.75	0.99
	VAM	27.73	32.78	79.48	77.01	7.67	7.35	3.93	3.28	0.88	1.06
	Phosphorein	26.49	28.72	75.61	71.69	7.25	6.76	3.64	3.15	0.79	1.02
LSD (5%)		0.39	0.09	0.18	0.32	0.27	0.19	N.S	N.S	N.S	N.S

However, the increases in non-reducing sugars and total carotene content did not elevate to the significance level. The described results were consistent through the two seasons of the experiment. Data also show that the highest values of tested parameters in cured roots were obtained as a results of interaction of VAM fungi with 60 kg P_2O_5/fed., in both seasons. The obtained results are in harmony with those of El-Shimi (2003).

Data presented in Table (16) show the interaction effect among micronutrients, P-rates and biofertilizers on organic composition of sweet potato cured roots. There were significant effects for the interaction on dry matter and total carbohydrates, while reducing and non-reducing sugars as well as total carotene contents of tuber roots were not significantly affected by the interaction. The obtained results were consistent in both seasons.

Table (16): Organic composition of sweet potato cured roots as affected by the interaction of micronutrients, P_2O_5 rates and biofertilizers, during 2002 and 2003 seasons.

Characters / Treatments			Dry matter (%)		Total carbohydrates (%)		Reducing sugars (%)		Non-reducing sugars (%)		Total carotene (mg/g d.w.)	
Micro[3]	P-rates	Bio.[1]	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Without	Control	Cont[2]	19.90	20.53	59.30	55.0	5.69	5.41	2.03	1.79	0.38	0.48
		VAM[4]	21.68	24.74	63.22	58.02	6.09	5.90	2.49	1.99	0.50	0.61
		Phos[5]	19.90	23.39	61.28	59.42	5.92	5.63	2.20	1.85	0.41	0.54
	30 kg P_2O_5/fed	Cont.	20.78	22.03	63.65	59.31	6.19	5.75	2.69	2.02	0.51	0.70
		VAM	23.59	27.10	69.78	65.74	6.59	6.39	3.14	2.39	0.65	0.88
		Phos.	21.54	26.05	68.17	63.81	6.38	5.99	2.90	2.18	0.56	0.79
	45 kg P_2O_5/fed	Cont.	21.54	24.31	7128	64.21	6.69	6.06	3.07	2.41	0.65	0.89
		VAM	26.03	29.96	73.48	71.91	7.04	6.88	3.73	2.85	0.76	0.99
		Phos.	22.94	27.37	72.58	66.95	6.91	6.34	3.33	2.67	0.69	0.91
	60 kg P_2O_5/fed	Cont.	23.75	26.11	71.79	66.73	6.93	6.28	3.37	2.96	0.74	0.98
		VAM	27.66	32.26	77.70	76.51	7.60	7.27	3.90	3.28	0.86	1.05
		Phos.	26.32	28.26	74.92	71.26	7.11	6.60	3.55	3.11	0.77	1.01
With	Control	Cont.	21.99	23.69	65.05	57.57	5.87	5.58	2.21	1.87	0.45	0.58
		VAM	24.43	29.34	66.81	62.71	6.36	6.11	2.62	2.18	0.59	0.70
		Phos.	23.29	26.08	65.05	60.35	5.87	5.79	2.41	2.00	0.51	0.63
	30 kg P_2O_5/fed	Cont.	23.16	26.10	67.91	61.29	6.31	5.86	2.80	2.35	0.62	0.79
		VAM	25.99	31.91	74.85	69.94	7.14	6.96	3.32	2.75	0.73	0.91
		Phos.	25.02	27.42	71.31	64.87	6.78	6.09	2.99	2.62	0.67	0.85
	45 kg P_2O_5/fed	Cont.	24.69	27.54	70.40	66.28	6.88	6.20	3.23	2.88	0.72	0.91
		VAM	27.62	33.17	80.04	76.41	7.58	7.26	3.85	3.21	0.84	1.02
		Phos.	26.13	29.03	74.22	66.28	7.09	6.51	3.40	3.07	0.77	0.97
	60 kg P_2O_5/fed	Cont.	26.54	28.07	72.07	70.11	7.11	6.63	3.53	3.06	0.76	1.00
		VAM	27.80	33.31	81.25	77.52	7.75	7.43	3.96	3.29	0.90	1.08
		Phos.	26.60	29.43	76.30	72.19	7.40	6.92	3.74	3.19	0.81	1.03
LSD (5%)			0.55	0.18	0.86	N.S	N.S	N.S	N.S	N.S	N.S	N.S

1- Bio. = biofertilizers 2- Cont.= control 3- Micro. = micronutrients
4- VAM = vascular arbuscular mycorrhiza 5- Phos.= phosphorein

In general, foliar spray with micronutrients, and 60 kg P_2O_5/fed. in the presence of VAM-fungi resulted in the highest values of dry matter, total carbohydrates, reducing and non reducing sugars as well as total carotene content in cured roots of sweet potato, in both seasons. Dry matter of plants sprayed with micronutrients, supplied with 45 kg P_2O_5/fed. and inoculated with VAM-fungi achieved great values which were nearly similar to those produced by the combination of 60 kg P_2O_5/fed. and VAM–fungi, in the absence or presence of micronutrients. The obtained results are supported by the findings of Alphonse *et al.* (2001) and El-Morsy *et al.* (2002) on sweet potato plants.

REFERENCES

A. O. A. C. 1990. Official methods of analysis. 15th ed. A.O.A.C., Washington, Dc, USA.

Abdel-Fattah, A.E. and A.M. Abdel-Hamed. 1997. Effect of phosphorus and sulphur application on sweet potato (*Ipomoea batatos* L.) plant production. J.Agric. Sci. Mansoura Univ. 22 (3): 883 – 890.

Al-Garawany, M.M., A.M. AL-Bahrany and S.H. Mahmoud. 1997. Effects of application rates and interactions of some nutrients on tomato plants. 4- Phosphorus/Iron. J. Agric. Sci. Mansoura Univ. 22 (1): 283 – 293.

Alphonse, M., M.A. Badawi, M.M. Abou-Elmagd and H.A. Mohamed. 2001. Response of sweet potato to organic and mineral fertilizers and bio-stimulant treatment. 2. chemical composition of cured and stored roots. Egypt J. Appl. Sci. 16(10): 182 – 209.

Booth, U.H. 1958. Extraction and estamination of carotene. Univ. Cambridge and medical Res. Cuuncil Dunn. National Lab., Cambridge, England.

Brown, J.D. and O. Lilleland. 1946. Rapid determination of potassium and sodium in plant material and soil extracts by flame photometry. Proc. Amer. Soc. Hort. Sci., 48:301–304.

Chapman, H.D. and P.F. Partt. 1961. Methods of analysis for soil, plant and water. Soil Dept. and Plant Nutrition, California Univ., Citrus Exp.Sta. Reverside, California.

Dubois,M.; A.Gilles; J.K. Homilton; P.A. Rebers and P.A. Smith. 1956 A colorimetric method for determination of sugars and related substances. Anal. Chem. 28(3):350-356.

El-Morsy, A.H.A., A.E. Abdel-Fattah and Z.S.A. El-Shal. 2002. Effect of phosphate fertilizer and VA mycorrhizal inoculation on growth, tuber yield and quality of sweet potato. Proc. Minia 1st Conf. for Agric. Enuiron. Sci., Minia Egypt, March 25 – 28, 1815 – 1827.

El-Shimi, A.A.N. 2003. effect of some levels of phosphorus fertilization and phosphorin biofertilizer on growth, yield and chemical composition of some sweet potato cultivars. J. Agric. Sci. Mansoura Univ. 28(4) : 2889-2901.

El-Zohery, S.S.M. 2003. Physiological studies on garlic crop. Ph.D. Thesis, Fac. Agric. Moshtohor, Zagazig Univ. Egypt.

Fayez, M., F. Emam-Nadia and H.E. Makboul. 1985. The possible use of nitrogen fixing *Azospirillum* as biofertilizer for plants. Egypt. J. Microbiol. 20 (2): 199–206.

Floyd, C.N., R.D.B. Lefroy and E.J. Souza. 1988. Soil fertility and sweet potato production on volcanic ash soils in the highlands of paupa New Guinea. Field crops Res. 19 (1): 1–25.

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agricultural research. John Wiley and Sons, NY, USA.

John, M.K. 1970. Colorimetric determination of phosphorus in soil and plant materials with ascorbic acid. Soil Sci. 109:214-220.

Marschner, H. 1995. Mineral nutrition in higher plants. Academic Press, Harcourt Brac Javanovish, Pulishers, P 674.

Michel, U., G.K. Gilles, P. Hamilton and F. Smith. 1956. Colorimetric method for determination of sugars and related substances. Analytic chemistry, 28 (3): 17-24.

Radwan, E.A. and A.A. Tawfik. 2004. Effect of Sulphur, Manganese and zinc on growth, yield and quality of potato (*Solanum tuberoium*, L.). J.Agric. Sci. Mansoura Univ. 29 (3): 1423-1431.

Sabik, F.A., M.S.M. Baza and Nadia, O. Monged. 2001. Effect of biofertilizers and micronutrients applied with different methods on faba bean. Egypt. J. Apl. Sci. 16 (10): 80 – 93.

Sivaprasad, P. and P.V. Rai. 1985. Photosynthesis and competition for photosynchate in VA-mycorrhiza, rhizobium and *cajanus cajan* Current. Sci. India. 54 (10): 468–469.

Srivastva, P.C. and U.C. Gupta. 1996. Trace elements: A concern. In: Trace elements in crop production. Science Publishers, Inc; Lebanon, NH 03766, USA.

Tisdale, S.L., W.L. Nelson and J.D. Beaton. 1985. soil fertility and fertilizers. 4th Ed. MacMillan, New York, USA.

تأثير التسميد الفوسفاتى المعدنى والحيوى والرش بالعناصر الدقيقة على البطاطا:
١ – المكونات الكيماوية للأوراق والجذور.

محمود عبد المحسن حسن[١] ، سمير كامل الصيفى[١] ، فاروق عبد العزيز عمر[١] و أسامة سيف الدين[٢]

١ – قسم البساتين – كلية الزراعة – جامعة قناة السويس بالإسماعيلية .

٢– قسم بحوث الخضر – معهد بحوث البساتين – الجيزة .

أجريت تجربتان حقليتان فى موسمى ٢٠٠٢ ، ٢٠٠٣على البطاطا صنف أبيس وذلك بمزرعة البرامون الزراعية التابعة لمحطة بحوث البساتين بالمنصورة . وذلك بهدف دراسة تأثيرالرش بخليط من العناصر الصغرى (الحديد والزنك والمنجنيز بمعدل ١٠٠ جزء فى المليون لكل منهم) والتلقيح بالفوسفورين أو الميكورهيزا وكذلك التسميد المعدنى الفوسفاتى بمعدل صفر ، ٣٠ ، ٦٠،٤٥ كجم فو٢أ٥ / فدان على التركيب الكيماوىللأوراق والقيمة الغذائية لجذور البطاطا بعد العلاج . وقد أوضحت النتائج أن الرش بالعناصر الدقيقة أدى الى زيادة محتوى الأوراق والجذور من النتروجين،ومحتوى الجذور من الفوسفور ومحتوى الأوراق من البوتاسيوم معنويا فى موسمى التجربة . كذلك زاد معنويا محتوى الأوراق والجذور من العناصر الدقيقة نتيجة الرش بالمغذيات الدقيقة.

وأدى إستخدام التسميد المعدنى الفوسفاتىبمعدل ٦٠ كجم فو٢أ٥ / فدان أو إستخدام الميكروهيزا كسماد حيوى الى أفضل نتائج فى زيادة محتوى الأوراق والجذور من النتروجين والفوسفور والبوتاسيوم والحديد والزنك والمنجنيز فى موسمى التجربة.

وقد أظهرت النتائج أيضا زيادة معنوية فى المكوناتالعضوية المتمثلة فى الكربوهيدرات الكلية والسكريات المختزلة والغير مختزلة والكاروتينات الكلية والمادة الجافة فى جذور البطاطا بعد العلاج وذلك نتيجة الرش بالعناصر الدقيقة والتسميد المعدنى الفوسفاتى بمعدل ٣٠ أو ٤٥ أو ٦٠ كجم فو٢أ٥/ فدان أو التلقيح بالميكروهيزا أو الفوسفورين كأسمدة حيوية .

وقد وجد تداخل معنوى مؤثر بين الرش بالعناصر الدقيقة والتسميد المعدنى الفوسفاتى والحيوى على المكونات الكيماوية للأوراق وجذور البطاطا المعالجة .