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

3- POSTHARVEST QUALITY OF STORED ROOTS

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ABSTRACT

Sweet potato plants were grown at El- Bramoon Agricultural Farm of El-Mansoura Horticultural Research Station, during the two successive seasons of 2002 and 2003, to study the influence of foliar nutrition with a mixture of some micronutrients, bio-phosphate fertilizers, i.e., Phosphorein and VA-mycorrhiza, and mineral phosphate fertilizer at 0, 30, 45 and 60 kg P_2O_5/fed., on quality features and organic composition of three months stored tuber roots, under room conditions. Results showed that the use of micronutrients significantly decreased weight loss percentage during storage period, in both seasons, and sprouting percentage, in the second season only. However it did not affect decay percentage, in both seasons, or sprouting percentage, in the first season. Increasing P-rate significantly reduced weight loss, decay and sprouting percentage during storage period. Roots of plants inoculated with VA-mycorrhiza recorded the lowest percentage of weight loss, decay and sprouting percentage, during the three months of storage period.

Organic composition, i.e., dry matter %, total carbohydrates, reducing and non-reducing sugars and total carotenes of stores tuber roots, increased significantly, in both seasons, as a result of treating plants with micronutrients, by increasing P-rate from 30 to 60 kg P_2O_5/fed. and by inoculating plants with bio-fertilizers, either VA-mycorrhiza or Phosphorein. Positive interactions between main factors were often detected, with the best results obtained by using 45 or 60 kg P_2O_5/fed. in the presence of micronutrients and VA-mycorrhiza.

INTRODUCTION

Sweet potato (*Ipomoea batatas*, L.) is considered one of the important vegetable crops in developing countries, where it plays a great role in overcoming food shortage problem. In Egypt, sweet potato has been generally cultivated for both human food consumption and starch manufacture, while foliage parts are utilized for animal feeding. Storage of sweet potatoes is generally an economically beneficial practice, resulting in fresh product availability over the entire year. Farm price is usually the lowest in the fall after harvest and gradually increases during winter and spring months (USDA, 1985). Therefore, the need for further research to improve the simple methods of sweet potato storage is of a special important, where a significant percentage loss is experienced. Accordingly, producing even a small loss reduction would be of immense benefits to farmer (Rashid, 1987).

Significant metabolic changes, result from treating plants with micronutrients and mineral and bio-phosphate, affect internal composition and texture during storage (Kushman and Wright, 1969).In this concem, several investigators indicated that treating plants with micronutrients decreased sprouting and weight loss percentages of garlic and onion bulbs (Mukesh *et al.*, 1999; El-Zohery, 2003 and El-Morsy *et al.*, 2005). Supplying sweet potato plants with high phosphorus rate, significantly decreased weight loss, decay and sprouting, during storage period (Mohamed, 2001). In addition, inoculation of sweet potato plants with mycorrhiza fungi reduced weight loss of tuber roots during storage, compared with control. (El-Morsy *et al.*, 2002).

Accordingly, the present investigation is aiming at studying the influence of micronutrients, mineral and bio-phosphate fertilizers, on post harvest quality of stored 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 inoculums 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:

Quality of tuber roots during storage period:

Random samples of cured roots (each was10 kg of marketable tuber roots), were collected from each sub-sub plot, cleaned with dry clean towels, packed in plastic boxes and stored for 90 days, at normal room temperature. The average of normal room temperature and relative humidity during storage months were as shown in Table (2).

Table (2): The average of normal room temperature and relative humidity during storage months.

Month	Temperature (C°)		Relative humidity (%)	
	2002	2003	2002	2003
September	34.5	33.2	69.2	65.4
October	30.4	31.3	64.8	67.5
November	27.6	29.1	58.7	60.4
December	20.1	23.5	60.3	63.1

Samples were picked up after 30, 60 and 90 days of storage to determine weight loss percentage according to the equation:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight of roots} - \text{weight of roots at sampling date}}{\text{Initial weight of tuber roots}} \times 100$$

-Decay and sprouting percentages were calculated, at the end of storage period, in relation to the total initial weight of stored tubers.

- Organic compositions:

Samples of sweet potato tubers were picked up randomly at the end of storing period (90 days) 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° 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 DISCUSSION

Weight loss, decay and sprouting percentages of stored tuber roots:

Data in Table (3) show clearly that keeping quality parameters of stored roots, i.e., weight loss, decay and sprouting percentage were influenced by micronutrients treatments. It is also clear that application of micronutrient to sweet potato plants significantly decreased weight loss% during the three months storage period, under room temperature, in both seasons. Micronutrients may reduce weight loss by developing storage root with bitter skin and develop flesh with more compound water which restricts water loss during the early storage periods. Also, the gradual increase in weight loss may be due to the increase in water loss and dry matter consumption in respiration and other metabolic reactions (Mohamed, 2001). Similar finding reported by El-Morsy (2005) on garlic.

Table (3): Weight loss, decay and sprouting percentages of sweet potato tuber roots as affected by micronutrients, P_2O_5-rates and biofertilizers, during storage in 2002 and 2003 seasons.

Characters	Weight loss (%)						Decay (%)		Sproutin g (%)	
	30 days		60 days		90 days					
Treatments	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
a- Effect of micronutrients										
Without	11.69	10.37	19.35	15.32	23.06	20.32	10.42	12.63	87.04	87.03
With	8.89	8.97	14.84	13.51	17.89	17.89	10.29	12.25	85.58	86.0
LSD (5%)	1.08	1.17	1.50	1.09	1.19	1.14	N.S	N.S	1.18	N.S
b- Effect of P-rates										
Control	12.26	11.55	20.24	16.98	24.77	22.02	12.22	13.44	90.77	88.70
30 kg P_2O_5/fed	10.40	10.04	17.35	15.10	20.79	19.46	10.82	12.86	87.19	87.88
45 kg P_2O_5/fed	9.67	8.91	15.38	13.25	18.04	17.34	9.54	12.37	84.91	86.23
60 kg P_2O_5/fed	8.86	8.17	15.40	12.32	18.29	15.93	8.84	11.10	82.36	83.25
LSD (5%)	1.21	0.32	0.81	0.43	0.94	0.62	0.32	0.30	0.37	0.79
c- Effect of biofertilizers										
Control	11.30	10.90	17.99	16.20	21.37	20.24	11.25	14.35	90.36	92.53
VAM[1]	9.17	8.39	16.11	12.60	19.44	16.89	9.60	10.54	83.02	81.09
Phosphorein	10.42	9.70	17.18	14.44	20.62	18.94	10.23	12.41	85.54	85.92
LSD (5%)	0.87	0.36	0.89	0.47	1.41	0.41	0.30	0.14	0.44	0.59

1- VAM = vascular arbuscular mycorrhiza.

Data of decay percentage (Table 3) show that treating sweet potato plants with micronutrients insignificantly decreased decay percentage of 90 days storage roots, compared with control treatment, under room conditions.

Concerning sprouting, percentage of sprouted roots throughout the three months storage period was significantly reduced by micronutrients application, in the first season only, but was not affected, in the second season. These results agree with those reported by Al-Easily (2002), who found that sprouting of storage roots was increased with prolonged storage period, under room temperature conditions.

As for P-rates effect, data in Table (3) indicated that increasing P-rates significantly decreased the percentages of weight loss, decay and sprouting during storage. It could be concluded that phosphorus at 60 kg P_2O_5/fed had beneficial effect in reducing all studying parameters. The favorable effects of P-fertilizer could be explained through the great role of phosphorus as a structural component of many plant compounds, such as phosphoproteins, phospholipids, that are known to be the main structural unites of all cell membranes, nucleotides and nucleic acids (Gardener *et al.*, 1985). These results are agreeable with those reported by Abdel-Fattah *et al.*, (2002) and El-Morsy *et al.*, (2002).

Data in Table (3) show that biofertilizers had significant effect on weight loss, decay and sprouting percentages of stored sweet potato roots, in both seasons, except Phosphorein which did not affect weight loss (%) after 60 or 90 days, compared with control, in the first season. Inoculation of sweet potato plants with VAM biofertilizer recorded the lowest values of all tested parameters during, the storage period of three months under normal room conditions, in both seasons.

Biofertilizers may reduce the susceptibility of root tissues to be infected with bacterial and fungal diseases as well as pest attacks. Also, it may develop roots with thicker skins. (Alphonse *et al*, 2001). These results agree with those reported by Das *et al.* (1998) who found that inoculation of potato plants with biofertilizers reduced pest damage of tubers.

Regarding the interaction effect of micronutrients x P-rates on storability of sweet potato roots under room conditions, data in Table (4) show that weight loss percentage was significantly reduced during storage periods, i.e., 60 and 90 days under normal temperature, in both seasons. However, there was no significant interaction on weight loss (%) after 30 days, in both seasons.

Table (4): Weight loss, decay and sprouting percentage2 of sweet potato tuber roots as affected by the interaction of micronutrients × P_2O_5 rates, during storage in 2002 and 2003 seasons.

Characters		Weight loss (%)						Decay (%)		Sprouting (%)	
		30 days		60 days		90 days					
Treatments		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Micro.[1]	P-rates	Effect of Micronutrients x P-rates									
Without	Control	13.57	12.09	22.0	18.37	26.67	23.90	11.86	13.38	90.32	88.51
	30 kg P_2O_5/fed	12.19	10.97	19.53	16.39	23.06	21.66	10.85	13.01	88.21	88.37
	45 kg P_2O_5/fed	11.32	9.60	18.63	13.65	21.92	18.81	9.89	12.45	85.90	86.51
	60 kg P_2O_5/fed	9.68	8.81	17.23	12.86	20.59	16.94	9.08	11.69	83.72	84.74
With	Control	10.94	11.01	18.48	15.59	22.87	20.13	12.59	13.50	91.22	88.88
	30 kg P_2O_5/fed	8.59	9.10	15.17	13.80	18.53	17.26	10.81	12.71	86.18	87.40
	45 kg P_2O_5/fed	8.03	8.23	12.13	12.85	14.15	15.86	9.18	12.30	83.92	85.96
	60 kg P_2O_5/fed	8.03	7.53	13.57	11.78	16.00	14.93	8.60	10.51	81.00	81.75
LSD (5%)		N.S	N.S	1.15	0.61	1.34	0.88	0.45	0.32	0.55	1.12

1- Micro. = micronutrients.

Decay and sprouting percentage were significantly reduced, in both seasons, as a result of supplying plants with different P_2O_5 rates, regardless the presence or absence of micronutrients, except for 30 or 45 kg P_2O_5/fed. in the absence of micronutrients, where they did not affect sprouting during storage period, in both seasons. These results are in agreement with those of Abdel-Fattah *et al.* (2002) who indicated that application of P-fertilizer at different doses with foliar spray of micronutrient, to garlic plants resulted in the lowest total weight loss percentage, during storage period.

As for the effect of interaction between micronutrients and biofertilizers on storage parameters of tuber roots, data in Table (5) indicated that the interaction, generally, resulted in the lowest values of weight loss, decay as well as sprouting, compared with the control. Weight loss, after the first month, decay and sprouting percentages, after 90 days of storage at room conditions, were significantly reduced by treating plants with both biofertilizers and micronutrients, in both seasons. However, the interaction did not affect weight loss and decay percentages after 60 and 90 days of storage, in both seasons.

Table (5): Weight loss, decay and sprouting percentages of sweet potato tuber roots as affected by the interaction of micronutrients × biofertilizers, during storage in 2002 and 2003 seasons.

Characters		Weight loss (%)						Decay (%)		Sprouting (%)	
		30 days		60 days		90 days					
Treatments		2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Micro.[1]	Biofertilizers	Effect of micronutrients x biofertilizers									
With-out	Control	12.52	11.87	20.09	17.16	23.76	22.13	11.50	14.89	90.68	94.49
	VAM[2]	10.68	8.89	18.28	13.43	21.94	18.39	9.48	10.44	83.89	80.38
	Phosphorein	11.88	10.34	19.68	15.36	23.49	20.47	10.29	12.61	86.54	86.22
With	Control	10.07	9.94	15.89	15.24	18.98	18.35	10.99	13.92	90.05	90.57
	VAM	7.67	7.90	13.94	11.77	16.94	15.39	9.72	10.63	82.15	81.8
	Phosphorein	8.96	9.06	14.68	13.51	17.74	17.40	10.16	12.21	84.54	85.62
LSD (5%)		1.25	0.12	N.S	N.S	N.S	N.S	0.42	0.20	0.63	0.77

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

Application of micronutrients with VAM-fungi resulted in the lowest values of weight loss, decay and sprouting percentage all over the storage period. These results are in harmony with those of El-Zohery (2003) on garlic plants.

Results in Table (6) showed no significant interaction for weight loss in percentage after 30 days, in both seasons, and after 90 days, in the second season only. However, weight loss after 90 days, in the first season, as well as weight loss after 60 days, decay and sprouting percentages, in both seasons, were significantly reduced during storage period under room condition. Also, results generally, showed that lowest values of weight loss % were recorded as a result of supplying plants with biofertilizers at 45 or 60 kg P_2O_5/ fed., in the presence of VAM fungi. These results are in accordance with those of El-Morsy *et al* (2002) on sweet potato.

Table (6): Weight loss, decay and sprouting percentages of sweet potato tuber roots as affected by the interaction of P_2O_5 rates × biofertilizers, during storage in 2002 and 2003 seasons.

Characters Treatments		Weight loss (%)						Decay (%)		Sprouting (%)	
		30 days		60 days		90 days					
P-rates	Bio.	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Control	Control	13.74	12.86	22.42	19.30	27.20	23.59	12.67	15.23	94.05	94.11
	VAM[1]	9.84	9.88	18.13	14.88	22.87	20.19	12.15	11.47	87.52	83.25
	Phos.	13.18	11.93	20.18	16.77	24.24	22.28	11.85	13.62	90.73	88.73
30 kg P_2O_5/ fed	Control	11.48	11.29	18.80	17.06	22.18	21.62	11.87	14.89	90.73	94.66
	VAM	9.64	8.79	15.45	13.32	18.52	17.35	9.96	11.02	84.10	81.75
	Phos.	10.07	10.03	17.80	14.92	21.68	19.42	10.65	12.67	86.75	87.25
45 kg P_2O_5/ fed	Control	10.52	10.28	16.15	14.67	18.76	18.39	10.69	14.18	89.22	92.28
	VAM	8.76	7.64	14.45	11.51	16.97	15.77	8.48	10.72	81.70	80.68
	Phos.	9.47	8.84	15.55	13.57	18.38	17.86	9.44	12.22	83.82	85.73
60 kg P_2O_5/ fed	Control	9.43	9.19	14.60	13.77	17.33	17.36	9.75	13.22	87.46	89.00
	VAM	8.45	7.29	16.40	10.69	19.39	14.25	7.82	8.93	78.75	78.70
	Phos.	8.68	8.02	15.20	12.49	18.17	16.19	8.96	11.14	80.87	81.98
LSD (5 %)		N.S	N.S	1.77	0.86	2.82	N.S	0.60	0.29	0.88	1.08

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

The interaction of all tested factors, i.e., micronutrients, P-rates and biofertilizers had no significant effect on weight loss during storage periods, i.e., 30, 60 and 90 days, under normal temperature, in both seasons, as shown in Table (7). Decay and sprouting percentages were significantly decreased, in both seasons, during storage period, as a result of the interaction. Generally, treating plants with foliar spray of micronutrients at 45 or 60 P_2O_5 kg /fed, with biofertilizers, recorded the lowest values of all investigated parameters, compared with other treatments.

Organic composition of the stored sweet potato roots:

Data presented in Table (8) show that dry matter, total carbohydrates, reducing sugars, non-reducing sugars and total carotene content of stored roots, significantly increased, in both seasons, in response to spray plants with micronutrients, compared with control. The positive effect of micronutrients on organic composition of stored roots might be due to their essential roles in
many important metabolic functions (Srivastva and Gupta, 1996). These results are in agreement with those of El-Morsy *et al.* (2004) on garlic plants.

4.7.2. Effect of P-rates:

Data presented in Table (8) show the effect of p-rates on organic composition of the stored sweet potato roots. Increasing the supplied p-rates from 30 to 60 kg P_2O_5/fed. significantly increased dry matter, total carbohydrates, reducing and non reducing sugars as well as total carotene contents of tuber roots, compared with control, in both seasons. These increases may be due to the role of phosphorus as essential component of many organic compounds in plant (Marschner, 1995). The obtained results agreed with those of Alphonse *et al.* (2001) who found that fertilization of sweet potato with P-fertilizer caused significant increases in all organic composition, i.e., total carbohydrates, total sugars, total carotene and cured protein.

As for the effect of biofertilizers on organic composition of stored roots, data presented in Table (8) reveal that all organic composition of stored roots were generally greater with biofertilizer treatments than without. Plants inoculated with VAM-fungi gave the highest values of all determined organic compositions in stored roots, followed by phosphorein treatment, in both seasons. It is well known that VAM-fungi are capable to contribute some hormones and supply plants with P-element as well as certain micronutrients that would contribute positively to organic composition of stored roots (Marschner, 1995). The obtained results are in harmony with those of Alphonse *et al.* (2001).

Table (7): Weight loss, decay and sprouting percentages of sweet potato tuber roots as affected by the interaction of micronutrients, P_2O_5 rates and biofertilizers, during 2002 and 2003 seasons.

Characters			Weight loss (%)						Decay (%)		Sprouting (%)	
Treatments			30 days		60 days		90 days					
Micro.[3]	P-rates	Bio.[1]	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Without	Control	Cont.[2]	15.51	13.69	23.77	21.22	28.06	26.06	13.09	15.57	93.99	96.90
		VAM[4]	10.58	10.16	19.60	16.09	24.85	21.86	11.04	10.86	86.95	81.20
		Phos.[5]	14.61	14.43	22.63	17.79	27.11	23.78	11.47	13.73	90.04	87.43
	30 kg P_2O_5/ fed	Cont.	13.03	12.75	21.00	18.34	24.51	23.92	12.06	15.19	91.35	95.63
		VAM	11.82	9.28	17.20	14.33	20.35	19.51	9.83	10.96	85.06	81.53
		Phos.	11.74	10.88	20.40	16.51	24.33	21.56	10.56	12.89	88.21	87.96
	45 kg P_2O_5/ fed	Cont.	11.56	10.99	19.40	14.81	22.85	20.11	10.83	14.71	89.4	94.03
		VAM	10.94	8.33	18.00	12.05	21.07	17.04	9.03	10.45	83.0	79.83
		Phos.	11.47	9.48	18.50	14.09	21.85	19.29	9.83	14.71	85.32	85.63
	60 kg P_2O_5/ fed	Cont.	9.99	10.04	16.20	14.27	19.61	18.42	10.02	13.92	88.0	91.40
		VAM	9.36	7.80	18.30	11.24	21.47	15.13	8.01	9.49	80.56	78.96
		Phos.	9.89	8.58	17.20	13.07	20.69	17.28	9.23	11.66	82.60	83.86
With	Control	Cont.	11.99	12.03	21.07	17.38	26.35	21.12	12.26	14.90	94.12	91.33
		VAM	9.10	9.59	16.67	13.67	20.9	18.51	13.26	12.09	88.10	85.30
		Phos.	11.75	11.42	17.73	15.74	21.37	20.78	12.24	13.51	91.43	90.03
	30 kg P_2O_5/ fed	Cont.	9.94	9.83	16.60	15.78	19.86	19.32	11.68	14.60	90.11	93.70
		VAM	7.45	8.29	13.70	12.30	16.68	15.18	10.09	11.09	83.14	81.96
		Phos.	8.39	9.18	15.20	12.33	19.04	17.28	10.66	12.46	85.29	86.53
	45 kg P_2O_5/ fed	Cont.	9.47	9.56	12.90	14.53	14.68	16.67	10.56	13.66	89.05	90.53
		VAM	6.59	6.94	10.90	10.97	12.86	14.50	7.94	10.79	80.41	81.53
		Phos.	8.01	8.19	12.60	13.06	14.91	16.43	9.05	12.25	82.32	85.83
	60 kg P_2O_5/ fed	Cont.	8.87	8.34	13.00	13.27	15.04	16.29	9.48	12.52	86.92	86.73
		VAM	7.54	6.78	14.50	10.15	17.31	13.73	7.60	8.38	76.92	78.43
		Phos.	7.67	7.47	13.20	11.92	15.64	15.11	8.70	10.63	79.14	80.10
LSD (5%)			N.S	N.S	N.S	N.S	N.S	N.S	0.85	0.47	1.25	1.53

1- Bio. = biofertilizers **2- Cont.= control** **3- Micro. = micronutrients**

4-VAM = vascular arbuscular mycorrhiza **5- Phos.= phosphorein**

Table (8): Organic composition of 90 days stored sweet potato roots as affected by micronutrients, P_2O_5 rates and 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
a- Effect of micronutrients										
Without	25.68	28.88	64.20	62.09	7.24	7.34	3.00	2.56	0.68	0.85
With	27.66	29.92	67.38	66.00	7.61	7.68	3.26	2.81	0.72	0.90
LSD (5%)	0.07	0.12	0.14	0.21	0.02	0.03	0.02	0.05	0.02	0.01
b- Effect of P-rates										
Control	24.14	26.56	59.66	56.44	6.64	6.63	2.44	2.08	0.51	0.63
30 kg P_2O_5/fed	26.11	28.85	64.15	62.13	7.19	7.30	2.95	2.56	0.66	0.85
45 kg P_2O_5/fed	27.81	30.74	68.20	66.93	7.77	7.86	3.39	2.92	0.77	0.96
60 kg P_2O_5/fed	28.63	31.43	71.16	70.67	8.10	8.25	3.74	3.18	0.85	1.05
LSD (5%)	0.08	0.08	0.23	0.11	0.06	0.06	0.02	0.03	0.02	0.01
c- Effect of biofertilizers										
Control	25.56	28.16	62.82	60.59	6.85	7.09	2.96	2.55	0.63	0.79
VAM[1]	27.89	31.27	68.81	67.98	8.14	7.95	3.32	2.86	0.79	0.96
Phosphorein	26.56	28.75	65.76	63.55	7.29	7.49	3.12	2.65	0.68	0.86
LSD (5%)	0.32	0.08	0.17	0.10	0.11	0.10	0.06	0.06	0.03	0.03

1- VAM = vascular arbuscular mycorrhiza.

Regarding the effect of interaction of micronutrients with P-rates on organic composition of the stored sweet potato roots, data in Table (9) showed significant effects for the interaction on dry matter, total carbohydrates, reducing and non-reducing sugars as well as total carotene of stored roots, in both seasons.

Table (9): Organic composition of stored sweet potato roots (at 90 days) as affected by the interaction of micronutrients × P_2O_5 rates, 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]	P-rates	Effect of micronutrients x P-rates									
Without	Control	22.54	25.94	58.25	54.39	6.48	6.55	2.32	2.00	0.47	.059
	30 kg P_2O_5/fed	24.77	27.82	61.98	59.81	6.90	7.08	2.76	2.33	0.63	0.82
	45 kg P_2O_5/fed	27.04	30.41	66.50	64.19	7.53	7.61	3.25	2.77	0.76	0.93
	60 kg P_2O_5/fed	28.39	31.33	70.09	69.97	8.06	8.12	3.68	3.13	0.85	1.03
With	Control	25.74	27.19	61.07	58.49	6.80	6.72	2.56	2.18	0.54	0.66
	30 kg P_2O_5/fed	27.45	29.88	66.33	64.44	7.49	7.51	3.13	2.74	0.68	0.89
	45 kg P_2O_5/fed	28.58	31.07	69.89	69.68	8.01	8.11	3.54	3.07	0.77	0.99
	60 kg P_2O_5/fed	28.87	31.52	72.24	71.38	8.14	8.37	3.81	3.23	0.86	1.07
LSD (5%)		0.11	0.11	0.32	0.15	0.09	0.12	0.06	0.10	0.05	0.04

1- Micro. = micronutrients.

Generally, most studied characteristics of organic composition had the highest values as a result of the interaction of 60 kg P_2O_5/fed. with micronutrients. The obtained results are in harmony with those of Badillo and Lopez (1976) on sweet potato and Abdel-Fattah *et al.* (2002) on garlic plants. Data presented in Table (10) show the effect of interaction of micronutrients and biofertilizers on organic composition of 90 days stored roots. Dry matter, total carbohydrates and reducing sugars significantly increased by the interaction of micronutrients and biofertilizers, while non-reducing sugars and total carotene were not affected by the interaction, in both seasons. In addition, it is worthy to mention that the combination of micronutrients and VAM-fungi recorded the highest values of all studied parameters in stored roots. These results agreed with those of Walter (1992) who found that sugars increased gradually throughout the storage period, where carbohydrates undergo some chemical changes that lead to an increase in sugar content and reduction in starch.

Table (10): Organic composition of 90 days stored sweet potato 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]	Bio.	Effect of micronutrients x biofertilizers									
Without	Control	24.97	28.01	61.59	58.63	6.70	6.99	2.82	2.42	0.62	0.77
	VAM[2]	26.73	30.39	67.11	65.93	7.85	7.67	3.21	2.75	0.76	0.93
	Phos.[3]	25.36	28.23	63.91	61.71	7.18	7.37	2.98	2.52	0.65	0.83
With	Control	26.15	28.32	64.05	62.05	7.00	7.19	3.06	2.68	0.64	0.82
	VAM	29.07	32.16	70.51	70.51	8.43	8.25	3.43	2.97	0.81	0.99
	Phos.	27.77	29.27	67.60	67.60	7.40	7.61	3.25	2.77	0.70	0.89
LSD (5%)		0.44	0.11	0.24	0.19	0.16	0.15	N.S	N.S	N.S	N.S

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

Data presented in Table (11) show the interaction effect of P-rates with biofertilizers, on organic composition of 90 daysstored roots. This interaction caused significant increases on dry matter, total carbohydrates and reducing sugars, in both seasons. However, no significant effect for the interaction was detected on non reducing sugars and total carotene content, in both seasons. In general, plants fertilized with 60 kg P_2O_5/fed., in the presence of VAM fungi gave the highest values of organic composition, while plants that were not supplied with P or were not treated with biofertilizer gave the lowest values, in both seasons. The obtained results are supported by the findings of Picha (1999) and El-Morsy *et al.* (2002) on sweet potato plants.

Table (11): Organic composition of 90 days stored sweet potato roots as affected by the interaction of P_2O_5 rates × biofertilizers, during 2002 and 2003 seasons.

Treatments / Characters		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	25.59	25.88	57.16	53.35	6.18	6.31	2.25	1.95	0.44	0.53
	VAM[1]	25.56	27.69	62.22	59.28	7.08	6.94	2.62	2.21	0.56	0.74
	Phosphorein	24.28	26.18	59.61	56.70	6.66	6.64	2.44	2.09	0.49	0.62
30 kg P_2O_5/fed	Control	24.76	27.18	60.65	57.92	6.67	6.97	2.71	2.41	0.59	0.77
	VAM	27.48	31.05	67.57	66.26	7.89	7.62	3.17	2.77	0.74	0.94
	Phosphorein	26.10	28.32	64.24	62.19	7.01	7.30	2.96	2.49	0.64	0.85
45 kg P_2O_5/fed	Control	26.77	29.22	64.85	36.57	7.16	7.36	3.23	2.75	0.70	0.89
	VAM	29.07	33.01	71.50	71.31	8.52	8.34	3.61	3.15	0.86	1.06
	Phosphorein	27.59	29.99	68.25	65.92	7.63	7.88	3.35	2.85	0.74	0.95
60 kg P_2O_5/fed	Control	28.12	30.44	68.62	67.53	7.40	7.70	3.64	3.09	0.73	1.00
	VAM	29.49	33.34	73.95	75.08	9.05	8.91	3.89	3.31	0.94	1.12
	Phosphorein	28.28	30.49	70.93	69.41	7.86	8.12	3.72	3.15	0.84	1.04
LSD (5%)		0.63	0.16	0.34	0.20	0.22	0.20	N.S	N.S	N.S	N.S

1- VAM =Vvascular Arbuscular Mycorrhiza

Results presented in Table (12) show the effect of the interaction of all studied factors, i.e., micronutrients, P-rates and biofertilizers on organic composition of 90 days stored roots of sweet potato. The obtained results indicated that non-reducing sugars, total carotene contents and dry matter (%), in the first season only, were not significantly influenced by the three ways interaction, whereas dry matter %, in the second season, reducing sugars and total carbohydrates were significantly increased in response to the three ways interaction, in both seasons.

Generally, plants sprayed with micronutrients, supplied with 60 kg P_2O_5/fed. and inoculated with VAM-fungi had the highest values of dry matter, total carbohydrates, reducing and non reducing sugars as well as total carotene contents of stored roots. The obtained results are supported by findings of Abdulla (1999) on potato, Mohamed (2001) and El-Morsy *et al.* (2002), on sweet potato plants.

Table (12): Organic composition of 90 days stored sweet potato 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.	P-rates	Bio.	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
Without	Control	Cont.	21.67	25.72	56.40	51.97	5.97	6.21	2.14	1.89	0.40	0.50
		VAM	23.37	26.70	60.34	57.11	6.96	6.88	2.53	2.11	0.56	0.70
		Phos.	22.58	25.40	58.03	54.29	6.50	6.56	2.29	2.00	0.46	0.58
	30 kg P_2O_5/fed	Cont.	23.45	26.91	59.00	55.83	6.45	6.92	2.49	2.25	0.57	0.75
		VAM	26.34	29.38	65.22	63.97	7.34	7.29	2.97	2.58	0.70	0.89
		Phos.	24.53	27.18	61.73	59.64	6.92	7.04	2.81	2.30	0.61	0.81
	45 kg P_2O_5/fed	Cont.	26.43	29.02	63.51	60.92	7.02	7.15	3.08	2.55	0.72	0.86
		VAM	28.22	32.47	69.92	67.75	8.08	7.90	3.47	3.03	0.85	1.03
		Phos.	26.48	29.74	66.09	63.89	7.49	7.79	3.19	2.72	0.72	0.90
	60 kg P_2O_5/fed	Cont.	28.35	30.39	67.48	65.99	7.37	7.68	3.57	3.01	0.80	0.98
		VAM	28.98	33.01	72.97	74.90	9.02	8.59	3.86	3.30	0.93	1.11
		Phos.	27.84	30.59	69.82	69.02	7.81	8.09	3.62	3.08	0.81	1.01
With	Control	Cont.	23.51	25.92	57.92	54.91	6.39	6.42	2.37	2.02	0.48	0.56
		VAM	27.74	28.68	64.11	61.45	7.21	7.01	2.71	2.32	0.62	0.77
		Phos.	23.51	26.96	61.20	59.12	6.82	6.73	2.59	2.19	0.53	0.65
	30 kg P_2O_5/fed	Cont.	26.06	27.45	62.31	60.01	6.90	7.02	2.93	2.57	0.60	0.78
		VAM	28.61	32.72	69.93	68.56	8.45	7.95	3.36	2.97	0.79	0.98
		Phos.	27.67	29.47	66.75	64.75	7.11	7.57	3.11	2.69	0.66	0.89
	45 kg P_2O_5/fed	Cont.	27.12	29.41	66.18	66.22	7.29	7.57	3.38	2.95	0.69	0.91
		VAM	29.91	33.55	73.08	74.88	8.97	8.79	3.74	3.28	0.88	1.09
		Phos.	28.71	30.24	70.42	67.95	7.77	7.98	3.50	2.99	0.75	0.99
	60 kg P_2O_5/fed	Cont.	27.89	30.49	74.93	69.07	7.43	7.73	3.71	3.17	0.77	1.02
		VAM	30.00	33.67	74.04	75.27	9.09	9.24	3.91	3.32	0.95	1.14
		Phos.	28.72	30.40	69.77	69.81	791	8.15	3.82	3.22	0.86	1.06
L.S.D at		5%	N.S	0.22	0.48	0.29	0.32	0.29	N.S	N.S	N.S	N.S

Bio. = biofertilizers, Cont.= control, Micro. = micronutrients, VAM = vascular arbuscular mycorrhiza and Phos.= phosphorein

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تأثير التسميد الفوسفاتى المعدنى والحيوى والرش بالعناصر الدقيقة على البطاطا:
٣- جودة الجذور المخزنة .

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زرعت نباتات البطاطا صنف أبيس فى مزرعة البرامون التابعة لمحطة بحوث البساتين بالمنصورة خلال الموسمين المتتالين٢٠٠٢ ،٢٠٠٣ وذلك لدراسة تأثير الرش بخليط من المغذيات الدقيقة وإستخدام التسميد الفوسفاتى الحيوى " الفوسفورين والميكورهيزا " والمعدنى بتركيز صفر ، ٣٠، ٤٥، ٦٠ كجم فو٢أ٥/ فدان على صفات الجودة والتركيب الكيماوى لجذور البطاطا المخزنة لمدة ثلاثة شهور تحت ظروف الغرفة العادية. وقد أوضحت النتائج أن أستخدام العناصر الدقيقة أدى الى نقص معنوى فى النسبة المئوية للفقد فى الوزن أثناء التخزين فى موسمي التجربة ، وفى النسبة المئوية للتزريع فى الموسم الثانى فقط ، فى حين لم تؤثر العناصر الدقيقة على النسبة المئوية للعفن فى موسمى التجربة أو التزريع فى الموسم الأول. وأدت زيادة معدل السماد الفوسفاتى المعدنى الى خفض النسب المئوية معنويا لكل من الفقد فى الوزن وللعفن وللتزريع خلال موسمى التجربة وأثناء التخزين. كذلك وجد أن جذور البطاطا الناتجة من نباتات ملقحة بواسطة الميكورهيزا سجلت أقل النسب المئوية لفقد الوزن والعفن والتزريع أثناء شهور التخزين الثلاثة.

أما المكونات العضوية المتمثلة فى النسبة المئوية للوزن الجاف والكربوهيدرات الكلية والسكريات المختزلة والغير مختزلة والكاروتينات الكلية فقد زادت زيادة معنوية عند المعاملة بالمغذيات الدقيقة أو عند رفع مستوى التسميد الفوسفاتى المعدنى من ٣٠ ال ٦٠ كجم فو٢أ٥/ فدان أو عند تلقيح النباتات باستخدام الميكروهيزا . وكان هناك تفاعل إيجابى بين العوامل المدروسة وكانت أفضل نتائجه هى التى تحصل عليها عند تفاعل العناصر الصغرى مع ٤٥ أو ٦٠كجم فو٢أ٥/ فدان وفى وجود الميكورهيزا.