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Full Length Research Paper

Response of productivity and storability of garlic (*Allium sativum* L.) to some potassium levels and foliar spray with mepiquat chloride (PIX)

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ABSTRACT

Two field trials were conducted on garlic (*Allium sativum*, L. Cv. Sids - 40) in the vegetable private farm at Kafr Meet Faris, Dakahlia Governorate, during 2008/2009 and 2009/2010 seasons to study potassium-fertilizer levels at 0, 24, 48, 72 or 96 kg K_2O/fed, mepiquat chloride (pix) at 0, 250 and 500 ppm as a foliar application at and their interactions on the plant growth, yield and its quality, chemical constituents of plant foliage and bulbs as well as storability during the storage period (9 months). The obtained results could be summarized as follows: In general, garlic plants received K-levels better than those of the unfertilized ones. most studied characteristics of garlic plants were significantly increased with increasing K-levels from 0 up to 96 kg K_2O/fed. Besides, the most interesting observation was the increasing of the storability by 96 kg K_2O/fed in both seasons. Moreover, this treatment significantly increased concentration of N, P, K, TSS and volatile oils in cloves comparing with those of the other treatments. On the other hand, foliar application of pix at 250 or 500 ppm significantly reduced plant height. However, increasing the applied pix level from 0 to 500 ppm significantly increased number of leaves, leaf area, and plant dry weight and bulbing ratio as well as total yield, bulb weight and diameter and clove weight. However, total weight loss, sprouting and decay percentage of bulbs were significantly reduced at the end of the storage period. The combined treatments of K_2O levels and pix were generally more effective than with single ones. The best results were obtained by using 96 kg K_2O/fed with foliar application of pix at 500 ppm. Therefore, this treatment could be recommended for raising garlic yield and improving bulb quality during the storage period under similar conditions to this work.

Keywords: Productivity, Storability, Garlic (*Allium sativum* L.), Potassium, Foliar Spray, Mepiquat Chloride (PIX).

INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important bulb vegetable crops and is next to onion in importance. It is commonly used as a spice or in the medicinal purposes. In Egypt, it has been generally cultivated for both local consumption and export. Therefore, increasing garlic yield and improving bulb quality are essential aims for both growers and consumers, but it usually depends on many factors especially that influence the plant growth throughout the growth period. Potassium nutrition is one of major factors that affect growth, yield and quality of garlic. It plays a vital role for a normal cell division, translocation of carbohydrates, reduction of nitrates and particularly in meristems; on the other hand, potassium doesn't appear to represent a permanent structural component; but it has a metabolic role (Black, 1960 and Bidwell, 1979).

There was a close relationship between the applied K-levels and garlic productivity. In this regard, El Mansi *et al*. (1985) found that garlic plant growth, total yield and its components as well as keeping quality of bulbs were significantly increased by increasing the applied K-levels

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from 0 up to 100 kg K_2O/fed. Similar findings reported by Abdel-Fattah *et al*. (2002), they showed that the most vegetative parameters, yield and yield components (bulb weight and diameter and clove weight) were significantly increased with increasing the applied K-levels from 48 to 96 kg K_2O/fed. Moreover, Several investigators reported that garlic plants growth, yield and storability were improving by potassium application (Setty *et al*., 1989; Eid *et al*., 1991; Wang *et al*., 1992; Salvaraj *et al*., 1993; Mohd *et al*., 1994; Abdel Fattah *et al*., 1996; Verma *et al*., 1996 and El Morsy *et al*., 2004).

On the other hand, there were many attempts have been directed to raising yields and improving yield quality of garlic. In this respect, several investigators mentioned that application of plant growth retardants may play an important role in the physiological growth and bulb production, In this respect, Foda *et al.* (1979) showed that foliar application of chlormequat on garlic plants at 1000 ppm significantly increased stem length, plant weight, number of leaves bulbing ratio bulb yield, the bulb diameter, number of cloves/bulb and weight loss after storage 6 months. Similar findings reported by (Salvaraj *et al*., 1995; Das *et al*., 1996 and Dimov, 2000). Likewise, use of mepiquat chloride (pix) as a foliar spray on potato plants at 250 or 500 ppm decreased shoot growth and significantly increased tuber yield compared to the untreated ones (Zayed *et al*.,1986; Sakr *et al*., 1989 and El Sayed, 1991), on the other hand, Abdel Fattah *et al.* (2001) showed that the sweet potato plants sprayed by 250 or 500 ppm of mepiquat chloride significantly increased leaf area and shoot dry weight/plant, total yield and marketable yield.

The aim of the present work was to study the response of garlic plants to potassium fertilizer levels and foliar spray with mepiquat chloride (pix) compounded, in addition to their interactions on garlic productivity and storability under the conditions of Dakahlia District.

MATERIALS AND METHODS

Two field experiments were carried out at the vegetable private Farm at Kafr Meet Faris, Dakahlia Governorate, during two growing seasons of 2008/2009 and 2009/2010. It aimed to study the effects of some potassium fertilizer levels i.e., 0, 24, 48, 72 or 96 kg K_2O/fed and mepiquat chloride (pix, NN-dimethyl-piperidinium chloride) at 0, 250 and 500 ppm as a foliar application at 60 and 90 days after planting on garlic (Sids-40) growth, yield and its components, as well as chemical constituents in plant foliage and cloves and bulb storability.

The experimental field soil was clay loam in texture with PH of 7.9, available N 21.3 ppm, P 2.7 ppm and K 305 ppm and organic matter 0.67%.

The experiment design was a split-plot with three replicates. The five levels of potassium fertilizer occupied the main plots, while pix treatments were randomly distributed in the sub-plot. The sub-plot area was 17.5 m^2 (5 rows, each 70 cm width and 5 m long). Nearly uniform cloves soaked in running water for 12 h prior to sowing and planted at 10 cm apart on two sides of each row.

Planting was carried out during the first week of October for both seasons. All the plants were fertilized with 120 kg N/fed (ammonium sulphate, 20.5% N) and 72 kg P_2O_5/fed (superphosphate, 15.5% P_2O_5) after 30 and 60 days from planting. The other cultural practices for garlic commercial production were used according to the instruction laid down by the Ministry of Agriculture, Egypt. The harvesting was done 180 days after planting in both seasons.

Data recorded:

Growth parameters:

A random sample of ten plants was taken from each plot after 120 days from planting to estimate plant height, number of leaves/plant, plant leaf area, bulbing ratio (neck diameter/bulb diameter) and plant dry weight (without roots).

Yield and its components:

At harvest time, all plants of each plot were cured, 15 days after harvest weighed in kg and converted to record as total yield (ton/fed). A random sample (10 bulbs) was taken from each treatment to determine bulb weight and diameter, as well as the number of cloves/bulb and clove weight.

Chemical analysis:

Random samples from plant foliage and cloves of each treatment were dried, ground and wet digested to determine nitrogen (N), phosphorus (P) and potassium (K) contents according to the methods described by Pregl (1945), John (1970), Brown and Lilleland (1946). Total soluble solids (TSS) and volatile oils were determined according to A.O.A.C. (1970) and Guenther (1961).

Storability:

After curing, random samples (10 kg of marketable yield from every plot were taken, stored at the normal room conditions. The percentage of total weight loss, sprouting

Table 1. Effects of potassium levels, pix and their interactions on Vegetative growth characters of garlic plants during two seasons (S_1 & S_2)

Characters / Treatments		Plant height (cm)		Number of leaves/plant		Leaf area (m^2)		Bulbing ratio		Plant dry weight (g)	
		S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
K-levels											
Control		76.11	79.20	10.59	11.27	0.561	0.642	0.34	0.32	21.49	22.50
24 kg K_2O/fed		79.78	80.20	11.11	11.64	0.683	0.746	0.32	0.31	22.82	24.16
48 kg K_2O/fed		81.22	81.56	11.22	12.16	0.780	0.794	0.32	0.31	24.93	26.28
72kg K_2O/fed		83.78	82.69	11.73	12.18	0.825	0.906	0.32	0.31	26.24	26.79
96 kg K_2O/fed		86.67	83.16	11.67	12.42	0.878	0.963	0.33	0.32	27.14	27.91
LSD at 5%		03.04	02.57	00.46	00.52	0.040	0.031	0.02	N.S	00.32	00.33
Pix levels											
Control		84.20	83.73	11.04	11.55	0.714	0.765	0.34	0.31	23.44	24.49
250 ppm		81.40	80.93	11.18	11.95	0.742	0.811	0.32	0.32	24.37	25.67
500 ppm		78.93	79.41	11.64	12.31	0.780	0.855	0.32	0.31	25.77	26.42
LSD at 5%		01.87	01.08	00.26	00.52	0.011	0.019	0.02	N.S	00.40	00.44
Interactions											
K-levels	Pix levels										
Control	Control	78.67	82.47	10.11	11.13	0.482	0.588	0.35	0.31	20.12	20.88
	250 ppm	75.00	77.67	10.66	11.07	0.575	0.669	0.34	0.34	20.87	22.44
	500 ppm	74.67	77.47	11.00	11.60	0.626	0.670	0.33	0.33	23.47	24.18
24 kg K_2O/fed	Control	83.33	82.53	11.00	11.40	0.668	0.720	0.33	0.32	21.20	22.18
	250 ppm	80.67	79.40	11.11	11.47	0.679	0.748	0.32	0.33	22.63	25.03
	500 ppm	75.33	78.67	11.22	12.07	0.703	0.771	0.31	0.27	24.64	25.27
48kg K_2O/fed	Control	84.33	84.13	11.22	11.33	0.772	0.732	0.33	0.29	23.76	25.91
	250 ppm	81.00	81.53	11.11	12.60	0.776	0.807	0.32	0.31	24.97	26.11
	500 ppm	78.33	79.00	11.33	12.53	0.792	0.842	0.31	0.33	26.06	26.83
72 kg K_2O/fed	Control	86.67	84.80	11.66	11.67	0.802	0.880	0.35	0.30	25.59	26.25
	250 ppm	85.00	83.27	11.33	12.20	0.809	0.878	0.31	0.32	26.22	26.92
	500 ppm	79.67	80.00	12.22	12.67	0.863	0.961	0.31	0.31	26.91	27.19
96 kg K_2O/fed	Control	88.00	84.73	11.22	12.20	0.844	0.906	0.34	0.32	26.51	27.26
	250 ppm	85.33	82.80	11.66	12.40	0.872	0.952	0.32	0.32	27.13	27.85
	500 ppm	86.67	81.93	12.44	12.67	0.918	1.030	0.32	0.32	27.76	28.63
L.S.D. at 5%		04.19	02.43	02.43	00.57	0.024	0.043	0.02	N.S	00.89	00.99

(S_1) = (2008/2009) & (S_2) = (2009/2010) seasons.

and decay were recorded at the end of the storage period (9 months).

Data obtained during the two seasons of the study were statistically analyzed according to Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1- Vegetative growth:

Data presented in Table 1 show the effect of potassium levels, mepiquat chloride (pix) levels and their interactions on growth aspects of garlic plants.

Concerning the effect of K-levels, it is clear from such data in Table 1 that plant height number of leaves, leaf area/plant and plant dry weight in both seasons as well as bulbing ratio in the first season only were significantly increased with increasing K-level up to 96 kg K_2O/fed. These results may be attributed to the great role of k-element in controlling various enzymes activities and plant metabolism, consequently stimulated plant growth. The obtained results concerted with those of El Mansi *et al.* (1985) and Abdel Fattah *et al.* (2002).

Regarding the effect of mepiquat chloride (pix) levels, the same data in Table 1 reveal that foliar application of pix levels exerted significant increases on all studied parameters of vegetative growth except plant height it was reduced in both seasons and bulbing ratio in the second season only. In this connection, plants sprayed

Table 2. Effects of potassium levels, pix and their interactions on Total yield and its components in Garlic plant during two seasons (S_1 & S_2).

Characters / Treatments		Total yield (ton/fed)		Bulb Weight (g)		Bulb diameter(cm)		No. of cloves/bulb		Clove weight (g)	
		S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2	S_1	S_2
K levels											
Control		5.679	6.095	53.28	56.17	4.47	5.29	18.9	18.9	3.06	3.08
24 kg K_2O/fed		5.958	6.476	56.53	59.16	4.87	5.63	18.8	18.4	3.32	3.50
48 kg K_2O/fed		6.204	6.819	59.67	63.85	5.29	5.91	19.4	18.4	3.54	3.71
72kg K_2O/fed		6.509	7.190	61.81	69.38	5.78	5.94	19.3	19.0	4.01	3.90
96 kg K_2O/fed		6.889	7.400	64.75	71.94	6.16	6.19	18.4	18.0	4.33	4.21
L.S.D. at 5%		0.151	0.095	02.20	01.85	0.23	0.21	N.S	N.S	0.19	0.11
Pix levels											
Control		5.944	6.598	57.70	60.03	5.00	5.59	18.7	17.9	3.39	3.44
250 ppm		6.267	6.760	59.15	64.75	5.35	5.85	19.1	19.5	3.64	3.68
500 ppm		6.533	7.030	60.77	67.51	5.59	5.95	19.1	18.3	3.89	3.92
L.S.D. at 5%		0.095	0.053	01.24	01.04	0.13	0.13	N.S	01.3	0.14	0.07
Interactions											
K-levels	**Pix levels**										
Control	Control	5.357	5.885	51.33	54.78	4.13	4.93	16.7	16.7	2.81	2.85
	250 ppm	5.696	6.114	53.50	56.32	4.44	5.30	19.0	20.0	3.10	3.06
	500 ppm	5.984	6.285	55.00	57.41	4.83	5.63	21.0	20.0	3.28	3.32
24 kg K_2O/fed	Control	5.739	6.276	54.92	56.45	4.58	5.43	19.3	19.3	3.07	3.18
	250 ppm	5.962	6.381	55.83	59.36	5.02	5.77	18.7	18.3	3.29	3.54
	500 ppm	6.174	6.770	58.83	61.68	5.02	5.70	18.3	17.7	3.60	3.77
48kg K_2O/fed	Control	5.847	6.704	58.67	58.57	4.97	5.70	19.0	17.0	3.22	3.45
	250 ppm	6.262	6.790	59.42	65.11	5.37	6.00	20.0	21.0	3.63	3.74
	500 ppm	6.504	6.962	60.92	67.88	5.52	6.03	19.3	17.3	3.76	3.93
72 kg K_2O/fed	Control	6.152	6.942	60.75	63.78	5.52	5.80	19.3	19.0	3.70	3.70
	250 ppm	6.515	7.209	63.08	70.55	5.75	6.00	19.0	18.7	4.00	3.87
	500 ppm	6.859	7.419	61.58	73.81	6.07	6.03	19.7	19.3	4.34	4.13
96 kg K_2O/fed	Control	6.623	7.181	62.83	66.58	5.81	6.07	19.3	17.7	4.12	4.01
	250 ppm	6.900	7.304	63.91	72.44	6.17	6.17	18.7	19.3	4.40	4.17
	500 ppm	7.144	7.714	67.50	76.78	6.50	6.33	17.3	17.0	4.46	4.44
L.S.D. at 5%		0.214	0.119	02.76	02.34	0.28	N.S	01.9	02.9	0.30	0.16

(S_1) = (2008/2009) & (S_2) = (2009/2010) seasons.

with pix at 500 ppm were generally stocky and healthy in appearance than untreated plants. These results could be attributed to the great role of plant growth retardants in the physiological growth. The obtained results are in harmony with those reported by Foda *et al.* (1979) on garlic, (Zayed *et al.*, 1986; Sakr *et al.*, 1989 and El-Sayed, 1991) on potato and Abdel-Fattah *et al.* (2001) on sweet potato.

As for the interactional effects, it is obvious from the same data in Table 1 that all treatments of K-levels were generally more effective in the presence than in the absence of pix. In this regard, plants received potassium fertilizer at 72 or 96 kg K_2O/fed and sprayed with pix at 500 ppm gave the highest values of plant growth in both seasons compared with the other treatments. Similar results were reported by Abdel Fattah *et al.* (2001).

2- Yield and its components:

Data illustrated in Table 2 show the effect of potassium levels, pix levels and their interactions on yield and its components of garlic. Such data indicate that applied potassium (K) at the high level (96 kg K_2O/fed) was generally beneficial than the other treatments. Moreover, this treatment significantly increased total yield, bulb weight and diameter as well as clove weight than the all studied K levels in both seasons. However, number of

Table 3. Effects of potassium levels, pix and their interactions on Chemical constituents in leaves and bulbs of Garlic plant.

Characters / Treatments		Chemical constituents							
		Leaves			Bulbs				
		N (%)	P (%)	K (%)	N (%)	P (%)	K (%)	TSS (%)	Volatile oils (g/kg FW)
K levels									
Control		2.66	0.590	2.13	1.61	0.378	1.39	3.92	0.29
24 kg K_2O/fed		2.73	0.623	2.16	1.71	0.394	1.44	4.23	0.33
48 kg K_2O/fed		2.73	0.654	2.20	1.66	0.413	1.50	4.90	0.38
72kg K_2O/fed		2.76	0.698	2.26	1.64	0.428	1.60	5.52	0.43
96 kg K_2O/fed		2.72	0.712	2.32	1.73	0.456	1.65	6.03	0.44
L.S.D. at 5%		0.04	0.014	0.20	0.02	0.007	0.02	0.11	0.02
Pix levels									
Control		2.66	0.626	2.17	1.63	0.395	1.47	4.54	0.35
250 ppm		2.70	0.658	2.21	1.68	0.413	1.52	4.91	0.38
500 ppm		2.79	0.683	2.25	1.71	0.433	1.56	5.32	0.40
L.S.D. at 5%		0.04	0.011	0.01	0.01	0.010	0.01	0.12	0.02
Interactions									
K-levels	Pix levels								
Control	Control	2.62	0.550	2.10	1.59	0.360	1.35	3.83	0.27
	250 ppm	2.70	0.590	2.14	1.62	0.377	1.40	3.87	0.29
	500 ppm	2.67	0.630	2.15	1.62	0.397	1.42	4.07	0.32
24 kg K_2O/fed	Control	2.77	0.603	2.12	1.66	0.373	1.41	3.83	0.30
	250 ppm	2.69	0.620	2.16	1.72	0.393	1.42	4.17	0.33
	500 ppm	2.73	0.647	2.19	1.75	0.417	1.47	4.70	0.35
48kg K_2O/fed	Control	2.71	0.620	2.15	1.62	0.397	1.47	4.50	0.35
	250 ppm	2.69	0.660	2.20	1.70	0.400	1.49	4.67	0.39
	500 ppm	2.79	0.683	2.25	1.67	0.443	1.54	5.55	0.39
72 kg K_2O/fed	Control	2.72	0.657	2.21	1.60	0.417	1.53	4.70	0.41
	250 ppm	2.69	0.713	2.26	1.63	0.433	1.60	5.77	0.43
	500 ppm	2.86	0.723	2.30	1.69	0.433	1.66	6.10	0.42
96 kg K_2O/fed	Control	2.51	0.700	2.28	1.68	0.427	1.60	5.83	0.43
	250 ppm	2.73	0.707	2.32	1.71	0.463	1.65	6.07	0.44
	500 ppm	2.92	0.730	2.37	1.81	0.477	1.70	6.20	0.45
L.S.D. at 5%		0.04	0.025	0.03	0.03	N.S	0.03	0.26	0.04

cloves/bulb was not significantly affected by potassium (K) levels in both seasons. The positive effect of K levels in improving total yield and its components may be imputed to the fact that K element is one of the most important of garlic plants. It is helps in producing stocky plants and healthy in appearance with thick leaves and larger bulbs. In addition, it has an indispensable role in translocation of synthesized carbohydrates from plant leaves towards bulbs (Black, 1960 and Bidwell, 1979). The obtained results are in accordance with those of El Mansi *et al.* (1985) and Abdel Fattah *et al.* (2002), they found that total yield and its components of garlic were significantly increased by increasing K-levels from 0 up to 100 or 96 kg K_2O/fed, respectively. Similar findings also reported by (Setty *et al.*, 1989; Eid *et al.*, 1991; Wang *et al.*, 1992; Salvaraj *et al.*, 1993; Mohd *et al.*, 1994; Abdel Fattah *et al.*, 1996; Verma *et al.*, 1996 and El Morsy *et al.*, 2004).

As for the effect of pix levels, data in Table 2 indicate that total yield and its components, with exception of the number of cloves/bulb in the first season were more better with spraying the plants with pix comparing with the untreated plants. Moreover, application of pix at 500 ppm was more useful treatment to increasing total yield and improving its components than the other treatments. These increases might be ascribed to the favorable role of plant growth retardants in the physiological growth and bulb production. Similar results were reported by (Foda *et al.*, 1979; Das *et al.,* 1985; Salvaraj *et al.*, 1995; Das *et al.*, 1996 and Dimov, 2000).

Regarding the interaction effects, it is clear from data in Table 2 that irrespective of bulb diameter season which

Table 4. Effects of potassium levels; pix and their interactions on Total weight loss, sprouting and decay of garlic bulbs at the end of storage period during two seasons (S_1 & S_2).

Characters / Treatments		Total weight loss (%)		Sprouting (%)		Decay (%)	
		S_1	S_2	S_1	S_2	S_1	S_2
K levels							
Control		75.44	73.67	5.54	5.37	78.89	78.22
24 kg K_2O/fed		73.00	72.22	5.30	5.22	77.00	76.44
48 kg K_2O/fed		73.11	69.89	5.31	4.99	77.33	73.89
72kg K_2O/fed		68.78	66.78	4.77	4.68	73.78	71.11
96 kg K_2O/fed		63.67	64.22	4.37	4.42	67.56	68.11
L.S.D. at 5%		01.32	01.37	0.18	0.14	01.07	01.35
Pix levels							
Control		73.13	71.93	5.31	5.19	77.33	76.13
250 ppm		71.00	69.40	5.03	4.94	75.13	73.73
500 ppm		68.27	66.73	4.83	4.67	72.27	70.80
L.S.D. at 5%		01.01	01.46	0.13	0.15	00.92	01.34
Interactions							
K levels	Pix levels						
Control	Control	78.00	76.67	5.80	5.67	81.33	81.00
	250 ppm	77.00	75.00	5.70	5.50	80.00	79.33
	500 ppm	71.33	69.33	5.13	4.93	75.33	74.33
24 kg K_2O/fed	Control	76.67	75.00	5.67	5.50	80.00	79.33
	250 ppm	72.67	72.67	5.27	5.27	77.33	77.00
	500 ppm	69.67	69.00	4.97	4.90	73.67	73.00
48kg K_2O/fed	Control	74.33	73.00	5.43	5.30	78.67	75.67
	250 ppm	73.33	69.33	5.33	4.93	77.67	74.33
	500 ppm	71.67	67.33	5.17	4.73	75.67	71.67
72 kg K_2O/fed	Control	71.33	68.33	5.13	4.83	76.33	73.33
	250 ppm	68.33	66.00	4.50	4.60	73.33	70.33
	500 ppm	66.67	66.00	4.67	4.60	71.67	69.67
96 kg K_2O/fed	Control	65.33	66.67	4.53	4.67	70.33	71.33
	250 ppm	63.67	64.00	4.37	4.40	67.33	67.67
	500 ppm	62.00	62.00	4.20	4.20	65.00	65.33
L.S.D. at 5%		02.26	N.S	0.29	N.S	N.S	03.00

(S_1) = (2008/2009) & (S_2) = (2009/2010) seasons.

was not significantly influenced in the second season. There were significant interactions between K levels and pix on total yield, bulb weight, number of cloves/bulb and clove weight in both seasons. In general, plants fed 96 kg K_2O/fed and sprayed with pix at 500 ppm produced the highest values. These results coincide with those of by (Zayed *et al.*, 1986; Sakr *et al.*, 1989; El Sayed, 1991 and Abdel Fattah *et al.*, 2001).

3- Chemical constituents:

Data in Table 3 show the effect of potassium levels, pix levels and their interactions on element concentrations of N, P and K in plant foliage and cloves and percentage of total soluble solids and volatile oils in cloves of garlic. From such data, it is evident that the K levels had a significant effect on chemical constituents in plant foliage and cloves of garlic. All tested chemical constituents were significantly increased with increasing K levels from 0 up to 96 kg K_2O/fed. These results are in agreement with those of (Abdel Fattah *et al.*, 1996 and 2002; and El Morsy *et al.*, 2004).

Concerning the effect of pix levels, data in Table 3 show that all concentrations of elements in both plant foliage and cloves and percentage of total soluble solids and volatile oils in cloves were significantly increased due to spraying the plants with pix comparing with the untreated plants. Such increments were positively connected with the application treatments. These results agreed with those reported by Abdel Fattah *et al.* (2001).

As for the interaction effects, it is obvious from data in

Table 3 that the interactions between K levels and pix had a significant effects on all concentrations of studied chemical constituents, with exception of the P in cloves which was no affected. Plants fed 96 kg K_2O/fed and sprayed with 500 ppm pix achieved the highest concentrations. Similar results were obtained by Abdel Fattah *et al.* (2001).

4- Storability:

Data in Table 4 show the effect of potassium levels, pix levels and their interactions on storability of garlic bulbs. Such data reveal that the total weight loss percentage of bulbs, sprouting and decay at the end of storage period were significantly affected in both seasons. Moreover, total weight loss, sprouting and decay percentage of garlic bulbs stored were reduced gradually by increasing the applied K level up to 96 kg K_2O/fed in both seasons. These results may be due to the great role of K in carbohydrate metabolism and improving membrane structure. The obtained results are in line with those reported by El Mansi *et al*., 1985; Abdel Fattah *et al*., 1996 and 2002; and El Morsy *et al*., 2004.

Regarding the effect pix levels, data in Table 4 indicate that bulb storability of plants sprayed with pix, was more better than that of the untreated plants. Moreover, foliar application of pix at 500 ppm was more beneficial than the other treatments, this treatment reduced total weight loss, sprouting and decay percentage. These results are in harmony with those of (Foda *et al.,* 1979 and Salvaraj *et al*., 1995).

Concerning the interaction effects, it is clear from data in Table 4 that the positive interactions between between K levels and pix levels were often observed on storability of bulbs. Application of K at 96 kg K_2O/fed with foliar spray of pix at 500 ppm gave the lowest total weight loss, sprouting and decay percentage at the end of storage period. These results were agreed with those of Abdel Fattah *et al.* (2001).

From the results of this study, it could be concluded that, application of potassium fertilizer at the level of 96 kg K_2O/fed with spraying the plants with mepiquat chloride (pix) at 500 ppm are the recommended treatments for increasing productivity and improving bulb quality of garlic under such conditions of this study.

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