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A Comparison Study on the Effect of Some Treatments on Earliness, Yield and Quality of Globe Artichoke (*Cynara scolymus* L.)

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Abstract: Two field experiments were conducted to study the effect of GA3 spraying, potassium spraying and potassium application to the soil on vegetative growth, yield, yield quality and chemical constituents' of globe artichoke. The obtained results show that GA3 spraying increased plant height and offshoots number per plant, while potassium application to the soil increased both leaf length and offshoots number per plant. Obtained data indicate also, that GA3 spraying or potassium application to the soil increased early yield, while potassium spraying on globe artichoke plants increased both late and total yield. GA3 spraying or potassium application to the soil increased both head weight and receptacle weight of the early yield. Also, potassium application to the soil increased head diameter, while spraying globe artichoke plants with GA3 increased head length in the late yield in both seasons but the differences were significant in the second only. Spraying GA3 increased the percentage of nitrogen, phosphorus, potassium and protein of leaves. Spraying potassium increased the percentage of nitrogen, potassium and protein in the leaves, while potassium application to the soil increased the percentage of phosphorus in the leaves. Spraying GA3 or potassium or applying potassium increased the endogenous phytohormones (IAA and GA3) and reduced the endogenous inhibitor activity of Abscic Acid (ABA). GA3 or potassium spraying or applying potassium to the soil increased the percentage of nitrogen, potassium and protein, but it decreased the percentage of phosphorus in the heads. Finally, the crude fibers of the head were increased by spraying GA3 and decreased by either spraying potassium on leaves or applying to the soil.

Keywords: Globe Artichoke, GA3, potassium, yield and quality

INTRODUCTION

Globe artichoke (Cynara Scolymus L.) is one of the most important vegetable crops in Egypt grown for both local consumption and exportation. Great attention is given recently by Egyptian government to promote globe artichoke productivity to satisfy the increased demands for both local and foreign markets. The demands on the Egyptian fresh globe artichoke to the European markets increase during the period from December to February, but the peak of production occurs usually during the period from March to May. Thus, the early production with good quality during the period from December to February is considered the most major important for promoting globe artichoke exportation. Some factors affect the earliness and quality of globe artichoke heads. Among these factors, gibberellins, plant growth regulators have received the most attention. It was found to affect vegetative growth, earliness, yield and quality of production[1,5]. Another important factor that found to have a marked effect on the growth, yield and quality of globe artichoke and many other vegetable crops, is potassium, El-Shal *et al.,*[6] and Mansour *et al.,*[7] on globe artichoke, El- Shimi *et al.,*[8] on strawberry, Fawzy *et al.,*[9] on sweet pepper and Fawzy *et al.,*[10] on Eggplant.

The present study aims to investigate the effect of GA3 and potassium treatments on inducing earliness and increasing yield in addition to improving the quality of globe artichoke.

MATERIALS AND METHODS

Two field experiments were carried out at Kaha vegetables Research Farm, Horticulture Research Institute, Agriculture Research Centre during the two successive seasons of 2003-2004 and 2004-2005. Planting dates were in the first week of June in the first and second seasons, respectively.

The Experiments Were Designed to Investigate:

- Effects of GA3 foliar spraying at 50 ppm concentration twice 60 and 75 days after planting.
- Effects of potassium fertilization K (s) at 100 kg k_2O/ Fed as foliar into two equal doses and sprayed in the same dates of GA3 foliar spraying.

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- Effects of soil fertilization with potassium K (a) at the rate of 100 kg k_2O/Fed divided into two equal doses 60 and 75 days after planting.
- Control.

The experiments were set up in randomized complete blocks with three replicates. Each replicate contained four treatments (plots). The plot area was 25 m^2 (5 rows with 1m width and 5 m long for each row).

Offshoots of the local cultivar were planted on one meter space on the row. The traditional agricultural practices were carried according to the recommendations of the ministry of Agriculture. Chemical and physical analysis of the experimental soil was determined according to Jakson method[11] (Table1).

Recorded Data:

Vegetative Growth: Five plants were taken randomly from each plot at the beginning of flowering stage to measure plant height (cm), leaves number per plant, leaf length (cm) and offshoots number per plant.

Yield (No. Of heads/plant):

Early Yield: Early yield was calculated through the period from the beginning of the harvest season till the end of February.

Late Yield: It was estimated during the period from the end of February till the end of harvest season.

Total Yield: It include both early and late yield during the harvest season.

Yield Quality: Samples of 10 heads were taken randomly from each plot from both early and late yield to estimate head weight (g.), head diameter (cm), head length (cm) and receptacle weight (g.).

Chemical Constituents:

Chemical Constituents of Leaves: Samples of leaves were taken at the beginning of flowering stage and oven dried at 70 C^0, then fine ground and wet digested. Total nitrogen was determined according to Koch and Mc Meckin[12], protein content was determined as nitrogen content and converted to its equivalent protein content by multiplying with 6.25 as described by Pregl[13], phosphorus was determined according to Troug and Meyer[14], and potassium was estimated according to Brown and Lille Land[15]. Samples of fresh leaves were taken at the beginning of flowering stage and extracted according to the method adopted by Badr *et al.,*[16] and were detected by Gas Liquid Chromatography (GLC), to estimate the endogenous Indole Acetic Acid (IAA), Gibberellins (GA3) and Abscise acid (ABA).

Chemical Constituents of Heads: Samples of heads were taken at the beginning of harvesting season and dried, the nitrogen, total protein, phosphorus and potassium were determined as mentioned before, while the crude fiber was determined according to Anonymus,[17] and estimated according to A..O.A.C.[18].

Statistical Analysis: The collected data were statistically analyzed by analysis of variance according to Gomez and Gomez[19].

RESULTS AND DISCUSSIONS

Vegetative Growth: It is clear from table (2) that spraying globe artichoke plants with GA3 increased significantly plant height and offshoots number per plant. Similar results were obtained by El –Greadly[2] and El-Bassiony *et al.,*[5] who pointed out that treating to globe artichoke plants by GA3 increased plant height and number of offshoots per plant. It could be concluded that the stimulation effect of GA3 on plant height may be due to its effects on internodes elongation, while the positive effect of GA3 on the number of offshoots per plant may be attributed to the promotive effect of GA3 on globe artichoke plants to produce more lateral branches on its main stem.

Regarding the effect of potassium fertilization on vegetative growth of globe artichoke plants, it was found from data in table (2) that applying potassium fertilizer to the soil increased leaf number per plant, leaf length and number of offshoots per plant. These promotive effects of potassium may be attributed to the function of potassium in regulating the maintenance of electro-chemical equilibria in the cells and the regulation of enzyme activities[20].

Yield (No. Of Heads per Plant):

Early Yield: It is clear from data in table (3) that GA3 spraying or applying potassium to the soil increased significantly the early yield. The positive effect of GA3 on early yield may be attributed to its effect on inducing blooming earliness. These results agree with that obtained by El-Greadly[2], Schrader[21], Garcia *et al.,*[22], and Abdel-Wahab[4]. Concerning the positive effect of potassium fertilizer it may be attributed to its effects on the energy status of the plant and translocation and storage of assimilates Imas and Bansal[23].

Late Yield: It is clear from data in table (3), that using potassium fertilizer as foliar spray increased late yield. Comparing with the other tested treatments in both seasons of study.

Table 1: Physical and chemical properties of the experimental soil.

(A) : physical properties %				
Clay	silt	Fine sand	Coarse sand	Texture grade
27.98	16.35	33.34	22.33	Sandy clay loam
B- Chemical properties				
E.C. (ds/m)			5.6	
PH (1:2.5)			7.32	
Soluble ions				
Cations $me.L^{-1}$				
Na^{+}			11	
K^{+}			2.61	
Ca^{++}			36.65	
Aninos $me.L^{-1}$				
CL^{-}			10.75	
HCO^{-3}			3.00	
SO^{-4}			66.44	
Available cations %				
N			0.137	
P			0.077	
K			0.205	

Table 2: Effect of GA3 and potassium treatments on vegetative growth of globe artichoke during 2003 -2004 and 2004 -2005 seasons.

Charac.	Plant height (cm)		Leaves number		Leaf length (cm)		Offshoots number	
Treat.	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II
1-GA3(50ppm)	57.50	41.83	43.50	28.33	54.00	61.83	4.83	3.50
2-K (s)	41.43	39.30	42.87	25.00	53.33	73.93	4.00	2.72
3-K(a)	29.80	37.50	45.60	33.67	61.83	78.50	4.00	3.75
4-Cont.	24.67	31.50	40.00	31.50	59.67	78.50	2.83	2.28
L.S.D. at 5%	10.76	NS	NS	NS	NS	6.71	NS	0.95

Table 3: Effect of GA3 and potassium treatments on early, late and total yield of globe artichoke during 2003 - 2004 and 2004-2005 seasons.

Charac.	Early yield		Late yield		Total yield	
Treat.	Season I	Season II	Season I	Season II	Season I	Season II
1-GA3(50ppm)	3.17	3.50	6.17	9.83	9.33	13.33
2-K(s)	1.00	2.72	10.00	11.95	11.00	14.67
3-K(a)	3.50	3.75	5.50	10.58	9.00	14.33
4-Cont.	2.00	2.28	5.67	11.67	7.67	10.83
L.S.D. at 5%	1.41	0.95	1.66	NS	1.37	1.32

Total Yield: Data in table (3) indicated clearly that using potassium fertilizer as foliar spray increased significantly total yield comparing with the other tested treatments in both seasons of study. The positive effect of potassium spraying on total yield may be attributed to its effect on translocation of sugars and formation of carbohydrates[24].

Yield Quality: Data in table (4) indicate the yield quality, i.e. head weight, head diameter, head length and receptacle weight of both early and late yield. It is clear from the data that spraying globe artichoke plants with GA3 or Applying potassium fertilizer to the soil increased both head weight and receptacle weight of the early yield, while there were no significant differences between the tested treatments on head diameter and head length in the early yield.

Table 4: Effect of GA3 and potassium treatments on head quality of globe artichoke plants during 2003 -2004 and 2004 -2005 seasons.

	Early yield								Late yield							
Chr.	Head weight (g)		Head diameter (cm)		Head Length (cm)		Receptacle weight (g)		Head weight (g)		Head diameter (cm)		Head Length (cm)		Receptacle weight (g)	
Tre.	Se.I	Se.II	Se.I	Se.II	Se.I	Se.II	Se.I	Se.II	Se.I	Se.II	Se.I	Se.II	Se.I	Se.II	Se.I	Se.II
1-(GA3)	177.77	231.5	7.45	8.25	9.00	10.00	83.17	105.73	152.02	148.71	7.45	7.02	9.18	8.53	53.39	64.49
2-(K)s	175.00	201.3	7.40	7.66	9.30	9.80	57.50	65.90	153.34	156.94	7.68	6.70	8.01	8.49	55.53	64.59
3-(K)a	183.17	208.33	7.62	8.00	8.54	9.53	72.83	78.65	164.96	158.05	8.22	7.97	7.96	7.96	63.57	58.69
4-Cont.	174.17	198.67	7.21	7.68	8.77	10.13	72.83	62.90	146.00	147.83	6.84	7.60	7.82	7.38	50.00	63.97
L.S.D. at 5%	NS	23.61	NS	NS	NS	NS	NS	21.28	NS	NS	NS	0.91	NS	0.73	NS	NS

Table 5: Effect of GA3 and potassium treatments on chemical constituents of leaves of globe artichoke during 2003 -2004 and 2004 -2005 seasons.

Charac.	N %		P %		K %		Proteins %	
Treat.	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II
1-GA3(50)	1.16	1.18	0.302	0.307	1. 64	1.68	7.180	7.187
2-(K)s	1.22	1.25	0.322	0.325	1.72	1.81	7.560	7.574
3-(k)a	1.07	1.09	0.410	0.396	1.66	1.72	6.620	6.617
4-Cont.	1.05	1.08	0.283	0.277	1.55	1.58	6.510	6.569
L.S.D. at 5%	0.04	0.03	0.005	0.007	0.03	0.09	0.048	0.035

Table 6: Effect of GA3 and potassium treatments on chemical constituents of receptical of heads of globe artichoke during 2003 -2004 and 2004 -2005 seasons.

Charac.	N %		P %		K %		Proteins %		Fibers %	
Treat.	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II	Season I	Season II
1-GA3	1.270	1.267	0.420	0.427	1.940	1.93	7.937	7.875	11.27	11.30
2-(K)s	1.580	1.573	0.445	0.472	2.140	2.12	9.875	9.812	9.64	9.75
3-(K)a	1.420	1.463	0.421	0.407	2.130	2.11	8.875	8.804	10.34	10.33
4-Cont.	1.060	1.056	0.563	0.567	1.900	1.89	6.625	6.562	11.07	11.05
L.S.D at 5%	0.057	0.016	0.007	0.007	0.045	0.034	0.011	0.021	0.59	0.59

Concerning the effect of the tested treatments on head quality of the late yield its clear from the data in table(4) that applying potassium to the soil significantly increased head diameter in the second season only,while spraying plants with GA3 increased significantly head length in the second season.

The effect of GA3 may be attributed to its ability to cause cell elongation or expansion through affecting the extensibility of the cell wall Lockhart,[25], or by affecting the process of cell division. Also, Loy[26] reported that GA3 can increase the size of meristematic region and also can increase the proportion of cells which are undergoing division. The obtained data agree with that reported by Elia *et al.,*[27] and Schrader[21] who concluded that GA3 increased average head weight of globe artichoke. Also the obtained data agree with those obtained by Garcia *et al.,*[22] who reported that GA3 increased receptacle weight. Also, it was clear from obtained data that applying potassium to the soil increased significantly head diameter in late yield. Thus the effect of potassium may be attributed to the role of potassium on the energy status of the plant and maintenance of tissue –water relation[23].

Chemical Constituents:

Chemical Constituents of Leaves: Data in table (5) indicate the percentage of nitrogen, phosphorus, potassium and protein in the leaves of globe artichoke plants, while Fig. (1) Indicate the endogenous phytohormones (ng/g. fresh weight). It is clear from data in table (5) that GA3 increased significantly the percentage of nitrogen, potassium and protein of leaves than control treatments. Bhattarcharjee *et al.,*[28] found variable effects of GA3 on leaf nitrogen content of

dahlia plants, on the other hand Abdel-Wahab[4] found that total nitrogen was not be affected by GA3 in globe artichoke plants. Castro *et al.,*[29], observed that GA3 treatments increased phosphorous accumulation in leaves and stems of tomato plants. Also, El-Greadly[2], reported that GA3 treatments increased potassium percentage in leaves of globe artichoke plants. The obtained results of GA3 treatments, agree with those obtained by Farrage *et al.,*[30] who noticed a considerable increasing of protein synthesis, which apparently increases the rate of cell wall synthesis. Also, they indicated that GA3 may play a role in the stimulation of the RNA controlled protein synthesis. Concerning the effect of potassium treatments on nitrogen, phosphorus, potassium and protein in leaves of globe artichoke plants, it is clear from table (5) that spraying potassium on globe artichoke plant increased nitrogen, potassium and protein percentage in the leaves while applying potassium fertilizer to the soil increased the percentage of phosphorus in the leaves of globe artichoke plants. The effect of potassium treatment may be attributed to its role in the regulation of enzyme activities[20].

Concerning the effect of GA3 and potassium treatments on the endogenous phytohormones, it is clear from Fig. (1) That all treatments used increased the levels of the endogenous promoter compounds (IAA and GA3), and reduced the inhibitor activity of ABA as compared with the untreated plants. The results indicate that GA3 increased the levels of endogenous IAA and GA3. This positive effect of GA3 may be attributed to enhancement of auxin biosynthesis,Sastry and Main,[31] and Jindal and Hembery[32], or to retardation of auxin destruction through decreasing IAA- oxidase activity[33]. Similar results were reported by El-Greadly[2] who found an increase in the endogenous gibberellins, auxins and decreases in ABA levels in treated artichoke plants with GA3 at 50 ppm.

Chemical Constituents of Heads: Data presented in table (6) showed that nitrogen, potassium and protein percentage were increased in the heads of the early yield by using treatment of potassium spraying followed by the other tested treatments. While opposite was true with phosphorus percentage. The positive effect of the potassium treatments on nitrogen, potassium and protein percentage may be attributed to their effect on these elements absorption and translocation[34]. It is clear from data in the same table that GA_3 increased the percentage of crude fibers, while the opposite was true with potassium treatments.

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