ISSN 1110-0419

Annals Of Agric. Sc., Moshtohor,
Vol. 44(3): 1207-1221, (2006).

PHYSIOLOGICAL EFFECTS OF K- SOIL APPLICATION AND ZN FOLIAR SPRAY AND THEIR INTERACTION ON GROWTH, FLOWERING, BULBS AND CHEMICAL COMPOSITION OF *Polianthes tuberosa* L. cv. "Double"

BY

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ABSTRACT

Two field experiments were carried out in the experimental farm of Faculty of Agriculture, Fayoum University at the two successive seasons 2001/2002 and 2002/2003 to explore the response of *Polianthes tuberosa* L. c.v. "Double" plants to the effect of K soil fertilization (0.0, 5, 10 and 20 g potassium sulphate/ plant) and foliar spray with Zn at two concentrations (1000 and 2000 ppm) on vegetative growth, summer and autumn flowering, bulbs and bulblets and chemical composition. The obtained data showed that fertilizing tuberose plants with K fertilizer at any level used in the study were accompanied with significant (in general) increase in vegetative growth characters (plant height, leaf length and fresh weight of leaves/clumb) compared with untreated plants and also increased all flowering traits parameters (summer and autumn flowering) i.e. length of floral stalk, fresh weight of spike, number of florets/ spike and yield of flowers, as well as, number of days to flowering. The results showed also that fertilizing tuberose plants with the highest rate of K (20 g/ plant) caused a significant increases on bulbs production (fresh weight and number of bulbs + bulblets/ plant and bulbs diameter),chlorophyll (a+ b) and total carotenoids in leaves, N, P and K percentages in leaves and bulbs and also Zn and Mn concentration in bulbs.

Regarding the effect of foliar spray with Zn on tuberose plants data revealed that, spraying tuberose plants with Zn at 2000 ppm increased insignificantly all the abovementioned characters of vegetative growth, summer and autumn flowering, bulbs production, as well as, leaves and bulbs chemical composition, in both seasons, while decreased each of P and Zn contents in bulbs in the two growing seasons and number of bulbs+ bulblets /plant in the second season.

The interaction effect between K fertilizer and Zn on all the abovementioned studies varied between the two seasons of the study and the above-mentioned parameters of vegetative growth, flowering, bulbs production and chemical composition.

INTRODUCTION

Tuberoses are among the most fragrant of all garden plants. They are members of the *Agavaceae*. *P. tuberosa*, commonly known as "Rajnigandha", is an important bulbous ornamental plant with high-value crop. Waxy white flowering spikes of tuberose with sweet and pleasant fragrance are in great demand for indoor decoration, garlands, bouquets, cut flower trade and extraction of essential oil.

Potassium fertilizer plays a major role in many physiological and biochemical processes; as cell- division and elongation, enzyme activation, synthesis of simple sugars and starch as well as accelerated translocation of carbohydrates, necessary for bulbs formation and development (Nelson, 1970; Marschner, 1986 and Beringer *et al.*, 1990). Potassium fertilization plays a major role to improve vegetative growth and flowering of ornamental plants. For instance Amarjeet *et al.* (1996), Bhuyan *et al.* (1996), Singh *et al.* (1996), Amarjeet and Godara (1998), Amarjeet *et al.* (2000), Pal and Biswas (2005) on *Polianthes tuberosa*, Singh *et al.* (1997), Barma *et al.* and Das (1998), Karaguzel and Doran (2000) and Mallick *et al.* (2001) on gladiolus plants. investigated that increasing K application, up to a particular level, affected positively the vegetative growth, flowering traits, bulbs and bulblets production as well as chemical composition.

Although micronutrients are needed in relatively very small quantities for good plant growth, their deficiencies cause great disorders in the physiological and metabolic processes of plant (Kanwer and Dhingra, 1962). Zinc was reported to stimulate the growth of various plants due to its enhancing effect on most metabolic processes such as carbohydrates, protein, phosphate RNA and ribosome formation (Price *et al.*, 1972 and Bidwell, 1980), in chlorophyll formation and nucleic acid metabolism (Mohr and Schopfer, 1995) and in oxidation-reduction processes (Mengel and Kirkby, 1982). They also concluded that, high pH and low organic matter in the soil considerably reduce the availability of most micronutrients. The intensive cropping without adequate conservation of soil fertility through balanced fertilization may be responsible for deficiencies of most nutrients, especially microelements in plants grown in Egypt (Sillanpaa, 1982). It was found by several investigators that, micronutrients play an important role in improving the vegetative growth and flowering of several ornamental plants Barman and Pal (1993), Mukesh *et al.* (2001), Munikrishnappa *et al.* (2002), Yadav *et al.* (2002 & 2003), Hardeep *et al.* (2003&2004) on tuberose and Selim *et al.* (2001) on *Calendula officinalis*, concluded that, spraying plants with Zn increase all vegetative growth characters and flowering. The effect of Zn on the chemical composition of plants were reported by many investigators, El- Deeb (1999) on *Philodendron scandatum*., Selim *et al.* (2001) on *Calendula officinalis* and Hardeep *et al., 2003)* on tuberose. They found that, Zn foliar spray increase the plant leaves content of chlorophyll a or b and total carotenoids. Yadav *et al.* (2002) on tuberose found that, leaf N and Zn contents increased with increasing Zn rates while leaf P and K contents were not affected. Hardeep *et al.* (2004) on tuberose plants indicated that leaf N and Zn content increased with increasing Zn rates while leaf P content decreased and K remained unaffected.

MATERIALS AND METHODS

The present work was conducted in the two successive seasons of 2001/2002 and 2002/2003 at the Experimental farm, Faculty of Agriculture, Fayoum University to investigate the effect of k fertilization and zinc foliar application on tuberose (*Polianthes tuberosa* L. c.v. Double).

The bulbs of tuberose were obtained from the local market at the average diameter 2-4 cm and were sown on 1st of April in 2001 and 2002 seasons. The experimental area was divided into 4 m2 (2x 2 m) containing three rows at a distance 65 cm, the bulbs were planted in each row at 30 cm apart and 5 cm depth,(15 bulbs/ experimental plot), each treatment was applied three replicates. All agro managements required for bulbs production were followed. Samples of the used soil were analyzed according to Balack (1965). Results of analysis are given in Table (1).

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

Properties	2001/2002	2002/2003	Properties	2001/2002	2002/2003
Particle size distribution			**Chemical properties**		
Sand %	32.100	32.270	**Calcium carbonate %**	4.800	4.600
Silt %	32.070	31.410	**Organic matter %**	1.250	1.280
Clay %	35.830	36.320	**Total nitrogen %**	0.062	0.066
Texture grade	Sandy clay	Sandy clay	**ECe (ds/m)**	2.900	2.600
Hydrolyic conductivity (cm^3/hr)	00.027	00.029	**pH of paste extract**	7.500	7.300
Available nutrients					
P	23.00	22.00	**Fe**	03.64	03.71
K	96.80	99.26	**Mn**	08.03	07.89
Zn	00.81	00.80			

Treatments comprised four different K rates, 0, 5, 10 and 20 g potassium sulphate/ plant and two various concentrations of both of Zn (as Edita form 13%) 1000 and 2000 ppm. Such quantities of potassium sulphate were applied as a soil dressing and divided into three equal portions for each plant. Addition of these portions began at the 5th week from planting the bulbs followed by the second addition after one month, while, the last one was applied after the first harvest of flowers. Foliar application of Zn treatments were performed three times at a week interval each dose of K fertilizer.

Either calcium super phosphate at 200 kg/ fed or ammonium nitrate at 100 kg/ fed were added to the soil before planting or after one month from planting. respectively.

The experimental layout was a split block design. The following measurements were determined at the end of each seasons:

1-**Vegetative growth characters** in terms of plant height (cm), leaf length (cm) and fresh weight of leaves (g).

2-**First flowering (summer flowering)** traits expressed as length of floral stalk (cm), fresh weight of spike (g), number of florets/spike, number of days to flowering and flower yield/plot.

3-**Second flowering (autumn flowering)** traits expressed as length of floral stalk (cm), fresh weight of spike (g), number of florets/spike, number of days to flowering and flower yield/plot.

4-**Bulbs and bulblets production** expressed as, number of bulbs and bulblets/ plant, bulbs diameter (cm) and fresh weight of bulbs and bulblets/ plant (g).

5-**Chemical composition;** concentrations of chlorophylls (a + b) and total carotenoids in the fresh leaves at the beginning of flowering, were determined according to the methods described by Welburn and Lichtenthaler (1984). Total N in the dry leaves and bulbs was determined using orange G dye colorimetric method according to Hafez and Hikkelsem (1981). For P, K in leaves and bulbs or Mn and Zn in bulbs were determined, the wet digestion of 0.1 g of fine dry material of leaves or bulbs of each treatment was done with sulphoric and perchloric acids as described by Piper (1947). Phosphorus was estimated colorimetrically by the method as outlined by King (1951) after extraction according to Olsen and Sommers (1982). Potassium was determined by Flame Photometer (Gallenkamp Co., England) as described by Brown and Lilliand (1966). Bulbs Mn and Zn were determined using atomic absorption spectrophotometer as outlined by Parkinson and Allen (1975). All the obtained results were statistically analyzed and comparisons among means of the different treatments were achieved using the least significant differences (L.S.D.) at p=0.05 as illustrated by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

1-Vegetative Growth Characters:

Data given in Table (2) exhibited that increasing K rate from 5 to 20 g potassium sulphate/plant insignificantly or significantly increased each of plant height and leaf length or fresh weight of leaves/ clumb, respectively, compared with untreated plants, in both seasons. The highest values of vegetative growth characters were obtained at the highest rate (20 g potassium sulphate/plant) in both seasons, while, in the first season 10 g potassium sulphate/plant promoted the heaviest leaves/ clumb. The obtained results are in harmony with those reported by Pal and Biswas (2005) on *Polanthes tuberosa* who reported that application of 20 g K/plant recorded the highest plant height.

Regarding the influence of foliar spray of tuberose plants with Zn, data in Table (2) indicated that, in both seasons, the higher concentration of Zn (2000 ppm) improved the highest records of plant height, leaf length and fresh weight of leaves/ clumb rather than the lower concentration (1000 ppm), but this increament was not significant. The obtained results are in agreement with the findings of Mukesh *et al.* (2001), Munikrishnappa *et al.* (2002) and Hardeep *et al.* and Yadav *et al.* (2003) who reported that spraying tuberose plants with Zn increased vegetative growth characters.

Table (2): Effect of k as soil application and foliar application of Zn on vegetative growth characters of *Polianthus tuberosa* L. plants during the two successive seasons 2001/2002 and 2002/2003.

Character		Plant height (cm)			Leaf length (cm)			Fresh weight of leaves/clumb		
Treatment		Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean
2001/2002										
K	0.0	68.62	68.14	68.38	49.36	9.50	49.43	115.33	86.66	100.99
	5	69.24	71.97	70.61	47.21	49.77	48.49	155.00	133.3	144.17
	10	70.88	70.20	70.54	49.26	50.08	49.67	167.84	201.67	184.76
	20	71.96	71.02	71.49	49.99	53.42	51.71	158.3	204.34	181.34
Mean		70.17	70.3		48.96	50.69		149.13	156.50	
L.S.D. 5%										
K		N.S.			N.S.			32.20		
Zn		N.S.			N.S.			N.S.		
K+Zn		N.S.			N.S.			N.S.		
2002/2003										
K	0.0	64.46	68.63	66.55	43.22	44.92	44.07	137.83	162.67	150.25
	5	65.60	69.22	67.41	64.53	46.33	46.43	165.00	143.34	154.17
	10	66.77	67.73	67.25	62.63	49.42	46.05	202.33	170.84	186.59
	20	68.66	68.66	68.66	44.37	50.17	47.27	487.67	230.00	208.84
Mean		66.37	68.56		44.19	47.72		173.21	176.71	
L.S.D. 5%										
K		N.S.			2.86			37.96		
Zn		N.S.			3.04			N.S.		
K+Zn		N.S.			N.S.			N.S.		

Data presented in the same Table (2) showed that vegetative growth characters were not significantly affected by the amount of K added combined with the two levels of Zn, in both seasons. Generally, the tallest plants or the heaviest leaves/ clumb were improved resulted from the combined interaction between 5 or 20 g potassium sulphate/plant and 2000 ppm Zn, respectively. Whereas, the highest value of leaf length was obtained at 20 or 10 g potassium sulphate/ plant combined with Zn at 2000 or 1000 ppm, respectively, at the respective seasons.

2-First Flowering Traits (Summer Flowering):

Data illustrated in Table (3) showed that, application of K fertilizer at the highest rate (20 g potassium sulphate/ plant) improved the highest records of length of floral stalk, fresh weight of spike, number of florets/ spike and flowering yield/plot, as well as, delayed spike emergence and considerably prolonged the flowering period compared with the other rates of K and untreated plants, in both seasons. The obtained results agreed with those reported by Amarjeet *et al.* and Bhuyan *et al.* (1996), Amarjeet and Godara (1998) and Pal and Biswas (2005) on *Polianthes tuberosa* and Karaguzel and Doran (2000) and Mallick *et al.* (2001) on gladiolus. They mentioned that, the higher doses of K fertilizer produced high quality of plant and yield of flower.

Table (3): Effect of K as soil application and foliar spray of Zn on bulbs production of *Polianthus tuberosa* L. plants during the two successive seasons 2001/2002 and 2002/2003.

Character	Length of floral stalk (cm)			Fresh weight of spike (gm)			No. of florets/spike			No. of days to flowering			Flower yield/plot		
Treat-ments	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean
K level	2001/2002														
0.0	23.91	24.63	2.27	50.70	50.54	50.62	25.76	28.95	27.36	103.00	123.00	113.00	12.00	9.33	10.67
5	23.55	25.04	24.30	51.68	51.54	51.61	27.66	28.18	27.92	109.33	119.67	114.50	13.67	10.67	12.17
10	24.75	24.92	28.84	47.42	56.49	52.00	28.74	27.64	28.19	112.33	123.33	117.83	12.67	13.00	12.83
20	26.05	24.96	25.51	54.63	51.06	52.85	29.70	28.46	29.08	119.00	117.67	118.33	12.67	13.00	12.83
Mean	2.56	2.89		51.11	52.41		27.97	28.31		43.67	483.67		13.00	12.25	
L.S.D.5%															
K	1.02			N.S.			N.S.			N.S.			N.S.		
Zn	N.S.			N.S.			N.S.			6.93			N.S.		
K x Zn	1.02			N.S.			2.33			13.26			2.70		
	2002/2003														
0.0	29.67	35.21	29.67	42.16	43.07	42.62	23.02	23.47	23.25	118.00	117.00	117.50	13.33	8.00	10.67
5	31.20	33.85	32.53	40.59	5.19	42.89	23.41	24.5	23.98	117.00	12.00	120.50	9.55	12.00	10.78
10	33.77	36.43	35.10	46.14	40.08	43.11	25.66	25.65	25.66	124.50	122.00	123.25	12.33	11.00	11.67
20	38.66	3.80	36.73	44.18	45.28	44.73	25.74	26.04	25.89	123.33	126.00	12.67	12.67	10.67	11.67
Mean	33.32	35.07		43.27	3.40		24.6	24.92		120.71	122.25		11.92	10.2	
L.S.D.5%															
K	2.11			N.S.			N.S.			4.41			N.S.		
Zn	0.84			N.S.			N.S.			N.S.			N.S.		
K x Zn	1.69			N.S.			N.S.			3.68			3.74		

K: Potassium Zn 1: 1000 ppm Zn 2: 2000 ppm

Foliar spray with zinc at the concentration of 2000 ppm had a slight positive effect on length of floral stalk, fresh weight of spike, number of florets/ spike and number of days to flowering, while, decreased flowering yield/ plot, in both seasons. In this respect, Selim *et al.* (2001) on *Calendula officinalis*, Mukesh *et al.* (2001), Munikrishnappa (2002), Yadav *et al.* (2002&2003) and Hardeep *et al.* (2002&2004) on tuberose. They reported that spraying tuberose plants with Zn, in general, increasing flowering traits.

Concerning the interacting effect of K levels with Zn at any concentration used in the study on flowering traits the obtained data varied between the two seasons of study (Table, 3).Comparison among the different treatments clearly indicated that, fertilization with 20 g potassium sulphate/ plant combined with Zn foliar spray at 1000 ppm improved significantly the values of length of floral stalk, in both seasons. Fresh weight of spike was not significantly affected by the interacting effect between the amount of K added and different levels of Zn, but the heaviest spike was improved resulting from combined application of 10 g K/ plant combined with Zn at 2000 or 1000 ppm at the respective seasons. The highest numbers of florets/ spike were improved at 20 g K/ plant combined with Zn at 1000 or 2000 ppm at first or second seasons, respectively. Treating tuberose plants with 5 or 20.0 g K/ plant combined with Zn at 1000 ppm at the respective seasons, affected positively and significantly the flowering yield/ plot. On the other hand, treated the plants with 20.0 g K /plant combined with Zn at 1000 or 2000 ppm delayed significantly number of days to flowering, in the first and second seasons, respectively.

3-Second Flowering Traits (Autumn Flowering):

Data presented in Table (4) show that, gradual increase of K rate from 5 to 20 g potassium sulphate/ plant caused gradual increase in length of floral stalk, fresh weight of spike and number of florets/ spike compared with untreated plants, in both seasons. On the other hand, soil application of K fertilizer at any rate not affected significantly yield of flowers, while, 10 g K/ plant improved the highest yield compared with the other rates.

Foliar spray with zinc at the higher concentration (2000 ppm) affected positively all flowering parameters (length of floral stalk, fresh weight of spike and number of florets/ spike), in both seasons. While, the reverse trend was obtained at yield of flowering, i.e., Zn at 1000 ppm improved the higher yield compared with the other concentration (2000 ppm).

The comparisons presented in Table (4) illustrated the presence of some interaction effects, between the different levels of K and Zn on different characters of autumn flowering of tuberose, in both seasons. The comparison among the eight treatments combinations indicated that the tallest floral stalk was obtained resulting from the combined application between 20 g K/ plant and Zn at 1000 or 2000 ppm in both seasons, respectively. The highest value of fresh weight of spike promoted at 5 or 10 g K/ plant combined with Zn at 2000 ppm at the respective seasons. Treating tuberose plants with 20 or 10 g K /plant combined with Zn at 2000 ppm in both seasons, respectively, affected significantly the number of florets/ spike. While, flowering yield/ plot were not affected significantly, in both seasons.

Table (4): Effect of K as soil application and foliar spray of Zn on second flowering of *Polianthus tuberosa* L. plants during the two successive seasons 2001/2002 and 2002/2003.

Character	Length of floral stalk (cm)			Fresh weight of spike (gm)			No. of florets/ spike			Flower yield/plot		
Treat-ments	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn-1	Zn 2	Mean
K level	2001/2002											
0.0	26.67	35.21	30.94	78.63	112.42	95.53	44.47	48.88	46.68	3.33	4.33	3.83
5	31.20	33.85	32.53	85.93	99.45	92.69	49.07	46.40	7.74	4.67	6.00	5.33
10	33.77	36.43	35.10	98.39	90.10	94.25	49.51	47.33	48.4	7.67	4.00	5.83
20	38.66	34.80	36.73	97.95	95.25	96.60	47.45	51.39	49.42	4.33	4.33	4.33
Mean	33.32	35.07		90.23	99.30		47.62	58.51		5.00	4.67	
L.S.D.5%												
N	1.8			N.S.			2.79			2.79		
Zn	0.84			N.S.			N.S.			N.S.		
K x Zn	1.69			20.4			3.73			3.73		
	2002/2003											
0.0	30.09	31.89	30.99	67.32	88.84	78.08	41.50	42.83	42.17	4.67	3.00	3.83
5	30.00	3.27	32.14	89.37	80.8	84.85	47.58	43.22	45.40	4.67	5.33	5.00
10	29.23	36.58	32.91	79.57	110.34	94.96	41.40	52.13	46.77	6.33	4.67	5.50
20	31.79	36.88	34.34	100.53	92.47	96.50	46.34	47.82	47.08	4.67	4.33	4.50
Mean	30.28	34.91		94.20	93.0		44.21	46.50		5.08	4.33	
	L.S.D.5%											
K	N.,S.			6.59			N.S.			N.S.		
Zn	1.82			8.06			N.S.			N.S.		
K x Zn	N.S.			16.11			3.70			N.S.		

K: Potassium Zn 1: 1000 ppm Zn 2: 2000 ppm

4-Bulbs and bulblets production:

Data listed in Table (5) indicated that, in both seasons of study, soil K-application at 20 g potassium sulphate/ plant affected positively and significantly or not significantly the fresh weight and number of bulbs+ bulblets/ plant or bulbs diameter, respectively, compared with the other rates of K application, as well as, untreated plants. The favorable effect of K application could be related to the basic and major role of K in many physiological and biochemical processes, cell division and elongation, enzyme activation, synthesis of simple sugars and starch, and acceleration of carbohydrate translocation necessary for tuber formation and development (Marschner, 1986). These results are in agreement with Bhuyan *et al.* and Singh *et al.* (1996) on tuberose and Singh *et al.* (1996&1997) and Barma *et al.* and Das (1998) on gladiolus. They mentioned that, the effect of K fertilizer had much more pronounced effect on bulbs production of tuberose or gladiolus.

Foliar spray with Zn at 2000 ppm concentration followed by significant or not significant increment on fresh weight and number of bulbs + bulblets/ plant or bulbs diameter, respectively, compared with the lower concentration (1000 ppm), in both seasons, with one exception the highest number of bulbs+ bulblets/ plant in the second season was associated with Zn application at 1000 ppm. This results are not in harmony with those reported by Yadav *et al.* (2002), who reported that tuberose bulbs production was not affected by Zn application.

Table (5): Effect of K as soil application and foliar application of Zn on bulbs production of *Polianthus tuberosa* L. plants during the two successive seasons 2001/2002 and 2002/2003.

Character		Plant height (cm)			Leaf length (cm)			Fresh weight of leaves/clumb		
Treatment		Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean
2001/2002										
K	0.0	30.84	38.17	34.51	451.11	392.22	218.67	3.15	3.07	3.11
	5	33.59	45.25	39.42	395.00	305.55	350.28	3.22	3.90	3.56
	10	37.84	41.00	39.42	265.00	544.11	404.56	3.42	3.81	3.62
	20	45.70	38.61	42.16	40.00	555.56	497.78	4.02	3.55	3.79
Mean		36.99	40.76		687.78	49.36		3.45	3.58	
L.S.D. 5%										
K		5.84			75.60			N.S.		
Zn		N.S.			N.S.			N.S.		
K+Zn		N.S.			153.25			0.56		
2002/2003										
K	0.0	35.00	46.00	40.50	255.00	302.33	278.67	3.62	3.60	3.40
	5	37.33	46.17	41.75	373.75	407.50	390.63	3.76	3.53	3.65
	10	38.17	51.75	44.96	428.75	380.84	404.80	3.51	3.92	3.72
	20	45.00	54.33	49.67	387.92	430.00	408.96	3.58	3.92	3.75
Mean		0.77	45.90		379.90	433.44		3.78	3.56	
L.S.D. 5%										
K		9.46			80.61			N.S.		
Zn		4.81			N.S.			N.S.		
K+Zn		11.65			145.96			N.S.		

Regarding the influence of the interacting effect of K levels with Zn at any concentration used in the study on bulbs production, data revealed that the results varied between the two seasons and clearly indicated that, fertilization with 5 or 20 g potassium sulphate/ plant with Zn at 2000 ppm resulted in the best value of number of bulbs+ bulblets/ plant at the respective seasons. While treated the plants with 20 g K/ plant combined with Zn at 2000 ppm affected significantly and promoted the highest records of fresh weight of bulbs+ bulblets/ plant, in both seasons. On the other hand, treated the plants with 20 g K/ plant in combination with Zn at 1000 or 2000 ppm increased bulbs diameter at the two respective seasons.

5-Leaves chemical composition:

Data presented in Table (6) showed that, increasing K rate from 5 to 20 g potassium/ plant increased, significantly, chlorophyll a+ b and total carotenoides, as well as, N, P and K percentages in leaves compared with untreated plants. This trend was similar in both seasons. The detected positive effects of potassium fertilizer on biochemical constituents might be related to the well known role of K on improving photosynthetic activities and enhancing the translocation of carbohydrates to different plant organs (Bidwell, 1979).

Table (6): Effect of K as soil application and foliar spray of Zn on leaves chemical composition of *Polianthus tuberosa L.* plants during the two successive seasons 2001/2002 and 2002/2003.

Character	Chlorophyll (a+b) (mg/g)			Total carbohydrates (mg/g)			N %			P %			K %		
Treatments	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean
K level	2001/2002														
0.0	7.00	8.51	7.76	1.01	1.03	1.02	1.60	1.70	1.65	0.47	0.57	0.52	0.71	0.97	0.84
5	7.45	9.48	8.47	1.09	1.24	1.17	1.64	1.68	1.66	0.60	0.60	0.60	0.85	1.02	0.94
10	8.62	10.31	9.47	1.13	1.10	1.12	1.63	1.69	1.66	0.70	0.74	0.72	0.95	1.06	1.01
20	11.34	11.94	11.6	1.26	1.51	1.39	1.65	1.71	1.68	0.82	0.89	0.86	0.95	1.07	1.01
Mean	8.60	10.06		1.12	1.22		1.63	1.70		0.65	0.70		0.87	1.03	
L.S.D.5%															
K	0.67			0.08			0.01			0.05			0.07		
Zn	0.27			0.04			0.02			0.02			0.03		
K x Zn	0.55			0.07			0.03			0.04			0.06		
	2002/2003														
0.0	3.35	6.73	5.04	1.05	1.07	1.06	1.64	1.68	1.66	0.40	0.52	0.46	0.97	0.95	0.96
5	5.85	7.24	6.55	1.11	1.13	1.12	1.63	1.71	1.67	0.1	0.59	0.50	0.99	1.11	1.05
10	6.21	8.12	7.17	1.22	1.55	1.39	1.66	1.72	1.69	0.86	0.71	0.70	1.10	1.20	1.15
20	6.35	9.46	7.91	1.36	1.63	1.50	1.65	1.73	1.69	0.77	0.86	0.82	1.20	1.1	1.31
Mean	5.44	7.89		1.19	1.35		1.65	1.71		0.57	0.67		1.07	1.17	
L.S.D.5%															
K	0.44			0.09			0.02			0 04			0.08		
Zn	0.20			0.04			0.02			0.02			0.03		
K x Zn	0.41			0.41			0.03			0.03			0.07		

K: Potassium Zn 1: 1000 ppm Zn 2: 2000 ppm

Table (7): Effect of K as soil application and foliar spray of Zn on bulbs chemical composition of *Polianthus tuberosa* L. plants during the two successive seasons 2001/2002 and 2002/2003.

Character	N %			P %			K %			Zn (ppm)			Mn (ppm)		
Treat-ments	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean	Zn 1	Zn 2	Mean
K level	2001/2002														
0.0	0.12	0.16	0.14	0.29	0.24	0.27	0.35	0.33	0.34	47.70	47.60	47.65	54.60	56.40	55.50
5	0.14	0.18	0.16	0.33	0.28	0.31	0.37	0.42	0.40	51.30	53.50	52.40	60.30	62.60	61.45
10	0.15	0.19	0.17	0.42	0.32	0.37	0.39	0.44	0.42	61.60	55.90	58.75	72.30	73.30	72.80
20	0.17	0.19	0.18	0.47	0.36	0.42	0.42	0.46	0.44	66.60	62.50	64.55	75.30	80.30	77.80
Mean	0.15	0.18		0.38	0.30		0.38	0.41		56.80	54.88		65.63	68.15	
L.S.D.5%															
K	0.02			0.03			0.03			4.05			4.82		
Zn	0.01			0.01			0.01			1.68			1.95		
K x Zn	0.03			0.02			0.03			3.36			3.89		
	2002/2003														
0.0	0.13	0.17	0.15	0.26	0.25	0.26	0.36	0.43	0.40	41.30	41.60	41.45	53.00	53.50	53.25
5	0.14	0.18	0.16	0.28	0.29	0.29	0.37	0.46	0.42	44.60	45.90	45.25	58.50	68.60	63.55
10	0.15	0.19	0.17	0.33	0.31	0.32	0.37	0.49	0.43	48.60	47.60	48.10	72.50	75.00	73.75
20	0.14	0.20	0.17	0.36	0.32	0.34	0.44	0.49	0.47	55.00	50.10	52.55	78.50	80.50	79.50
Mean	0.14	0.19		0.31	0.29		0.39	0.47		47.38	46.30		65.63	69.40	
L.S.D.5%															
K	0.01			0.02			0.03			3.40			4.79		
Zn	0.02			N.S.			0.01			N.S.			2.03		
K x Zn	0.02			0.02			0.03			2.91			4.07		

K: Potassium Zn 1: 1000 ppm Zn 2: 2000 ppm

Regarding the effect of foliar spray on Zn on tuberose plant, data in Table (6) show that, Zn at 2000 ppm concentration affected significantly chlorophyll (a+ b), total carotenoides, and N, P and K percentages, in the two growing seasons. These results may be attributed to the basic role of zinc in the different metabolic activities in different plant species (Price *et al.*, 1972). These results are in harmony with findings of El-Deeb (1999) on *Philodendron scandens* and Selim *et al.* (2001) on *Calendula officinalis* who mentioned that, Zn increased chlorophyll (a and b) and total carotenoides.

The interaction between K-fertilization and Zn as tabulated in Table (6) exhibit that, the combination of 20 g potassium sulphate/ plant with Zn at 2000 ppm was the most beneficial treatment which gave significantly the highest means of chlorophyll (a+ b) and total carotenoides, as well as, N, P and K percentages in leaves in both seasons.

6-Bulbs chemical composition:

Results of Table (7) indicated that fertilization of tuberose plants with K at the rates used in the study was accompanied with a significant increase in N, P, K, Zn and Mn contents in bulbs compared with untreated plants, in the two growing seasons.

Concerning the effect of foliar spray with Zn, data in Table (7) revealed that Zn at 200 ppm concentration increased significantly each of N, K and Mn contents, while, decreased P and Zn in bulbs, in both seasons.

The interaction effects between K and Zn rates on bulbs macro and micronutrients contents of mineral elements in tuberose plants in both seasons, the results showed that the interaction between K at 20 g/ plant and Zn at 2000 or 1000 ppm increased, significantly, bulbs contents of N, K and Mn or P and Zn, respectively.

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تأثير التسميد الأرضى بالبوتاسيوم والرش بالزنك والتفاعل بينهما على النمو والتزهير ومحصول الأبصال والمحتوى الكيماوى لنباتات التيبوروز

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أجريت هذه الدراسة في مزرعة التجارب بكلية الزراعة بالفيوم -جامعة الفيوم لدراسة تأثير مستويات مختلفة من البوتاسيوم صفر، ٥، ١٠ ،٢٠ جرام سلفات بوتاسيوم/ نبات مع الرش بالزنك بتركيزات ١٠٠٠ ،٢٠٠٠ جزء في المليون على النمو الخضري والازهار والأبصال والتركيب الكيماوي لنبات التيبوروز *Polianthes tuberosa* خلال موسمين متتاليين ٢٠٠١ /٢٠٠٢، ٢٠٠٢ /٢٠٠٣ وقد تم التوصل الي النتائج التالية:-

باستبعاد تأثير الزنك وجد أنه فى كلا الموسمين المعاملة بأى تركيز من سلفات البوتاسيوم أدت الى زيادة صفات النمو الخضرى (ارتفاع النبات- طول الأوراق- الوزن الطازج للأوراق/ نبات) وكذلك زيادة جميع قياسات النمو الزهرى (الصيفى والخريفى) وهى طول الحامل الزهرى- الوزن الطازج للنورة- عدد الأزهار على النورة ومحصول الأزهار كما أدى الى زيادة عدد الأيام حتى ظهور الأزهار فى الازهار الصيفى. كما أوضحت النتائج أن معاملة النباتات بالبوتاسيوم بمعدل ٢٠ جرام سلفات بوتاسيوم/ نبات أدى الى زيادة

نمو الأبصال زيادة معنوية (الوزن الطازج وعدد الأبصال والبصيلات/ نبات وقطر البصلة). كما أدت المعاملة بنفس المعدل من سلفات البوتاسيوم الى زيادة كل من الكلوروفيل (أ+ب) والكاروتينات فى الأوراق وكذلك زيادة محتوى كل من الأوراق والأبصال من النيتروجين والفوسفور والبوتاسيوم وكذلك زيادة الزنك والمنجنيز فى الأبصال.

بالنسبة للرش بالزنك وجد أن رش النباتات بالزنك بتركيز ٢٠٠٠ جزء فى المليون فى كلا الموسمين أدى الى زيادة غير معنوية (غالبا) لجميع صفات النمو الخضرى والزهرى (الصيفى والخريفى) وانتاج الأبصال بالاضافة الى التركيب الكيماوى للأوراق والأبصال- ولكن أدى الي نقص محتوى الأبصال من الفوسفور والزنك فى كلا الموسمين- ونقص عدد الأبصال والبصيلات/نبات فى الموسم الثانى.

بالنسبة للتداخل بين تأثير النيتروجين والزنك فقد أوضحت النتائج أن تأثير هذا التداخل اختلف بين قياسات كل من النمو الخضرى والزهرى وانتاج الأبصال والتركيب الكيماوى للأبصال والأوراق وكذلك اختلف بين الموسمين.