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Gibberellic Acid Usage Relieving Salinity Adverse Effects on Growth, Flowering and Bulb Production of Tuberose Plants (*Polianthes tuberosa*, L.)

Hassan, A. A.[1*] and M. M. Abd El-Azeim[2]

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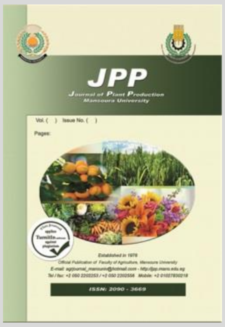
[1]Horticultural science Department, Faculty of Agriculture, Minia University, Egypt.
[2]Soil Science Department, Faculty of Agriculture, Minia University, Egypt.



ABSTRACT

The current research was carried out during two successive seasons of 2017 and 2018 at the Nursery of Ornamental plants, Fac. of Agric., Minia University, to explore alleviating side effects of soil salinity on growth, flowering and bulb production of tuberose plants by usage of gibberellic acid (GA_3). Different vegetative growth traits, flowering parameters and bulb production aspects were greatly and gradually reduced parallel to the increase in soil salinity level with the least values being given due to highest salinity level. In addition, flowering date was delayed due to salinity treatments. By contrast, all these traits were enhanced upward according to the increase in GA_3 (50 or 100 ppm) concentration including earlier flowering. It could be concluded that, the counteraction between GA_3 and salinity, for bulb production traits was significant in both seasons. The combined treatment of high salinized/high GA_3 was capable of giving similar to those given by the un-salinized/un-gibberellin treatment. The role of GA_3, when applied at 100 ppm to highly salinized soils (1.2%), in enhancing number, fresh weight and dry weight of daughter bulbs give rise to increases of 71.3, 40.8 and 37.8% in the first season and 66.7, 48.7 and 56.0%, in the second season, respectively. Therefore, tuberose plants could be produced, under salt affected soils, by the use of GA_3 which counteracted hindered effects of salinity on plant growth and flowering. The application of such growth regulator resulted in growth, flowering and bulb productivity values nearly equalized those given by control treatments.

Keywords: Gibberellic acid, Tuberose, Bulb production, Soil salinity.

INTRODUCTION

Tuberose (*Polianthes tuberosa*, L.) is known to be one of the most popular summer flowering bulbs that produces delightful, showy and fragrant flowers during summer and autumn months. Tuberose is an excellent cut flower plant and commonly grown in parks and gardens as a graceful and attractive plant for decorative and landscaping uses. Mo-reover, flowers are good sours of valuable aromatic volatile oil.

Soil salinity becomes a major problem in various widespread areas of the cultivated land in Egypt. One of the approaches to utilize such salt affected soil and enable it to reach the productive level, however, is the use of some growth regulating substances such as gibberellic acid which known to have the capability of alleviating, counteracting or overcoming the impaired effects of salinity on plant growth and development. Besides, GA_3 has desirable effects on growth, flowering and bulb production of many flowering bulb plants Starck and Kosinska (1980). In Egypt, Anthropogenic activities, intensive irrigation with saline water, extreme use of inorganic and organic fertilizers and quick urbanization are the major sources of soil salinity and salts impacts on plant production are consequently of major national concerns Abd El-Azeim *et al*. (2016). Soil texture type signifies one of the most important soil edaphic features that effect the spreading of organic matter in soils and eventually play a critical role in solubility, bioavailability and retention of salts in a soil ecosystem Abd El-Azeim *et al.* (2016).

A good number of authors reported the harmful effects of salinity on different flowering bulb in terms of vegetative growth characters, flowering parameters and/or bulb productivity. Examples are Mousa and Lakany (1983) on Narcissus, Sonneveld and Voogt (1983) on Amaryllis, Badran *et al.* (1984) on *Tropaeolum majus*, Milina and Khader (1989) on tuberose, Meawad (1991) on Gladiolus, Badran *et al*. (2006) on jojoba, Elhindi (2012) and Mazhar *et al*. (2012) on Chrysanthemum, Abdel-Maksoud *et al*. (2014) on daisy and Nofal *et al*. (2015) and Mahmoud (2016) on marigold. Meanwhile, other researchers revealed the enhancing influence of gibberellic acid on various flowering bulbs such as Dahlia (Singh *et al*., 1994; Gomaa, 2003 and Youssef and Gomaa, 2008); Lilium (Jungil and Moonsoo, 1997); Iris (Abou-Taleb and Kandeel, 2001 and Atta-Alla and Zaghloul, 2002); Tuberose (Auda *et al*., 2002); Strelitzia (Youssef, 2004); Narcissus (Gommaa *et al*., 2005); Hemerocallis (Ismaeil and Youssef, 2008) and Tulip (Rajaei and Onsinegad, 2014).

The salinization of soil and water in Egypt is a substantial constraint for crop productivity. It is well documented that spread of salt-affected soils in arid and semiarid regions of the world and the amount and quality of irrigation water available are the main limiting factors to the extension of agriculture (Haddad *et al*., 2019). The scarcity of fresh water resources in Egypt led to the use of saline

*** Corresponding author.**
E-mail address: ahmed_hassan@mu.edu.eg
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water for irrigation, which led to adverse effects on soil properties and salinity levels, plant growth, and crop yield and quality. There are different managements for alleviating soil salinity deleterious effects on plant growth and crop yield. Based on the previous facts, the current study aims to investigate alleviating adverse effects of soil salinity levels on the growth and flowers quality parameters of tuberose using different levels of gibberellic acid (GA_3).

MATERIALS AND METHODS

1 Experimental Design.

Experiments were conducted throughout two consecutive seasons of 2017 and 2018 at the experimental farm, faculty of Agriculture, Mina University, in order to explore effects of four soil salinity levels (0.0, 0.4, 0.8 and 1.2% of NaCl + $CaCl_2$) (1:1) and three gibberellic acid concentrations (0, 50 and 100ppm), as well as, their interaction on growth, flowering and bulb productivity on tuberose (*Polianthes tuberosa*, L. cv.) plants.

The experiment design was arranged in complete randomized blocks (in split-plot design), with four replicates and five plants/replicate, where soil salinity treatments presented the main plots and GA_3 concentrations devoted to the sub-plots. New pots of 25 cm diameter were filled with 6.6 kg clay loamy soil for each pot after mixing such amount of soil with assigned amounts of NaCl + $CaCl_2$ at the rate of 0.0, 0.4, 0.8 and 1.2% as salinity treatments.

2 Soil sample analyses

The soil was selected as its variety of physicochemical and biochemical properties (Table 1) representing typical alluvial soils prevailing in Egypt.

Table 1. Some soil physiochemical properties of the investigated soil.

Soil chemical properties		Value	Soil physical properties	Value
pH (1:2.5 water)		7.7	F.C. %	42.45
$CaCO_3$ (g kg^{-1})		17.9	PWP %	13.78
CEC ($cmol_c$ kg^{-1})		37.87	WHC %	48.76
EC (dS m^{-1} at 25 ^{0}C)		1.35	A. V. (F.C. – PWP) %	28.67
OM (g kg^{-1})		28.61	A. V. (WHC-PWP) %	34.98
Total N (g kg^{-1})		1.29	Bulk density (BD) g/cm^3	1.31
Total C/N ratio		14.14	Particle density (PD) g/cm^3	2.22
SOC (g kg^{-1})		18.48	Sand %	28.9
Organic N (g kg^{-1})		0.76	Silt %	32.8
Organic C/N ratio		24.31	Clay %	38.3
Mineral N (mg kg^{-1})		58.46	Soil texture	Clay loamy
Total P (g kg^{-1})		0.56		
Available P (mg kg^{-1})		13.11		
Total K (g kg^{-1})		4.37		
Exch. K^+ (mg/100 gm soil)		2.85		
Exch. Ca^{++} (mg/100 gm soil)		31.12		
Exch. Mg^{++} (mg/100 gm soil)		8.77		
Exch. Na^+ (mg/100 gm soil)		2.52		
DTPA Ext. (mg kg^{-1})	Fe	8.23		
	Cu	2.01		
	Zn	2.87		
	Mn	8.11		

Previous to the start of the experiment, the soil was air dried, sieved to < 2.0 mm, and moisture availability was adjusted at 65 % of the soil field capacity using deionized water before the addition of NaCl + $CaCl_2$. Sub-samples of the prepared soils were used to determine soil physical and chemical properties using standard methods (Page *et al*., 1982); and Methods of soil analysis (Jackson, 1975).

3 Experimental Procedures.

Tuberose bulbs with average diameter of 2.3 cm were planted on May 14th for both seasons (one bulb/pot) according to the four assigned salinity treatments. Gibberellic acid was foliar sprayed at three concentrations of 0, 50 and 100 ppm three times starting June 14th for both seasons with three-week intervals.

All plants, including control ones, were fertilized with 4.5 gm ammonium nitrate (33.5% N); 3 gm triple superphosphate (45.5% P_2O_5) and 3 gm potassium sulphate (48% K_2O) per each pot. These amounts of fertilizers were divided to three equal batches and added on June 20th, July 20th and Oct. 20th. Data were recorded for number and fresh and dry weights of leaves/plant, flowering date (from planting date till the opening of the first flower), number and fresh and dry weights of flowers/plant, stalk length, diameter and fresh weight. While number and fresh and dry weights of daughter bulbs were dig out on the third week of Dec. for both seasons. Obtained data were statistically analyzed using analysis of variance and least significant difference (LSD) at the probability level of 5% according to MSTAT-C (1986).

RESULTS AND DISCUSSION

1 Understanding soil salinization process and data of the investigated soil.

In the present study, the investigated clay loam soil displayed a wide range of physicochemical properties dominated in alluvial agricultural soils in Egypt as described in Table 1. The investigated soil was comprised of almost equal amounts of sand (28.9%), silt (32.8%) and clay (38.3%). These components are important adsorption media for salts in soils. The clay soil retains high amount of salts when compared to sandy soil. Also, investigated soil reflected a wide range of soil chemical properties, for example, 7.7 for pH, 28.61 g kg^{-1} OM, 18.48 g kg^{-1} OC, 17.9 g kg^{-1} $CaCO_3$ and CEC 37.87 $cmol_{(+)}$ kg^{-1}. Before soil treatment with NaCl + $CaCl_2$ salts, the soil native value of EC was 1.35 dS m^{-1}, a ratio among the world-wide permissible range of salts in soils and lower than the critical value (> 4 dS m^{-1} at 25 ^{0}C) reported in the literature for saline soils. High concentrations of salts and higher values of EC (4.5 dS m^{-1}) were observed in treated soils with NaCl + $CaCl_2$ salts at the highest rate of 1.2%, while the lowest levels of EC (2.6 dS m^{-1}) were detected in agricultural treated soils with lower rate of salts (0.4% of NaCl + $CaCl_2$, 1:1) which is still under soil salinity level.

The role of gibberellic acid in alleviating soil salinity deleterious effects on different vegetative growth characters, flowering aspects and bulb productivity could be discussed under the following headings:

2 Vegetative Growth Characters:

Vegetative growth characters, namely, leaves number, fresh weight and dry weight/plant were greatly reduced in both seasons due to soil salinity levels in comparison with un-salinized control plants, (Table 2). The reduction in these vegetative characters were gradual and parallel to the gradual increase in salinity level with the least values being obtained due to the high salinity level (1.2 %).

This treatment gave, significantly, the lowest values than zero, 0.4 and 0.8% salinity treatments. The numerical reduction due to this treatment in comparison with control treatment reached 24.0, 38.9 and 38.8% for leaves number, fresh weight and dry weight/plant, respectively, in first season. The corresponding reductions in second season came to 21.3, 39.4 and 40.3% respectively. The harmful effects of salinity on vegetative growth as indicated in the present experiment were also insured by Mousa and Lakany (1983) on Narcissus; Badran *et al*. (1984) on *Tropaeolum majus*; Meawad (1991) on Gladiolus; Badran *et al*. (2006) on jojoba; Mazhar *et al*. (2012) and Elhindi (2012) Chrysanthemum; Abdel-Maksoud *et al*. (2014) on daisy and Mahmoud (2016) on marigold.

Concerning gibberellic acid, such growth regulator, when applied at low or high concentrations (50 or 100 ppm), resulted in significant promotion in leaves number and fresh and dry weights/plant, in both seasons, over those obtained from untreated control plants as shown in Table (2). Also, significant increases were existed between low and high GA_3 concentrations in favor of high one. Leaves number, fresh weight and dry weight per tuberose plant were increased by 37.3, 89.3 and 107.9%, respectively due to high GA_3 concentration in comparison with the control in first season with the same trend being observed in second season. The role of GA_3 in augmenting vegetative growth was reported by Singh *et al*. (1994) and Youssef and Gomaa (2008) on Dahlia; Jungil and Moonsoo (1997) on Lilium; Abou-Taleb and Kandeel (2001) on Iris; Auda *et al*. (2002) on tuberose; Youssef (2004) on Strelitzia and Ismail and Youssef (2008) on Hemerocallis.

Table 2. Effect of soil salinity and GA_3 on vegetative growth characters of tuberose during both 2017 and 2018 seasons.

Salinity levels % A	GA_3 concentration ppm B							
	1st season (2017)				2nd season (2018)			
	Number of leaves/plant							
	0	50	100	Mean A	0	50	100	Mean B
Control	15.4	18.5	21.0	18.3	17.6	19.2	22.4	19.7
0.4	14.9	17.0	19.1	17.0	16.7	18.2	20.3	18.4
0.8	13.9	16.0	18.0	16.0	15.8	17.1	19.2	17.4
1.2	10.6	14.1	16.9	13.9	13.4	15.1	17.9	15.5
Mean B	13.7	16.4	18.8		15.9	17.4	20.0	
LSD 5 %	A 1.4 B 1.1 AB 2.2				A 1.3 B 1.2 AB 2.4			
Leaves fresh weight/plant (g)								
	0	50	100	Mean A	0	50	100	Mean B
Control	30.9	40.9	56.8	42.9	38.5	45.6	66.7	50.3
0.4	25.6	36.3	49.1	37.0	32.7	41.4	55.8	43.3
0.8	22.5	29.9	42.4	31.6	29.3	33.1	46.2	36.2
1.2	18.2	24.7	35.6	26.2	23.2	28.1	40.3	30.5
Mean B	24.3	33.0	46.0		30.9	37.1	52.3	
LSD 5 %	A 2.8 B 2.5 AB 5.0				A 3.1 B 3.0 AB 6.0			
Leaves dry weight/plant (g)								
	0	50	100	Mean A	0	50	100	Mean B
Control	2.97	4.14	5.58	4.32	3.72	4.62	6.84	5.06
0.4	2.37	3.67	5.06	3.70	3.08	4.20	5.77	4.35
0.8	2.02	3.03	4.39	3.15	2.67	3.37	4.78	3.61
1.2	1.74	2.52	3.67	2.64	2.04	2.84	4.18	3.02
Mean B	2.28	3.34	4.74		2.88	3.76	5.39	
LSD 5 %	A 0.31 B 0.27 AB 0.55				A 0.35 B 0.33 AB 0.67			

The interaction between salinity levels and gibberellic acid concentrations was significant, in both seasons, for the three studied vegetative growth characters. These traits, when tuberose plants were grown at salinity level up to 12000 ppm and received GA_3 spray at 100 ppm, were statistically equal to those of control plant as clearly illustrated in Table (2)

3 Flowering Parameters:

Flowering date was gradually delayed parallel to the gradual increase in salinity level with significant differences between the three salinity levels on one hand and control treatment on the other hand in both seasons. Moreover, the high salinity level (1.2%) resulted, significantly, in the latest flowering date in comparison with the medium and low salinity levels, (0.8 and 0.4%), as shown in Table (3). Flowering date was delayed by 35.8 days in the first season and 34.2 days in the second season due to the high salinity level in comparison with control treatment. In accordance with these results were those given by Milina and Khader (1989) on tuberose; Meawad (1991) on Gladiolus and Nofal *et al*. (2015) and Mahmoud (2016) on marigold.

In contrast with salinity, gibberellic acid caused earlier flowering date, when applied at 50 or 100 ppm, than control plants. Significant differences were obtained, in both seasons, each of the three GA_3 concentrations, 0, 50 and 100 ppm as shown in Table (3). The low and high GA_3 concentrations caused earlier flowers than the control plants by 9.5 and 20.9 days in the first season and by 8.8 and 20.7 days in the second one, Table (3). The role of GA_3 in producing early flowers was illustrated by Abou-Taleb and Kandeel (2001) and Atta-Alla and Zaghloul (2002) on Iris; Gomaa (2003) on Dahlia; Ismaeil and Youssef (2008) on Hemerocallis and Rajaei and Onsinegad (2004) on tulip.

Significant differences were obtained due to the interaction between salinity and GA_3 treatments in both seasons. The latest flowering date (137.3 and 134.2 for both seasons) were due to the high salinity level/zero GA_3, while the earlier date (78.2 and 76.8) were due to zero salinity/100 GA_3 as indicated in Table (3).

It was amazing to observe the possibility of obtaining early flowers of tuberose plants, gown in high soil salinity (1.2 %) with the supplement of 100 ppm GA_3, similar to those of control plants (un-salinized/un-gibberellin) as shown in Table (3).

Table 3. Effect of soil salinity and GA_3 on flowering parameters of tuberose during both 2017 and 2018 seasons.

Salinity levels % A	GA_3 concentration ppm B							
	1st season (2017)				2nd season (2018)			
	Flowering date (day)							
	0	**50**	**100**	**Mean A**	**0**	**50**	**100**	**Mean B**
Control	92.0	81.8	78.2	84.0	89.5	80.1	76.8	82.1
0.4	98.7	91.8	84.8	91.8	96.5	91.1	82.5	90.0
0.8	105.6	97.4	89.4	97.5	102.6	95.1	87.2	95.0
1.2	137.3	124.6	97.6	119.8	134.2	121.3	93.3	116.3
Mean B	108.4	98.9	87.5		105.7	96.9	85.0	
LSD 5 %	A 6.2 B 5.7 AB 11.4				A 7.0 B 6.4 AB 12.8			
Flowering stalk length (cm)								
	0	50	100	Mean A	0	50	100	Mean B
Control	52.0	55.2	67.5	58.2	53.1	57.8	69.7	60.2
0.4	48.9	50.9	64.3	54.7	52.1	54.3	66.9	57.8
0.8	41.7	43.1	55.9	46.9	44.2	45.3	59.1	49.5
1.2	36.6	38.7	46.1	40.5	40.1	41.3	48.7	43.4
Mean B	44.8	47.0	58.5		47.4	49.7	61.1	
LSD 5 %	A 3.1 B 3.7 AB 7.4				A 2.4 B 3.4 AB 6.8			
Flowering stalk diameter (mm)								
	0	50	100	Mean A	0	50	100	Mean B
Control	6.01	5.84	5.62	5.82	6.33	6.16	5.71	6.07
0.4	5.13	5.04	4.90	5.03	6.04	5.90	5.61	5.85
0.8	4.80	4.67	4.55	4.67	5.71	5.52	5.33	5.52
1.2	4.52	4.32	4.12	4.32	5.31	5.24	5.06	5.20
Mean B	5.12	4.97	4.80		5.85	5.71	5.43	
LSD 5 %	A 0.34 B N.S. AB N.S.				A 0.22 B N.S. AB N.S.			

In regard to the other flowering parameters, namely, flowering stalk length, diameter and fresh weight and number and fresh weight of flowers per plant, they were significantly decreased in both seasons due to the three used salinity levels 0.4, 0.8 and 1.2%, in comparison to control. Among these three salinity levels, the high one (1.2%) caused, significantly over the lower ones, the highest reduction in the five flowering parameters in both seasons as clearly shown in Tables (3 and 4). The reduction in these flowering parameters due to the high salinity level (1.2%) was drastic as it reached 30.4, 25.9, 48.2, 36.6 and 44.4% for flowering stalk length, diameter and fresh weight and flower number and fresh weight/plant, respectively.

In comparison with those of control plants in first season was almost similar trend in the second season, Tables (3 and 4). These results were in harmony with the findings reported by Mousa and Lakany (1983) on Narcissus; Sonneveld and Voogt (1983) on Amaryllis; Badran *et al*. (1984) on *Tropaeolum majus*; Milina and Khader (1989) on tuberose; Meawad (1991) on Gladiolus; Mazhar *et al*. (2012) on Chrysanthemum; Abdel-Maksoud *et al*. (2014) on daisy and Nofal *et al*. (2015) on marigold.

In relation to gibberellic acid treatments, each of flowering stalk length and fresh weight, as well as, number and fresh weight of flowers/plant were greatly augmented, in both seasons, due to the application of GA_3 at 50 or 100 ppm over those of control plants. The high GA_3 concentration resulted, significantly, in taller and heavier flowering stalk and more number and heavier flowers/plant than those given by the low concentration in both seasons. The values given by the high GA_3 concentration recorded more than 20 % over those of low concentration in both seasons, Tables (3 and 4).

However, flowering stalk diameter was not significantly influenced by GA_3 treatments. The capability of GA_3 of promoting different flowering parameters was detected on Dahlia (Singh *et al*., 1994 and Gomaa, 2003); Lilium (Jungil and Moonsoo, 1997); Iris (Atta-Alla and Zaghloul, 2002); Strelitzia Narcissus (Gommaa *et al*., 2005) and tulip (Rajaei and Onsinegad, 2014).

The interaction between salinity levels and GA_3 concentration was significant, in both seasons, for flowering stalk length and fresh weight and flowers number and fresh weight/plant as shown in Tables (3 and 4). It was interesting to find out that the obtained values of the treatment of high salinity (1.2%) in combination with high GA_3 (100 ppm), for the four flowering parameters were not significantly differed than those of the control treatment (un-salinize/un-gibberellic) in the two seasons, Tables (3and4).

4 Bulb Production:

All of three bulb production traits, number, fresh weight and dry weight of daughter bulbs/plant, were considerably decreased due to the three salinity levels, such reduction was gradual and parallel to the gradual increase in salinity level in both seasons. The high salinity level, 1.2%, give, significantly, the lowest values for the three traits, in comparison with the medium (0.8%), low (0.4%) and control (0.0%) salinity levels in the two seasons as show in

Table (5). Numerically, the reduction in number, fresh weight and dry weight of daughter bulbs / plant due to the high salinity level, in comparison with control treatment recorded 36.9, 32.6 and 31.3% in the first season and 35.4, 33.8 and 29.8% in the second season. In close agreement with these results were the findings of Mousa and Lakany (1983), Milina and Khader (1989) and Meawad (1991) on Narcissus, tuberose and Gladiolus respectively.

Table 4. Effect of soil salinity and GA_3 on flowering parameters of tuberose during both 2017 and 2018 seasons.

Salinity levels % A	GA3 concentration ppm B							
	1st season (2017)				2nd season (2018)			
	Fresh weight of stalk plus flowers (g)							
	0	50	100	Mean A	0	50	100	Mean B
Control	42.4	55.0	70.1	55.8	43.6	60.0	76.4	60.0
0.4	34.5	46.4	60.6	47.2	37.7	54.8	65.2	52.6
0.8	27.5	39.6	51.4	39.5	30.4	46.3	57.6	44.8
1.2	18.3	29.8	38.6	28.9	19.2	32.2	44.8	30.7
Mean B	30.7	42.7	55.2		32.7	48.3	60.3	
LSD 5 %	A 3.8	B 3.2	AB 6.4		A 3.4	B 4.1	AB 8.2	
Number of flowers/stalks								
	0	50	100	Mean A	0	50	100	Mean B
Control	12.0	14.8	19.2	15.3	13.5	17.4	22.4	17.8
0.4	11.2	12.7	17.0	13.6	12.7	15.2	19.9	15.9
0.8	10.4	11.1	15.1	12.2	11.9	13.6	18.0	14.5
1.2	7.4	9.3	12.3	9.7	8.2	10.9	14.1	11.1
Mean B	10.3	12.0	15.9		11.6	14.3	18.6	
LSD 5 %	A 0.8	B 1.2	AB 2.4		A 0.6	B 0.9	AB 1.8	
Fresh weight of flowers/plant								
	0	50	100	Mean A	0	50	100	Mean B
Control	19.0	23.4	29.4	23.9	19.5	26.0	32.7	26.1
0.4	16.1	19.2	26.9	20.7	16.6	22.5	29.4	22.8
0.8	13.6	17.6	22.9	18.0	14.1	19.0	25.5	19.5
1.2	6.5	12.8	17.6	12.3	7.9	14.3	20.4	14.2
Mean B	13.8	18.3	24.2		14.5	20.5	27.0	
LSD 5 %	A 2.0	B 1.8	AB 3.7		A 2.2	B 2.1	AB 4.2	

Table 5. Effect of soil salinity and GA_3 on blub production of tuberose during both 2017 and 2018 seasons.

Salinity levels % A	GA3 concentration ppm B							
	1st season (2017)				2nd season (2018)			
	Number of daughter bulbs/plant							
	0	50	100	Mean A	0	50	100	Mean B
Control	5.44	9.56	11.65	8.88	6.02	10.01	11.87	9.30
0.4	5.02	9.04	11.07	8.38	5.31	9.62	11.52	8.81
0.8	4.88	7.81	8.51	7.07	5.12	8.12	9.37	7.54
1.2	3.94	6.11	6.75	5.60	4.31	6.53	7.18	6.01
Mean B	4.82	8.13	9.50		5.19	8.57	9.99	
LSD 5 %	A 0.54	B 0.64	AB 1.28		A 0.48	B 0.60	AB 1.20	
Fresh weight of daughter bulbs/plant (g)								
	0	50	100	Mean A	0	50	100	Mean B
Control	19.7	28.3	31.1	26.4	21.9	31.1	34.9	29.3
0.4	17.9	26.7	28.6	24.4	19.8	30.3	33.3	27.8
0.8	16.7	22.5	23.5	20.9	18.3	26.5	28.5	24.4
1.2	14.3	18.8	20.1	17.7	15.0	20.9	22.3	19.4
Mean B	17.2	24.1	25.8		18.8	27.2	29.8	
LSD 5 %	A 1.2	B 1.4	AB 2.8		A 1.5	B 1.8	AB 3.6	
Dry weigh of daughter bulbs/plant (g)								
	0	50	100	Mean A	0	50	100	Mean B
Control	12.4	16.9	18.6	16.0	13.4	18.2	19.7	17.1
0.4	11.5	15.8	17.7	15.0	12.3	17.6	19.2	16.4
0.8	10.8	13.2	14.8	12.9	11.3	15.9	17.7	14.8
1.2	9.0	11.7	12.4	11.0	9.1	12.6	14.2	12.0
Mean B	10.9	14.4	15.9		11.5	16.1	17.6	
LSD 5 %	A 0.8	B 1.3	AB 2.7		A 1.2	B 1.4	AB 2.8	

Significant differences were obtained due to the use of GA_3 at 50 or 100 ppm over control plants in both seasons in regard with number and fresh and dry weights of daughter bulbs/plant. in addition, the high concentration of GA_3 (100 ppm) was superior to the low one (50 ppm) as illustrated in Table (5).

The increase in number, fresh weight and dry weight of daughter bulbs/plant due to GA_3 treatments came, respectively, to more than 60%, 40% and 30% in the two seasons over those of control plants, Table (5). On the line with these results were those of Abou-Taleb and Kandeel (2001) and Atta-Alla and Zaghloul (2002) on Iris;

Auda *et al*. (2002) on tuberose; Gommaa *et al*. (2005) on Narcissus; Youssef and Gomaa (2008) on Dahlia and Rajaei and Onsinegad (2014) on tulip.

The interaction between salinity and GA_3, for the three bulb production traits was significant in both seasons. The combined treatment of high salinized/high GA_3 was capable of giving similar to those given by the un-salinized/un-gibberellin treatment, Table (5). The role of GA_3, when applied at 100 ppm to the high salinized plants (1.2%), in enhancing number, fresh weight and dry weight of daughter bulbs came to 71.3, 40.8 and 37.8% in the first season, respectively and 66.7, 48.7 and 56.0%, respectively, in the second season.

The adverse effects of salinity especially at higher levels on vegetative growth, flowering and bulb productivity of tuberose plants could be attributed to one or more of the upcoming reasons:

1- Inhibition of cell division and cell elongation.
2- Hormonal imbalance due to the reduction in the synthesis of growth regulators such as cytokinin's and gibberellins as a result of water stress caused by salinity.
3- Interfering with stomatal closure causing excessive water loss and leaf injury symptoms like those of drought.
4- Low rate of carbon fixation and less efficient in metabolizing the dry matter.
5- Obvious disruption in the components of the meristematic cells, i.e. mitochondria, nucleus, nucleolus, golgi and photosynthetic apparatus and reduction in chlorophyll content.
6- Inhibition of cambium activity and negative effect on water relations and/or nutritional status within plant.
7- Inhibition of N, P and K uptake and protein synthesis by plant.
8- Increasing the accumulation of sodium and calcium.
9- Reducing water uptake by plants in response to the reduction in osmotic potential of the root medium.

These reasons were specified also by many researchers for example, (Orazbaeva, 1978; Starck and Kozinska, 1980; Starck and Czajkowska, 1981; Awad *et al*., 1982; Dahiya and Dhankhar, 1984, El-Banna, 1985 and Abdel-Mageed *et al*., 2018).

The role of gibberellic acid in enhancing different vegetative growth characters, flowering aspects and bulb productivity could be attributed to its capacity in modifying the growth patterns of treated plants by affecting the DNA and RNA levels, biosynthesis of specific enzymes, proteins, carbohydrates and photosynthetic pigments. It was found also to induce cell division and cell enlargement in the growing tissues and growth centers, to increase cambial activity, to initiate root primordial and to be involved in apical dominance. In addition, GA_3 is known to act as a flower induction, thereby, its stimulative influence on flower production. Producing early flowering due to GA_3, as given in this study, might be due to its basic effect in improving vegetative growth which reflects in producing early flowering and better quantitative and qualitative flowering parameters, as well as, bulb production later on, (Leopold and Kriedmann, 1975; Louis, 1979 and Krishnamorthy, 1981).

In relation to the role of GA_3 in alleviating or counteracting the adverse effects of salinity, Starck and Czajkowska (1981) demonstrated that GA_3 stimulated K absorption in NaCl stressed plants, reduced Na absorption rate, doubled the K/Na ratio, prevented Na accumulation in shoot apex and leaf blades and improved P translocation to the youngest parts of the shoots. Moreover, Weier (1974) increased the role of GA_3 in stimulating cell division and expansion and promoting the synthesis of specific enzymes**.** Orazbaeva (1978) found that GA_3 overcome the reduction in protein synthesis induced by osmotic and salt stress and increased Co_2 assimilation and the translocation of labeled compounds. In addition, Starck and Kozinska (1980) stated the role of GA_3 in alleviating the inhibition of N, P and K uptake caused by salinity.

CONCLUSION

Tuberose vegetative growth, flowering and bulb production traits were greatly reduced in both seasons due to increased soil salinity levels in comparison with un-salinized control plants. The harmful effects of salinity on these traits were gradual and paralleled with the gradual increase in salinity level with the least values being obtained due to the high salinity level. By contrast, gibberellic acid as growth regulator, when applied at low or high concentrations (50 or 100 ppm), resulted in significant promotion in tuberose growth, flowering and bulb production traits in both seasons, compared to untreated control plants. The interaction between salinity levels and gibberellic acid concentrations was significant, in both seasons, for the studied vegetative growth, flowering and bulb production characters. Tuberose flowering date was gradually delayed and paralleled with the gradual increase in salinity level with significant differences between different salinity levels and control treatment in both seasons. In contrast with salinity, gibberellic acid caused earlier flowering date, when applied at 50 or 100 ppm, where significant differences were obtained over control plants.

Significant differences were obtained due to the use of GA_3 at 50 or 100 ppm over control plants in both seasons in regard with growth, flowering and bulb traits. in addition, the high concentration of GA_3 (100 ppm) was superior to the low one (50 ppm) as reflected on growth traits, flowering parameters and bulb production. The interaction between salinity and GA_3 at all application rates, for growth traits, flowering parameters and quality of bulb traits and production was significant in both seasons.

The combined treatment of high salinized/high GA_3 was capable of giving similar promotions to those given by the un-salinized/un-gibberellin treatment due to the role of GA_3 in enhancing growth parameters and consequently alleviating adverse effects of high salinity on flowering parameters and quality of bulb production.

REFERENCES

Abd El-Aziem MM, Mohamed WS, Hammam AA (2016). Soil Physiochemical Properties in Relation to Heavy Metals Status of Agricultural Soils in El-Minia Governorate, Egypt. J. soil Sci. and Agric. Eng., Mansoura Univ 7(6): 423-431.

Abdel-Mageed, Y. T., Hassan, H. A., Abdel-Rahim, A. F., Abd Al-Azeim, M. M. and Matouk, M. A. (2018): Evaluation of Groundwater Quality for Irrigation and its Effects on some Soil Chemical Properties in the Western Desert of El-Minia Governorate, Egypt

Abdel-Maksoud, B. A., El-Torky, M. G., Sewedan, E. A., Osman, A. R. and El-Kinany, R. G. (2014): Effect of proline or humic acid on vegetative and rooting growth and flowering characteristic of daisy (*Bellis perenis*, L.) under salinity stress.

Abou-Taleb, N. S. and Kandeel, A. M. (2001): Effect of fertilization level and GA_3 application on growth, flowering, bulb productivity and chemical composition of *Iris tingitana* cv. Wedgwood. Arab Univ. J. Agric. Sci., 9 (2): 803-824.

Atta-Alla, H. K. and Zaghloul, M. (2002): Effect of cold storage, GA_3 and fertilization on the growth, flowering and chemical composition of *Iris tingitana* cv. Wedgwood. J. Agric. Sci., Mansoura Univ., 27 (9): 6267-6285.

Auda, M. S., El-Shakhs, M. H. and Shahin, S. M. (2002): Response of *Polianthes tuberosa*, L. to different moisture stress levels and gibberellic acid. Egypt. J. Appl. Sci., 17 (7): 708-727.

Awad, A. E., Mostafa, M. B., Owais, A. H. and Kamel, A. A. (1982): Effect of growth regulators and salinity treatments on growth, chemical composition and anatomical structure of Datura plants. Res. Bull., Fac. of Agric., Zagazig Univ. 527.

Badran, F. S., Ahmed, E. T., El-Sayed, A. A., Mohamed, M. A. and Ibrahim, S. M. (2006): Effect of GA_3 treatment on osmoted stressed jojoba seedlings. I. Vegetative growth. Assiut J. Agric. Sci., 37(3): 47-69.

Badran, F. S., Mohey-Eldin, M. M. and El-Maziny, M. Y. (1984): Response of *Tropaeolum majus*, L. to P and GA_3 under salt affected soils. 2nd National Conf. on the Problems of Land Degradation in Egypt, pp.

Dahiya, S. S. and Dhankhar, O. P. (1984): Studies on salt tolerance of ber Haryana J. Hort. Sci. 11 (1/2): 53-58 (C. F. Hort. Abst. 55: 2305).

El-Banna, Y. F. (1985): The effects of salinity on the morphology, anatomy and ultrastructure of field bean and wheat plants and their modification by selected growth regulating chemicals. Ph. D. Disser. Wye College, Univ. of London.

Elhindi, M. Kh. (2012): Alleviation of adverse effects of seawater on growth and chemical constituents of *Chrysanthemum morifolium* by foliar Fe and Mn application. American J. Plant Nutrition and Fertilization Technology., ISSN 1793-9445, pp.13.

Gomaa, A. O. (2003): Effect of foliar spraying with Gibberellic acid and calcium on growth and flowering of *Dahlia pinnata* plant. Sec. Conf. of Agric. and Biological Res. Division, April 21-23, 2003.

Gommaa, S. A., Rezk-Alla, B. B. and Labib, N. I. (2005): Effect of spraying garlic extraction, gibberellic acid and potassium fertilizer on vegetative growth, flowering and bulb productivity of *Narcissus tazetta*, L. cv. Geranium. Egypt. J. Appl. Sci., 20 (5A): 304-333.

Haddad, S. A., Lemanowicz, J. and Abd El-Azeim, M. M. (2019): Cellulose decomposition in clay and sandy soils contaminated with heavy metals. International Journal of Environmental Science and Technology July 2019, Volume 16, Issue 7, pp 3275–3290.

Ismaeil, F. H. and Youssef. A. S. (2008): Effect of gibberellic acid and stimufol fertilizer on growth and flowering of *Hemerocallis aurantiaca* plant. J. Biol. Chem. S. Env. Sci., 3 (4): 421-448.

Jackson, M. L. (1975): Soil chemical analysis- Advanced course.

Jungil, L. and Moonsoo, Ch. (1997): Effect of mulching and GA_3 treatment in shade culture on the growth of Lilium spp. In high temperature season. J. Korean Society for Hort. Sci., 38 (3): 288-291.

Krishnamorthy, N. H. (1981): Plant Growth Substances. New Delhi, Tata McGraw Hill Publ. Co. Limited.

Leopold, A. C. and Kriedmann, P. E. (1975): Plant Growth and Development. Sec. Edit., McGraw Hill Publ. Co., Limited.

Louis, G. N. (1979): Controlling biological behavior of plants with synthetic plant growth regulation chemicals. Plant Growth Substances Meeting of the Amer. Chem. Sec., West Long Branch, New Jersey, U.S.A.

Mahmoud, E. A. (2016): Enhancement the characters of Calendula officinalis plant grown under saline and non saline conditions by using growth stimulants. Ph. D. Disser., Fac. of Agric., Cairo Univ.

Mazhar, A. A., Shedeed, S. I., Abdel-Aziz, N. G. and Mahgoub, M. H. (2012): Growth, flowering and chemical constituents of *Chrysanthemum indicum*, L. plant in response to different levels of humic acid and salinity. J. Appl. Sci. Res., 8 (7): 3697-3706.

Meawad, A. A. (1991): Effect of salinity and zinc treatments on anatomical structure and correlation coefficient between some parameters of gladiolus plants. Egypt. J. Appl. Sci., 6 (30): 629-642.

Milina, G. and Khader, M. A. (1989): Effect of NaCl and $CaCo_2$ on the growth attributes of tuberose (*Polianthes tuberosa*, L.) var. Single. South Indian Hort., 37 (4): 239-241. (C. F. Hort. Abst. 1991, 61 (4): 2979.

Mousa, G. T. and Lakany, A. A. (1983): Effect of salinity and alkalinity on vegetative growth, flowering and nutrient content of *Narcissus tazetta*, L. Assiut J. Agric. Sci., 14 (3): 391-402.

MSTAT-C (1986): A Microcomputer Program for the Design, Management and Analysis of Agronomic Research Experiments (Version 4.0). Michigan State Univ., U.S.A.

Nofal, F. H., El-Hegai, M. U. and Seleem, E. A. (2015): Response of Calendula officinalis, L. plants to growth stimulants under salinity stress. American – Eurasian J. Agric. Envir. Sci., 15 (9): 1767-1778.

Orazbaeva, R. S. (1978): Effect of GA_3 and cytokinins on contents of nitrogen compounds in wheat seedling. Alma. Atakazakh SSR, 112-120. (C. F. Crop Physiol. Abst., 6).

Page, A. L., Miller, R. H. and Keeney, D. R. (1982): Methods of soil analysis; 2. Chemical and microbiological properties, 2. Aufl. 1184 S., American Soc. of Agronomy

Rajaei, N. and Onsinejad, R. (2014): Effect of municipal solid waste compost and gibberellic acid on morphological and physiological traits of tulip (*Tulipa ssp*.) cv. Bright Parrot. European J. Experimental Biology, 4 (1): 361-368.

Singh, J. N., Singh, D. K. and Sharma, K. K. (1994): Effect of GA_3 and alar on growth, flowering and seed production of Dahlia (*Dahlia variabilis*, L.) Orissa J. Hort., 22: 1-2.

Sonneveld, G. and Voogt. W. (1983): Studies on the salt tolerance of some flower crops grown under glass. Plant and Soil J., 74 (1): 41-52. (C.F. Hort. Abst. Vol. 56, No. 1:414).

Starck, Z. and Czajkowska, E. (1981): Function of roots in NaCl-stressed bean plants. Plant and Soil, 63 (1): 107-113. (C.F. Hort. Abst., Vol. 52: 5443).

Starck, Z. and Kozinska, N. (1980): Effect of phytohormones on absorption and distribution of ions in salt-stressed bean plants. Acta Societatis Botanicorum Poloniae, 49: 111-125.

Weier, T. E., Stocking, C. R. and Barbour, M. G. (1974): Botany, An Introduction to Plant Biology, 5th Edition, John Wiley and Sons, Inc., U.S.A.

Youssef, A. S. (2004): Physiological studies on growth and flowering of *Strelitzia regia* Ait. Plant. Ph. D. Disser., Fac. of Agric., Moshtohor, Zagazig Univ.

Youssef, A. S. and Gomaa, A. O. (2008): Influence of GA_3 application and kristalon fertilizer on growth, flowering and chemical composition of *Dahlia pinnata* plant (summer flowering type). Proc. 1st Inter. Conf. on Ornamentals, Alex. J. Agric. Res., 53: 191-207.

استعمال حامض الجبرلين يخفف التأثيرات الضارة للملوحة على النمو الخضرى والتزهير وانتاج الابصال لنباتات التوبيروز *Polianthes tuberosa*.

أحمد على حسن [1] و محى الدين محمد عبد العظيم [2]

[1]قسم البساتين – كلية الزراعة – جامعة المنيا- مصر

[2]قسم علوم الاراضى – كلية الزراعة – جامعة المنيا- مصر

أجريت هذه التجربة خلال موسمين 2017 و 2018 بمشتل نباتات الزينة بكلية الزراعة جامعة المنيا لدراسة تأثير ملوحة التربة وحامض الجبرلين على النمو الخضرى والتزهير وانتاج الابصال لنباتات التوبيروز. أوضحت النتائج أنه قد حدث نقص تدريجى كبير وملحوظ فى مختلف الصفات الخضرية والزهرية وانتاج الابصال بالتوازى مع الزيادة التدريجية فى مستوى ملوحة التربة وقد تم الحصول على أقل القيم نتيجة معاملة النباتات بأعلى مستوى من الملوحة. كذلك حدث تأخير فى موعد التزهير نتيجة معاملات الملوحة المختلفة. وعلى العكس من ذلك فقد حدث تحسن تصاعدى نتيجة الزيادة التدريجية فى تركيز حامض الجبرلين بما فى ذلك التبكير فى موعد التزهير. ويمكن تلخيص النتائج فى ان التضاد بين الملوحة واضافة حامض الجبرلين قد أحدث تأثيرات معنويه على خصائص انتاج الابصال فى كلا الموسمين. ونجد ان الاراضى المعاملة بأعلى نسبة ملوحة نظرا لمعاملتها بالجبرلين باعلى تركيز كانت قادرة على أعطاء نفس النتائج فى الاراضى الغير معاملة (الكنترول). عند اضافة حامض الجبرلين بتركيز (100 جزء فى المليون) للاراضى المعاملة بأعلى نسبة ملوحة (1.2%) عمل على تدعيم كلا من العدد والوزن الطازج والجاف للبصيلات حيث تسبب فى زيادات بنسبة 71.3 و 40.8 و37.8% فى الموسم الاول و 66.7 و 48.7 و 56.0 % فى الموسم الثانى على التوالى. وبناء على ذلك يمكن التوصية بانتاج نباتات التوبيروز فى الاراضى المتأثرة بالاملاح باستعمال حامض الجبرلين حيث اتضح ان استعمال حامض الجبرلين قد قلل التأثيرات المثبطة للملوحة فى مثل تلك الاراضى. حيث ان استعمال الجبرلين قد شجع النمو الخضرى والصفات الزهرية وكذلك انتاج الابصال بما يعادل معاملات الكنترول (بدون تمليح).