Effect of Irrigation and Polyacrylamide on the Production of Tuberose Plants in Sandy Soil

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ABSTRACT

This investigation was carried out during 2006 and 2007 on *Polianthes tuberosa* cv. "Double" grown in plastic pots of 30 cm diameter at Antoniades Research Branch, Horticulture Institute, Ministry of Agriculture, Alexandria, Egypt. The study was a trial to investigate the effect of different levels of irrigation (100 %, 80 %, 60 %, 40 % and 20 % of the field capacity) and different ratios of polyacrylamide (as a synthetic soil conditioner) (0.0 %, 0.1 %, 0.2 % and 0.4 %) and their combinations (20 treatments) on the vegetative growth, flowering characteristics, corms production and some chemical analysis of tuberose plants grown in sandy soil.

Results revealed that the irrigation level was more effective than polyacrylamide ratios on the all studied characteristics of tuberose plant.

Also, using the highest level of the available moisture (100 % of field capacity) combined with polyacrylamide at 0.2 % gave the highest significant values by the number of flowers per spike, rachis length, corms diameter, cormles number per plant, carbohydrates content of the new corms and the shortest period needed for corm sprouting. The maximum values of leaves number, area and dry weight, flowering duration, spike length, leaf chlorophyll and the minimum leaf proline were found by the highest irrigation level (100 % of field capacity) alone.

Besides, the highest oil percentage in the flowers was obtained at 80 % of field capacity combined with polyacrylamide at 0.1 % or 0.2 %.

Generally, irrigating the cultivated tuberose in the sandy soil with using irrigation level not less 60 % of field capacity combined with polyacrylamide at concentration of 0.2 % gave good improvements by the vegetative growth, flowering characteristics, corms production and essential oil percentage of the flowers.

Key words: Polianthes tuberose, irrigation, polyacrylamide.

INTRODUCTION

Tuberose *(Polianthes tuberosa L.)* can successfully be grown in pots, beds and borders. The flower remains fresh and pretty for a long time, stands long distance transportation, and fills a useful place in the flower market (Desai, 1957). The tuberose cut flowers are used for artistic garlands, floral ornaments, bouquets and buttonholes. Double flowered plants are most frequently grown for the domestic market or for export.

The tuberose natural flower oil is considered as one of the essential (volatile) oils which used in the preparation of the most expensive perfumes. This volatile oil contains geraniol, nerol, benzyl alcohol, methyl benzoate, methyl salicylate and methyl anthronilate (Yadav and Maity, 1989).

Water is becoming an economical scarce resource in many areas of the world, especially in the arid and semi-arid regions. So, increasing water use efficiency and saving irrigation water are important tasks. Nevertheless, even under adequate soil moisture, water stress might develops in plant tissues causing a great variations in most, if not all, the physiological and biochemical processes. Misra and Srivastava (2000) reported that water stress resulted in a significant reduction in chlorophyll content of leaves and in essential oil yield of *Mentha arvensis*. Mohamed (2002), on *Rosmarinus officinalis* and *Pelargonium graveolens*, found a gradual increase in fresh and dry weights/plant with increasing irrigation level. The maximum fresh and dry weights/plant and per feddan were obtained by drip irrigation at the rate of 8 l/h .

Generally, cultivation on arid sandy soil requires large quantities of water. The low water holding capacity of this soil causes rapid infiltration and deep percolation below the root zone. The uses of gel-forming hydrophilic polymers have been tested for some years to solve such problem. Polyacrylamide (PAM) is a polymer composed of many subunits of acrylamide molecules, which are linked to identical copies of it-self to form long chain-link molecules. PAM is synthesized from natural gas and was originally developed in the 1940s and 1950s for use as a soil conditioner. There is, in fact thousands kinds of PAM which vary with the length and ionicity of the polymer chain. Gel-forming or superabsorbant polymers are soil conditioners developed to aid plant establishment in drought prone soils. The polymers commonly available come mainly from three chemical families (Johnson, 1984). Mostafa (2002) reported that adding polyacrylamide at 0.1 – 0.2% to the sandy soil under the irrigation frequencies regime of once/2 days enhanced most of plant growth indices of *Dendranthema grandiflorum* cv. Hawaii.

Sivapalan (2006) demonstrated that the excess amount of water stored in the soil by polyacrylamide was available to plants and resulted in higher water use. Consequently, there were a 12 and 18 fold increases in water use efficiency of soybean plants grown in soils treated with 0.03 and 0.07% polyacrylamide, respectively.

The objective of this investigation was to study the effects of using different percentages of field capacity (irrigation levels), ratios of polyacrylamide and their combinations on the vegetative growth, flowering characteristics, corms and cormels production and some chemical analysis of *Polianthes tuberosa* cv. "Double" grown in sandy soil under the circumstances of Alexandria.

MATERIALS AND METHODS

The present study was carried-out during the two successive years of 2006 and 2007 at Antoniades Research Branch, Horticulture Research Institute, A.R.C. Alexandria, Egypt.

Tuberose (*Polianthes tuberosa*, L. cv. "Double") corms with averages diameter of 3.8 cm and 70.0 g of fresh weight were obtained from a commercial nursery in Alexandria and planted in plastic pots of 30 cm at a depth of 5 cm on May 9, 2006 and on May 30, 2007. The pots were filled with a sandy soil (9 Kg per pot). The analysis of the used sandy soil are presented in Table (1). At the beginning of the experiment all side buds on the planted corms were removed to allow only the terminal bud to develop for each corm.

There are 20 treatments which are the combinations of five levels of field capacity and four concentrations of polyacrylamide. Five irrigation levels were used to keep the soil moisture at the field capacity of the used sandy soil at 100%, 80%, 60%, 40% and 20%. The reduction in the moisture level of each treatment was determined daily by using Moisture Tester Model KS-DI (Gypsum Block) during growing seasons.

The amounts of water for the different treatments were added daily to each pot to keep the soil moisture of each treatment at the corresponding percentage using tap water as a source of irrigation. At the end of the experiment the total amount of irrigation water for each treatment was calculated and presented in Table (2).

The "Flowrowger" is a commercial name of a synthetic polymer with white granular substrate that contains 97 % polyacrylamide (PAM) and has water retention capacity of 600 times on its weight basis, was used as a source of polyacrylamide (PAM). Four concentrations from this polymer were used i.e., 0.0% (control), 0.1%, 0.2% and 0.4% on base of soil weight (w/w). Each level from this polymer was completely mixed with the used soil directly before planting (Devitt *et al.,* 1991).

Fertilization of the tuberose plants was started six weeks after emergence of all corms till the foliage yellowness. Two types of compound fertilizers [(20: 20: 20) at 1.5 g / l and (12: 12: 36) at 2 g / l] were used after dissolving in the irrigation water during the vegetative growth and flowering periods, respectively. Besides, Mg and Fe fertilizers were sprayed two times at 75 and 150 ppm respectively as reported by Matt and Muhar (1990).

Table 1: Some chemical analysis of the used sandy soil for the two successive seasons 2006 and 2007.

Season	pH	EC (mmohs/cm)	Soluble cations (mg/l)				Soluble anions (mg/l)		
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^-	Cl^-	SO_2^{--}
2006	8.10	2.30	6.0	4.4	13.5	1.1	6.0	15.5	2.5
2007	8.02	2.06	5.4	2.8	12.0	0.6	5.0	13.0	2.0

Table 2: Total amount of the water used for each plant (l/pot) in each treatment during the growing two seasons of 2006 and 2007.

Field Capacity (%)	Total water amount / plant (l) — Polyacrylamide added to soil (w/w)									
	First season (2006)					Second season (2007)				
	0.0%	0.1%	0.2%	0.4%	Mean	0.0%	0.1%	0.2%	0.4%	Mean
100	75.650	74.700	74.225	73.275	74.462	76.600	75.650	75.175	74.225	75.412
80	63.650	62.700	62.225	61.275	62.462	64.600	63.650	63.175	62.225	63.412
60	51.650	50.700	50.225	49.275	50.462	52.600	51.650	51.175	50.225	51.412
40	39.650	38.700	38.225	37.275	38.462	40.600	39.650	39.175	38.225	39.412
20	27.650	26.700	26.225	25.275	26.462	28.600	27.650	27.175	26.225	27.412

The used experiment design was a split plot containing three replicates, each replicate contained 20 different treatments. Main plots were the irrigation levels while the subplots were the concentrations of polyacrylamide. Three plants were used as an experimental unit (plot) for each treatment in each replicate (3×20×3 = 180 pots). The means of individual factors and their interactions were compared by L.S.D. test at 5% level of probability (Snedecor and Cochran, 1974).

The following data were recorded: corms sprouting time, leaves number, area and dry weight per plant, number of days to showing colour, number of flowers per spike, flowering duration, spike length, rachis length, corm diameter, number of cormels per plant, total chlorophyll content (according to Moran and Porath, 1980), essential oil percentage (according to Guenther, 1961), proline content as a water stress indicator (according to Bates *et al.*, 1973) and carbohydrates content (according to Dubios *et al.*, 1956) of the new corms

RESULTS AND DISCUSSION

Vegetative growth

Generally, data of the two seasons indicated that the irrigation level was more effective than that of the polyacrylamide concentration on all the studied characteristics of tuberose plants. This result may be due to the poor ability of sandy soil to hold enough water to supply the tuberose plants with their needs of water and essential elements to grow well, thus any application of water led to improve the growth rate of tuberose plants. The data of the two seasons in Table (3) showed that the shortest time needed for corm sprouting was found by using available moisture at 100 of field capacity combined with polyacrylamide at 0.2 %, compared with the other treatments. These results were probably due to that sprouting the tuberose corms require a suitable level of available moisture in the medium to encourage the initiation and development of the roots and buds, beside that using the proper concentration of the polyacrylamide led to improve the water holding capacity and reduce the infiltration rate of the sandy soil, thus the soil can reserve an enough amount of water needed for corm sprouting.

Also, data of the two seasons in Table (3) generally, indicated that using the highest level of the available moisture (100 % of field capacity) combined with polyacrylamide at 0.2% gave the highest values of the leaf characters (number, area and dry weight), as compared with the other treatments. These results may be due to that using a suitable level of moisture (100 % of field capacity) at a proper concentration of the polyacrylamide led to activate the root system to grow better and it can absorb the adequate amount of water and fertilizer needed for good plant growth. Besides, increasing the rate of accumulation of the biosynthesates materials in the leaves, thus the leaves number, area and dry weight could be increased. Similar trend of results was found by Tripepi *et al.* (1991) on *Betuala pendula* plant, Halepyati *et al.* (2002) on tuberose and Khattab *et al.* (2002) on *Salvia splendens*. Furthermore , in this investigation it is also clear that , in general, using polyacrylamide alone at concentration of 0.2% gave significant increases in all studied leaf characters (number , area and dry weight), compared with the other concentrations.

These results were probably due to the role of polyacrylamide at a suitable concentration on increasing the availability of water and nutrients , thus the rate of food biosynthesis could be increased . Consequently, the plants can produce many large leaves, thus the leaves area and dry weight increase. Similar trend of results was found by Al-Harbi *et. al.*, (1999) on cucumber and Klock – Moore (2000) on *Salvia splendens*.

Flowering characteristics

The results of the two seasons in Table (4) indicated that the minimum time needed to show colour in the flowering spike was obtained by using the highest level of the available moisture, as compared with the lowest level, which led to decrease the time with 29.95 and 31.81 days under the treatment of 20 % field capacity in the first and second season, respectively. These results may be due to that using a suitable level of the available moisture activates the root system to grow early on the planted corms and sprout early and absorbs an adequate amount of the nutrients needed for biosynthesis process, which led to produce and accumulate the flowering materials that accelerate the initiation and formation of the flowers. As a result the time needed for showing colour stage could be decreased. Similar trend of results was found by Mostafa and Asker (1997) on *Dianthus barbatus* and *Senecio cruentus*.

Besides, data presented in Table (4) showed that addition of polyacrylamide at 0.2 % gave the shortest time taken to showing colour stage in both seasons, compared with the other concentrations, these results may be due to the influence of the added polyacrylamide at a suitable ratio on increasing the efficiency of the soil water and fertilizer. Consequently, the plants reach showing colour stage early. Similar trend of results was found by Mostafa *et al.* (1997) on Chrysanthemum.

Generally, data on the number of flowers per spike showed that the maximum number of flowers per spike was found at the highest level of the available moisture of the sandy soil combined with 0.2 % polyacrylamide in both seasons (Table (4)). These results may be related to the effect of polyacrylamide at a suitable concentration on improving the physical properties of the sandy soil, especially when the soil contains the suitable amount of water, consequently the plants could produce good spikes which had many flowers. Similar trend of results was found by Devitt *et al.* (1991) on *Catharanthus roseus*.

Generally, data of the two seasons in Table (4) indicated that using the highest level of the available moisture (100 % of field capacity) gave the longest significant flowering period of tuberose flowers, as compared with all the other treatments. The previous result may be due to that using a suitable amount of the available moisture in the sandy soil led to increase the absorption of the necessary nutrient elements for growth. Thus the growth rate of tuberose plant could be increased, consequently producing vigorous plants with a large spike with more flowers, as a result the period of the flowering duration could be increased. Similar trend of results was reported by Mostafa and Asker (1997) on *Dianthus barbatus* and *Senecio cruentus*.

Table 3: Means of vegetative growth characteristics of *Polianthes tuberosa* cv. Double plants as influenced by irrigation (Irr.) levels (field capacity percentage), polyacrylamide (PAM) concentrations (%) and their combinations (Irr. × PAM) in the two seasons of 2006 and 2007.

Treatments		Sprouting time (day)		Leaves number per plant		Leaves area per plant (cm^2)		Leaves dry weight (g)	
Field capacity (%)	PAM (%)	2006	2007	2006	2007	2006	2007	2006	2007
100	0.0	18.11	21.60	106.55	92.49	3242.84	2434.22	26.67	19.04
	0.1	16.10	20.21	108.21	98.71	3343.85	2611.32	26.89	19.30
	0.2	15.66	20.16	112.66	98.44	3520.05	2717.61	27.85	19.83
	0.4	18.99	22.05	105.44	94.60	3177.71	2403.38	25.42	19.24
Mean		**17.21**	**21.00**	**108.21**	**96.06**	**3321.10**	**2541.640**	**26.70**	**19.35**
80	0.0	20.22	22.27	96.99	89.94	2866.05	2451.55	24.78	17.67
	0.1	17.33	20.16	102.88	98.77	2992.89	2535.76	25.18	18.30
	0.2	17.66	20.32	105.99	101.77	3072.77	2533.28	25.56	18.58
	0.4	21.33	23.27	99.11	96.16	2815.98	2268.36	24.63	18.00
Mean		**19.13**	**21.50**	**101.49**	**96.66**	**2936.90**	**2447.240**	**25.04**	**18.14**
60	0.0	26.88	24.77	98.99	89.60	2489.79	2138.11	22.10	16.57
	0.1	25.99	25.60	95.10	91.77	2595.94	2273.33	22.83	17.37
	0.2	21.88	23.82	97.22	95.27	2695.49	2250.62	23.69	17.45
	0.4	28.22	27.10	96.33	92.66	2370.36	2146.65	21.72	16.39
Mean		**25.74**	**25.32**	**96.91**	**92.32**	**2537.90**	**2202.180**	**22.58**	**16.95**
40	0.0	29.99	30.27	93.66	81.60	2121.23	2173.67	19.28	15.04
	0.1	28.10	27.38	95.32	86.43	2243.29	2145.01	20.45	15.81
	0.2	25.33	26.82	94.88	90.38	2347.67	2164.27	20.87	16.22
	0.4	28.77	27.99	94.10	83.16	2151.16	2071.22	20.10	15.69
Mean		**28.05**	**28.12**	**94.49**	**85.39**	**2215.80**	**2138.550**	**20.17**	**15.69**
20	0.0	33.44	32.93	90.55	80.05	1886.11	2373.50	17.63	14.26
	0.1	31.21	30.82	94.77	81.38	2070.99	2262.67	18.20	13.81
	0.2	29.55	29.38	92.88	86.21	2220.23	2276.80	19.02	15.00
	0.4	30.33	32.88	94.55	82.32	1969.63	2109.33	17.96	14.53
Mean		**31.13**	**31.50**	**93.19**	**82.49**	**2036.70**	**2255.580**	**18.20**	**14.40**
$\bar{X}$ PAM	0.0	25.73	26.37	97.55	86.74	2521.21	2314.21	22.09	16.51
	0.1	23.75	24.83	99.26	91.41	2649.39	2365.62	22.71	16.92
	0.2	22.02	24.10	100.72	94.41	2771.25	2388.52	23.40	17.42
	0.4	25.53	26.66	97.90	89.78	2496.97	2199.79	21.96	16.77
L.S.D. at 0.05	Irrigation	0.90	2.26	NS	5.12	253.50	129.98	1.26	1.12
	PAM	0.75	0.73	NS	2.48	40.96	103.09	0.28	0.35
	Irr.×PAM	1.68	1.63	NS	NS	NS	NS	0.64	NS

Also, means of spike length per plant in the two seasons in Table (4) cleared that reducing the level of the available moisture of the sandy soil less than 100 % of field capacity gave a descendent decrease of the spike length per plant. The shortest spike length per plant was found by using 20 % of the available moisture of the soil, which led to decrease the spike length with 29.05 and 24.07 cm less than the treatment of 100 % of field capacity in the first and second season respectively. These results were probably due to the role of water at a suitable level in plant, which is necessary for nutrient elements absorption, chemical combinations that result in the formation of plant food, as a medium through which food and nutrient elements are moved from cell to cell, and to fill the vacuoles in the cells necessary to keep the tissues turgid, as a result the size of the cells and the division rate of the apical meristem could be increased, consequently the spike length will increase. Similar trend of results was reported by Mousa and El-Keltawi (1983) on *Strelitzia reginae*.

The data of both seasons in Table (4) showed that the longest rachis per flowering spike was obtained by adding the highest level of the available water (100 % of field capacity) combined with polyacrylamide at 0.2 %. This result may be related to the effect of polyacrylamide at a suitable concentration on improving the physical properties of the sandy soil especially when the soil contains the enough amount of the available moisture, accordingly the plants could absorb the needed water and nutrient elements for improving the whole growth of the plants, as a result, the length of the rachis will increase. Similar trend of results was reported by Devitt *et al.* (1991) on *Catharanthus roseus* and Mostafa and Asker (1997) on *Dianthus barbatus* and *Senecio cruentus*.

Corm production

Generally, data of the two seasons in Table (5) cleared that the largest corms diameter and the highest number of new cormles per plant were found by adding the highest level of water content (100 % of field capacity) combined with polyacrylamide at 0.1 % or 0.2 %. These results may be due to the role of polyacrylamide at a suitable concentration on improving the physical properties of the sandy soil, especially when the soil contains the proper level of the available moisture, consequently producing vigorous plants, and accordingly resulted in more back translocation and accumulation of organic matter, which led to the production of large corms with many cormles per plant. Similar results were found by El-Naggar and Nassar (1994) on *Narcissus tuzetta* and Al-Humaid and Al-Moftah (2005) on *Polianthes tuberosa*.

Chemical analysis

The data of the two seasons in Table (6) showed that the maximum total chlorophyll content of tuberose leaves was found by using the highest level of the available moisture (100 % of field capacity) combined with polyacrylamide at 0.2 %, compared with the other treatments. These results were probably due to that using a suitable level of available moisture led to increase the absorption of water and nutrient elements, especially nitrogen and magnesium needed for chlorophyll formation, besides presence of polyacrylamide at a proper concentration increases the availability of nitrogen and leaf water potential, thus the synthesis of the green pigment could be increased. Similar results were obtained by Al-Moftah and Al-Humaid (2004) on *Polianthes tuberosa*.

The data in Table (6) indicated also that using available moisture at 80 % of field capacity combined with polyacrylamide at concentration of 0.2% gave the highest percentage of the oil content of tuberose flowers. This finding may be attributed to that using polyacrylamide at a proper concentration led to increase the capacity of the sandy soil to conserve a large amount of water and improve the physical characters of the soil and as a result producing a good flowers, thus their oil content could be increased.

Furthermore, data of the two experimental seasons in Table (6) showed that using the lowest level of the available moisture (20 % of field capacity) in absence of the polyacrylamide gave the highest value of proline in tuberose leaves, as compared with the other treatments. This result was probably due to that protein formation requires a suitable level of water inside the plant tissues, thus decreasing this level led to decrease the rate of protein formation, consequently the free amino acids especially proline could be increased in the tuberose leaves. Similar results were found by Khalil (2003), Kim *et al.* (2004) and Kohler *et al.* (2008) on other plants.

Also, data of the two seasons in Table (6) cleared that the highest rate of carbohydrates content (%) of the new tuberose corms was found by adding the highest level of the available moisture (100 % of field capacity) combined with polyacrylamide at 0.2%. This result may be related to the effect of polyacrylamide at a proper concentration on improving the physical properties of the sandy soil and decreased the leached amount of organic and inorganic solutes, especially when the soil contains the suitable amount of the available moisture, consequently producing vigorous plants with many large leaves, as a result, a large amount of carbohydrate could be formed and translocated to the new corms.

Table 4: Means of flowering characteristics of *Polianthes tuberosa* cv. Double plants as influenced by irrigation (Irr.) levels (field capacity percentage), polyacrylamide (PAM) concentrations (%) and their combinations (Irr. × PAM) in the two seasons of 2006 and 2007.

Treatments		Time needed to showing colour(day)		Number of flowers per spike		Flowering duration (day)		Spike length per plant (cm)		Rachis length (cm)	
Field capacity (%)	PAM (%)	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
100	0.0	106.55	106.11	26.44	25.10	25.55	23.16	79.55	75.32	30.77	27.16
	0.1	107.44	104.99	27.44	24.83	27.77	25.43	83.32	77.71	31.66	28.82
	0.2	104.66	103.33	28.21	26.83	28.44	25.44	84.99	77.27	31.77	29.10
	0.4	107.77	107.44	25.99	24.55	25.88	22.93	81.44	74.10	29.22	26.44
Mean		**106.60**	**105.46**	**27.02**	**25.32**	**26.91**	**24.24**	**82.32**	**76.10**	**30.85**	**27.88**
80	0.0	114.88	116.11	23.66	22.77	24.77	22.71	70.99	68.88	25.88	24.10
	0.1	114.88	114.33	24.77	24.55	25.44	24.60	74.10	71.10	26.88	28.05
	0.2	112.88	112.88	26.10	24.99	27.10	24.82	75.32	71.99	27.77	27.82
	0.4	118.55	118.66	24.99	23.38	23.10	21.88	72.10	70.04	24.33	24.55
Mean		**115.30**	**115.49**	**24.88**	**23.92**	**25.10**	**23.50**	**73.13**	**70.50**	**26.21**	**26.13**
60	0.0	121.77	126.22	21.44	20.05	17.99	17.38	68.10	64.82	22.99	21.16
	0.1	125.33	125.33	22.77	21.38	19.55	18.49	71.33	67.88	23.77	23.72
	0.2	122.88	122.66	23.77	23.21	21.77	19.60	72.44	68.94	24.99	21.38
	0.4	128.55	128.44	22.10	21.16	17.88	15.93	69.88	66.49	22.55	21.49
Mean		**124.63**	**125.66**	**22.52**	**21.45**	**19.30**	**17.85**	**70.44**	**67.03**	**23.58**	**21.93**
40	0.0	137.88	137.44	15.10	14.16	11.77	11.10	60.22	56.71	16.21	15.60
	0.1	134.88	134.44	15.77	14.27	14.33	14.55	62.88	59.55	19.55	19.04
	0.2	133.22	133.10	16.88	15.88	15.44	14.32	64.66	62.05	22.21	19.16
	0.4	134.10	136.11	14.33	14.55	14.33	12.05	62.22	60.99	18.33	16.60
Mean		**135.02**	**135.27**	**15.52**	**14.71**	**13.96**	**13.00**	**62.49**	**59.82**	**19.07**	**17.60**
20	0.0	137.33	139.11	10.55	9.94	5.99	7.04	52.22	50.71	11.88	11.38
	0.1	137.44	137.11	12.88	11.60	7.99	7.32	52.44	52.05	15.10	16.05
	0.2	133.22	134.99	13.77	12.21	9.21	8.21	56.10	53.55	18.44	16.49
	0.4	138.22	137.88	10.99	9.77	6.33	6.33	52.33	51.83	14.21	13.15
Mean		**136.55**	**137.27**	**12.05**	**10.88**	**7.38**	**7.23**	**53.27**	**52.03**	**14.91**	**14.27**
$\bar{X}$ PAM	0.0	123.68	124.99	19.44	18.40	17.21	16.28	66.21	63.29	21.55	19.88
	0.1	123.99	123.24	20.72	19.32	19.01	18.08	68.81	65.66	23.39	23.13
	0.2	121.37	121.39	21.75	20.62	20.39	18.48	70.70	66.76	25.04	22.79
	0.4	125.44	125.70	19.68	18.68	17.50	15.82	67.59	64.69	21.73	20.44
L.S.D. at 0.05	Irrigation	1.74	0.14	0.53	0.51	0.86	1.13	0.88	2.21	1.14	0.95
	PAM	1.62	0.20	0.33	0.28	0.75	0.46	0.68	0.72	0.69	0.61
	Irr. ×PAM	NS	0.47	0.75	0.64	NS	1.04	NS	0.91	1.55	1.38

Table 5: Means of corms production of *Polianthes tuberosa* cv. Double plants as influenced by irrigation (Irr.) levels (field capacity percentage), polyacrylamide (PAM) concentrations (%) and their combinations (Irr. × PAM) in the two seasons of 2006 and 2007.

Treatments		Corm diameter (cm)		Cormles number per plant	
Field capacity (%)	PAM (%)	2006	2007	2006	2007
100	0.0	7.40	7.18	49.33	37.16
	0.1	7.74	7.24	51.33	39.50
	0.2	7.46	7.30	52.83	41.50
	0.4	7.36	7.09	48.33	35.50
Mean		**7.49**	**7.20**	**50.45**	**38.41**
80	0.0	6.95	6.50	37.83	30.00
	0.1	7.03	6.55	41.33	33.00
	0.2	6.99	6.63	44.00	34.33
	0.4	6.88	6.46	40.33	29.00
Mean		**6.96**	**6.53**	**40.87**	**31.58**
60	0.0	6.65	6.22	28.33	25.16
	0.1	6.76	6.29	31.50	26.16
	0.2	6.68	6.33	33.66	26.50
	0.4	6.60	6.19	30.33	24.66
Mean		**6.67**	**6.25**	**30.95**	**25.62**
40	0.0	6.24	5.71	18.83	21.16
	0.1	6.40	5.78	19.83	23.00
	0.2	6.33	5.82	22.83	23.83
	0.4	6.27	5.74	21.16	22.00
Mean		**6.31**	**5.76**	**20.66**	**22.50**
20	0.0	5.34	5.41	13.66	14.16
	0.1	5.71	5.57	15.66	19.16
	0.2	5.69	5.67	16.66	20.33
	0.4	5.58	5.54	13.66	17.83
Mean		**5.58**	**5.52**	**14.91**	**17.87**
$\overline{X}$ PAM	0.0	6.51	6.20	29.60	25.53
	0.1	6.73	6.28	31.93	28.16
	0.2	6.63	6.35	34.00	29.30
	0.4	6.54	6.19	30.76	25.80
L.S.D. at 0.05	Irrigation	0.24	0.35	4.80	5.22
	PAM	0.05	0.03	0.27	1.02
	Irr. × PAM	0.12	0.05	1.78	2.29

Table 5: Means of corms production of *Polianthes tuberosa* cv. Double plants as influenced by irrigation (Irr.) levels (field capacity percentage), polyacrylamide (PAM) concentrations (%) and their combinations (Irr. × PAM) in the two seasons of 2006 and 2007.

Treatments		Corm diameter (cm)		Cormles number per plant	
Field capacity (%)	**PAM (%)**	**2006**	**2007**	**2006**	**2007**
100	0.0	7.40	7.18	49.33	37.16
	0.1	7.74	7.24	51.33	39.50
	0.2	7.46	7.30	52.83	41.50
	0.4	7.36	7.09	48.33	35.50
Mean		**7.49**	**7.20**	**50.45**	**38.41**
80	0.0	6.95	6.50	37.83	30.00
	0.1	7.03	6.55	41.33	33.00
	0.2	6.99	6.63	44.00	34.33
	0.4	6.88	6.46	40.33	29.00
Mean		**6.96**	**6.53**	**40.87**	**31.58**
60	0.0	6.65	6.22	28.33	25.16
	0.1	6.76	6.29	31.50	26.16
	0.2	6.68	6.33	33.66	26.50
	0.4	6.60	6.19	30.33	24.66
Mean		**6.67**	**6.25**	**30.95**	**25.62**
40	0.0	6.24	5.71	18.83	21.16
	0.1	6.40	5.78	19.83	23.00
	0.2	6.33	5.82	22.83	23.83
	0.4	6.27	5.74	21.16	22.00
Mean		**6.31**	**5.76**	**20.66**	**22.50**
20	0.0	5.34	5.41	13.66	14.16
	0.1	5.71	5.57	15.66	19.16
	0.2	5.69	5.67	16.66	20.33
	0.4	5.58	5.54	13.66	17.83
Mean		**5.58**	**5.52**	**14.91**	**17.87**
$\overline{X}$ PAM	0.0	6.51	6.20	29.60	25.53
	0.1	6.73	6.28	31.93	28.16
	0.2	6.63	6.35	34.00	29.30
	0.4	6.54	6.19	30.76	25.80
L.S.D. at 0.05	Irrigation	0.24	0.35	4.80	5.22
	PAM	0.05	0.03	0.27	1.02
	Irr. × PAM	0.12	0.05	1.78	2.29

Table 6: Means of chemical analysis of *Polianthes tuberosa* cv. Double plants as influenced by irrigation (Irr.) levels (field capacity percentage), polyacrylamide (PAM) concentrations (%) and their combinations (Irr. × PAM) in the two seasons of 2006 and 2007.

Treatments		Total chlorophyll content (mg/ g fresh weight)		Essential oil (%)		Proline content (mg/g)		Carbohydrates content (%)	
Field capacity (%)	PAM(%)	2006	2007	2006	2007	2006	2007	2006	2007
100	0.0	70.07	73.30	0.253	0.296	1.40	1.27	25.69	26.97
	0.1	71.16	75.25	0.263P	0.317	1.38	1.24	26.57	27.30
	0.2	72.70	75.93	0.256	0.330	1.35	1.22	26.68	27.84
	0.4	69.95	72.43	0.249	0.301	1.42	1.29	25.30	26.28
Mean		**70.97**	**74.22**	**0.255**	**0.311**	**1.39**	**1.26**	**26.06**	**27.10**
80	0.0	67.00	68.38	0.267	0.308	1.54	1.59	23.91	25.70
	0.1	68.16	68.98	0.276	0.342	1.52	1.56	24.14	25.82
	0.2	69.46	69.95	0.291	0.319	1.50	1.53	24.47	26.13
	0.4	66.90	67.84	0.273	0.304	1.56	1.61	23.74	25.52
Mean		**67.88**	**68.79**	**0.276**	**0.318**	**1.53**	**1.57**	**24.06**	**25.79**
60	0.0	64.79	63.99	0.271	0.297	1.93	1.90	23.12	24.51
	0.1	65.93	65.10	0.280	0.320	1.90	1.88	23.12	25.28
	0.2	67.06	65.92	0.283	0.322	1.88	1.85	23.52	25.49
	0.4	63.52	63.02	0.268	0.288	1.94	1.92	23.09	23.28
Mean		**65.32**	**64.51**	**0.275**	**0.306**	**1.91**	**1.89**	**23.21**	**24.64**
40	0.0	60.24	59.28	0.235	0.287	2.28	2.24	19.77	20.54
	0.1	62.68	61.58	0.246	0.300	2.24	2.18	22.82	21.50
	0.2	63.33	62.74	0.244	0.294	2.21	2.16	22.91	22.99
	0.4	61.46	60.63	0.229	0.281	2.26	2.21	21.38	21.47
Mean		**61.93**	**61.06**	**0.238**	**0.290**	**2.25**	**2.20**	**21.72**	**21.63**
20	0.0	54.54	54.52	0.228	0.259	2.51	2.53	16.75	16.01
	0.1	58.98	56.21	0.230	0.270	2.47	2.49	19.75	17.73
	0.2	59.49	58.78	0.238	0.268	2.43	2.47	19.97	17.74
	0.4	57.07	55.29	0.225	0.254	2.49	2.51	18.48	16.46
Mean		**57.52**	**56.20**	**0.230**	**0.262**	**2.48**	**2.50**	**18.74**	**16.99**
$\bar{X}$ PAM	0.0	63.33	63.89	0.251	0.289	1.93	1.91	21.85	22.74
	0.1	65.38	65.42	0.259	0.310	1.90	1.87	23.28	23.53
	0.2	66.41	66.66	0.262	0.306	1.87	1.85	23.51	24.04
	0.4	63.78	63.84	0.249	0.285	1.93	1.91	22.40	22.60
L.S.D. at 0.05	Irrigation	2.38	2.44	-	-	0.15	0.04	0.39	0.66
	PAM	0.62	0.57	-	-	0.01	0.01	0.31	0.35
	Irr×PAM	1.38	NS	-	-	NS	0.012	0.70	0.78

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الملخص العربي

تأثير الري والبولي أكريلاميد على إنتاج نباتات التبروز في الأراضي الرملية

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أجرى هذا البحث فى فرع بحوث الحدائق النباتية بأنطونيادس – معهد بحوث البساتين بالإسكندرية عامي ٢٠٠٦ و ٢٠٠٧ على الصنف المجوز للتبروز المنزرع في أصص بلاستيك مقاس ٣٠ سم مملوءة بتربة رملية بهدف دراسة تأثير خمسة مستويات من المحتوى المائي للتربة: هي ١٠٠% ، ٨٠ % ، ٦٠ % ، ٤٠ % ، ٢٠ % من السعة الحقلية للتربة الرملية وأربعة تركيزات من البولي أكريلاميد هي صفر ، ٠,١ % ، ٠,٢ % ، ٠,٤ % منفرده أو في جميع التوافيق الممكنة بينهما لتعطى ٢٠ معاملة على بعض صفات النمو الخضري والزهري والتحليل الكيماوي.

أظهرت النتائج المتحصل عليها أن مستويات الري كانت أكثر فاعلية في التأثير على جميع الصفات المدروسة لنباتات التبروز بمقارنتها بتركيزات البولي أكريلميد. وعموما استخدام أعلى مستوى من الرطوبة الأرضية (١٠٠ % سعة حقلية) في وجود محسن التربة عند تركيز ٠,٢ % أعطى أعلى زيادة معنوية في كل من عدد الأزهار لكل نورة ،وزن الأزهار الجاف ، طول الجزء المزهر من النورة ، قطر الكورمة ، عدد الكوريمات لكل نبات ، محتوى الكورمة من الكربوهيدرات وأقصر فترة لإنبات الكورمات بعد زراعتها.

على الجانب الآخر فقد أعطى أعلى مستوى من الرطوبة الأرضية (١٠٠% من السعة الحقلية عند الرى) منفردا أعلى قيم لكل من عدد الأوراق ومساحتها ووزنها الجاف لكل نبات ، قطر الأزهار ومدة بقائها ، طول الحامل الزهري ، محتوى الأوراق من الكلوروفيل الكلى وأقل محتوى من البرولين.

أما أعلى محتوى من الزيت الطيار في الأزهار قد تم الحصول علية عند مستوى رطوبة أرضية قدرها ٨٠ % من السعة الحقلية وفى وجود البولي أكريلميد بتركيز ٠,١ % و ٠,٢ %.

وعموما فإن النتائج المتحصل عليها توصى برى نباتات التبروز المنزرعة في الأرض الرملية بمستوى رطوبى لا يقل عن ٦٠ % من السعة الحقلية مع استخدام البولي أكريلميد بتركيز ٠,٢ % حيث يؤدى ذلك للحصول على معدلات جيدة للنمو الخضري والزهري وإنتاج الكورمات ونسبة الزيت في أزهار الصنف المجوز.