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Effect of Bulb Diameter and Concentrations of Gibberellic Acid and Microelements on the Growth and Yield of Bulbs and Bulblets of *Polianthes tuberosa* L.

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Abstract. The experiment was carried out in the green net canopy of the Depart. of Hort. and Landscape Design at the College of Agric. and Forestry for the period from April 8 to December 30, 2020, on the tuberose plant Polianthes tuberosa L., cv. Single, to study the effect of three factors on the growth and bulbs and bulblets production, included first: three diameters of the bulbs: Large (24-31 mm), medium (17-23 mm) and small (9-16 mm), second: soaking with gibberellic acid (GA3) in concentrations: 0, 200 and 400 mg.l-1 for 24 hours before planting, and fertilizing with microelements at: 0, 0.75 and 1.50 g.l-1 with the fertilizer called IQ COMBI, sprayed on the vegetative growth twice, The factorial experiment was carried out using split plots in a randomized complete block design with three replicates and fifteen plants for treatment. The results indicated the following:

The use of large bulbs led to give the largest significant values of the number of leaves, number of lateral branches, leaf area, chlorophyll intensity, all the characteristics of the bulbs and the bulblets produced. The largest significant values were recorded in the characteristics of bulbs weight and circumference and bulblets weight and circumference when not treated with GA3. Spraying with micro-elements at a 0.75 g.l-1 had a significant effect in recording a significant increase in the characteristics, number of leaves, leaf area, chlorophyll intensity, bulb weight and volume, bulblet weight, diameter, circumference and volume. The results of the triple interaction between the factors under study indicated that the largest significant values were recorded when treating large bulbs with GA3 at 200 mg.l-1 and spraying with micro-elements at 0.75 g.l-1 for characteristics number of leaves 45.87 leaf.Pl-1, number of lateral branches 24.21 branch.pl-1, leaf area 63.13 cm2, chlorophyll intensity, weight of produced bulbs 52.77 g, diameter 43.63 mm, volume and number of bulblets.

Keywords: Tuberose, *Polianthes*, GA3, bulb diameter, Micronutrients.

Introduction

Tuberose *Polianthes tuberosa* L. is one of the most important summer perennial ornamental bulbs. It belongs to the family Agavaceae, (Dole and Wilkins, 2005). The plant is an herbaceous bulbous plant, reaching a height of 90-120 cm. The leaves are basal (6-9 leaves) coiled around the bulb. They are a light green long stripe that arises on the stems in the form of a rose. The inflorescence is an spike, on which there are funnel-shaped florets, very aromatic, white, waxy, the plant blooms in summer and autumn (Safeena *et al.* 2015 and Mandal *et al*. 2018). It occupies an important economic position in the global markets, due to its many and varied uses in the garden. Its cut flowers compete with the most important cut flowers known, due to its long inflorescence, the distinctive waxy nature of its florets (Usman and Ashfaq, 2013 and Safeena *et al.*, 2015). On the other hand, it is also grown for the production of crude essential oil used in the manufacture of perfumes and deodorants (Sheela, 2008 and Bahadoran *et al.*, 2012).

The bulb diameter plays an important role in the growth, flowering and bulb production of *P. tuberosa*, as the plant height and number of leaves gradually increased with the increase in bulb diameter. The diameter of the bulbs is also an important factor in commercial production of bulbs and bulblets (Yadav *et al.*, 1984, Vishwakarma and Kumar, 2018). In the study of Khan *et al*. (2020) showed that the diameter of the bulbs grown on *P. tuberosa* has an important role in growth, flowering and bulb production. The results showed that the largest significant values were recorded when planting large bulbs for the characteristics of bulb number, weight, diameter, bulblets number and weight for each plant.

GAs are found in all flowering and non-flowering plants, and include a large group of diterpenoid compounds, some of which are bioactive compounds as growth regulators, controlling growth processes (Davies, 1995). In the study of Hassan and Abd El-Azeim (2019) showed that spraying with GA_3 at a concentration of 100 $mg.l^{-1}$ led to a significant increase in the number of leaves and number of bulblets per plant. Desai *et al.* (2020) showed that treating *P. tuberosa* with gibberellic acid at a concentration of 1.50 $mg.l^{-1}$ led to a significant increase in leaf number, leaf area, number of bulbs, number of bulblets for plant and chlorophyll content in leaves. On the other hand, Lakshmi *et al.* (2020) indicated the response of bulbs of *P. tuberosa* cultivar Prajwal to spraying with GA_3 in concentrations of 200 $mg.l^{-1}$ showed a significant increase in the traits of the number and weight of bulbs per plant.

The growing medium and plant nutrients are the most important for the proper growth and development of ornamental plants, that there are 17 nutrients necessary for plant growth, four of which are functional, The flowering crops are most sensitive to plant nutrient deficiencies, symptoms of a deficiency of micro-elements rarely appear on ornamental plants, tuberose plants respond well to the addition of organic and chemical fertilizers and that it is recommended to add micro-nutrients sprayed on the plants vegetative growth (Atal *et al.* 2021). Devi *et al.* (2017) observed, when studying the spraying of *P. tuberosa* plant cultivar Single with 0.5 % ZnSO4 and 0.25% CuSO4, showed the largest significant values of leaf number and the number of bulbs bulb weight, weight of the largest bulb per plant, and the diameter of the largest bulb. Sudhagar *et al.* (2019) found in their study on *P. tuberosa* cultivar Single that fertilization by 20 kg of zinc $sulfate.ha^{-1}$ led to the highest significant values of the number of side branches, the number of leaves, and leaf area.

This experiment is the first study in Nineveh Governorate, it aims to know the possibility of growing tuberous bulbs, *Polianthes tuberosa* L., Cv. Single under the conditions of the Mosul region, using bulbs of different diameters, as well as studying the role of GA_3 and the effect of micro-elements in supporting the plant for growth and their effect on bulb and bulblet production.

Materials and Methods

The experiment was conducted on the tuberose plant *Polianthes tuberosa* L. variety Single, the bulbs were planted in the green net canopy of the Department of Horticulture and Landscaping / College of Agric. and Forestry / University of Mosul, during the period from April 8 to December 30, 2020. The experiment included three factors First: the diameter of the bulbs, which are: Large (24-31 mm), medium (17-23 mm) and small (9-16 mm), the second: Soaking with Gibberellic acid (GA_3): at concentrations: 0, 200 and 400 $mg.l^{-1}$ for 24 hours before planting, and the third: fertilization with micro-elements: Used a fertilizer IQ COMBI produced by Agri Sciences company containing the following micro-elements: (iron 6%, zinc 6%, manganese 6%, copper 0.5%, boron 0.2% and molybdenum 0.2%), sprayed on the vegetative growth, when the fourth leaf was formed on the plant, the spray was repeated again a month after the first spray with concentrations: 0.0, 0.75 and 1.50 $g.l^{-1}$. The factorial experiment was carried out using split plots in a randomized complete block design with three replicates and fifteen plants for treatment.

After receiving the bulbs from the product on February 8, 2020, it was powder dusting with fungicide (Velvet 80% wp), stored under laboratory conditions until planting. The green net's canopy soil was hoeing by removing all plant residues, then add the fully decomposed sheep waste. After treating the bulbs with GA_3, the bulbs were planted in the green canopy in furrows, the distance between them 30 cm and a distance between bulbs 30 cm at a depth of 8-10 cm. The maximum temperature during the study period ranged between 41.3-18.7 °C and minimum 29.5-6.3 °C, and the percentage of shading during the study period was 31.4%.

The studied traits included: number of leaves for each plant, leaf area (cm^2), chlorophyll intensity (SPAD), bulb weight (gm), bulb diameter (cm) and bulb volume (cm^3), bulblet weight (gm), bulblet diameter (mm) and their number of bulblet per plant. Analysis of variance was carried out using SAS (2002) and the differences between the treatments were compared according to Duncan's Multiple Range Test (DMART) at a probability level of 5% (Al-Rawi and Khalaf Allah, 1980).

Results and discussion

Number of leaves (leaf. plant^{-1}): The results in Table (1) showed that the largest significant values of the number of leaves were recorded when planting a large bulb. On the other hand, treated bulbs with GA_3 at 200 mg.l^{-1} caused to record the largest significant values 34.09 leaf.pl^{-1}. Spraying plants with micro-elements had a significant effect, as the largest values were recorded at 0.75 and 1.50 g.l^{-1}. The results indicate that the largest significant values 41.49 leaf.pl^{-1} were recorded with the largest bulbs treated with GA_3 at 200 mg.l^{-1}. The largest significant values were recorded from the planting medium diameter bulbs and sprayed with micro-elements at 0.75 g.l^{-1}. On the other hand, largest significant values were recorded when treated with GA_3 at 200 mg.l^{-1} with spraying with micro-elements at 0.75 and 1.50 g.l^{-1}. The results showed that the treatment of medium diameter bulbs with GA_3 at a concentration of 400 mg.l^{-1} interact with spraying with micro-elements at 0.75 g.l^{-1} gave the best result.

Table 1. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on leaves number (leaf. plant^{-1}) of *P. tuberosa* plant.

Bulb diameter (mm)	GA_3 Conc. (mg.l^{-1})	Micronutrient conc. (g.l^{-1}) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	14.75i	30.08e-g	28.16 h-m	24.33 d	
	200	36.12 c	45.87 a	42.50 ab	41.49 a	33.87 a
	400	37.87 bc	35.75 cd	33.75 c-e	35.79 b	
Medium (23-17)	0	27.00 gh	35.25 c-e	36.29 c	32.84 c	
	200	30.50 d-g	42.12 ab	33.91 c-e	35.51 bc	35.08 a
	400	26.33 gh	46.25 a	38.14 bc	36.90 b	
Small (16-9)	0	35.50 c-e	17.16 i	23.83 h	25.49 d	
	200	17.16 i	26.00 gh	32.68 c-f	25.28 d	23.13 b
	400	15.41 i	16.24 i	24.25 h	18.63 e	
Inter. Bulb diameter and Micronutrient	Lage	29.58 c	37.23 b	34.80 b		
	Medium	27.94 c	41.20 a	36.11 b	Effect of GA_3	
	small	22.69 d	19.80 e	26.92 c		
Inter. GA_3 and Micronutrient	0	25.75 e	27.49 de	29.42 cd	27.55 c	
	200	27.92 de	37.99 a	36.36 a	34.09 a	
	400	26.53 de	32.74 b	32.04 bc	30.44 b	
Effect of Micronutrient		26.73 b	32.74 a	32.61 a		

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT.

Leaf area (cm^2): The results in Table (2) indicate that the larger diameter bulbs recorded the highest significant values of leaf area 57.74 cm^2. The treatment with GA_3 at 400 mg.l^{-1} resulted to record the largest significant values. Spraying with micro-elements at 0.75 g.l^{-1} led to record the largest significant values 53.34 cm^2. The results of the interaction between the study factors, that planting large bulbs after treated with 400 mg.l^{-1} and spraying with micro-elements at a concentration of 1.50 g.l^{-1} gave the largest significant values 66.25 cm^2.

Table 2. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on leaf area (cm^2) of *P. tuberosa* plant.

Bulb diameter (mm)	GA_3 Conc. (mg.l^{-1})	Micronutrient conc. (g.l^{-1}) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	46.62 ef	63.00 a	62.15 b	57.25 b	
	200	56.31 cd	63.13 ab	45.78 e-g	55.07 c	57.74 a
	400	53.91 d	62.52 b	66.25 a	60.89 a	
Medium (23-17)	0	42.94 gh	57.23 c	43.53 f-h	47.90 d	
	200	53.29 d	48.02 e	40.70 hi	47.33 d	50.84 b
	400	53.86 d	63.86 ab	54.18 cd	57.30 b	
Small (16-9)	0	34.69 k	43.03 gh	38.52 ij	38.74 f	
	200	46.77 ef	42.57 gh	43.19 gh	44.17 e	41.79 c
	400	47.38 e	36.75 jk	43.20 gh	42.44 e	
Inter. Bulb diameter and Micronutrient	Lage	52.28 c	62.88 a	58.06 b		
	Medium	50.03 d	56.37 b	46.13 e	Effect of GA_3	
	small	42.95 f	40.78 g	41.63 fg		
Inter. GA_3 and Micronutrient	0	41.41 e	54.42 a	48.06 c	47.96 b	
	200	52.12 b	51.24 b	43.22 d	48.86 b	

	400	51.72 b	54.37 a	54.54 a	53.54 a	
Effect of Micronutrient		48.42 b	53.34 a	48.61 b		

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT.

Chlorophyll intensity (SPAD): The results in Table (3) indicate that the largest significant values were recorded when planting large bulbs. The values of chlorophyll intensity increased with the increase in the concentration of GA_3, and it reached a maximum of 53.71 SPAD at the concentration of 400 mg.l^{-1}. Spraying plants with micro-elements at 0.75 g.l^{-1} led to record the largest significant values. It is noted that the largest significant values were recorded when treating large bulbs with concentrations of 200 and 400 mg.l^{-1}. The largest significant values were recorded when planting large bulbs interact with spraying with micro-elements at a concentration of 0.75 g.l^{-1}. On other hand, when spraying with a concentration of 0.75 g.l^{-1} of micro-elements with no treatment or treatment at a concentration of 200 mg.l^{-1} of GA_3 led to record the largest significant values were 57.58 and 56.55 SPAD. In general, it can be said that the largest significant values of chlorophyll intensity could be recorded when planting large bulbs interact with the 200 mg.l^{-1} of GA_3 and fertilized with micro-elements at 0.75 g.l^{-1}.

Bulb weight (g): It is noted from the results that when planting large and medium bulbs gave the largest significant values 39.30 and 38.84 g, respectively (Table, 4). The treatment with high concentration of GA_3 significantly reduced the weight of the bulbs. Spraying with micro-elements had a significant effect by recording the largest values of 39.94 g at a concentration of 0.75 g.l^{-1}.

Table 3. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on the intensity of chlorophyll in leaves (SPAD) after 100 days from planting *P. tuberosa* bulbs.

Bulb diameter (mm)	GA_3 Conc. (mg.l^{-1})	Micronutrient conc. (g.l^{-1}) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	54.18 de	64.84 b	46.16 f-h	55.06 b	
	200	54.05 de	68.53 a	64.58 b	62.39 a	59.53 a
	400	64.50 b	52.88 de	66.05 ab	61.14 a	
Medium (23-17)	0	47.15 fg	52.98 de	42.90 h-j	47.68 c	
	200	44.75 f-i	56.23 cd	44.09 g-i	48.35 c	50.30 b
	400	51.87 e	54.44 de	58.35 c	54.88 b	
Small (16-9)	0	48.20 f	54.92 de	30.98 k	44.70 d	
	200	47.63 f	44.91 f-i	39.90 j	44.14 d	44.65 c
	400	45.24 f-i	47.52 fg	42.57 ij	45.11 d	
Inter. Bulb diameter and Micronutrient	Lage	57.57 b	62.08 a	58.93 b		
	Medium	47.92 de	54.55 c	48.44 de	Effect of GA_3	
	small	47.02 e	49.11 d	37.81 f		
Inter. GA_3 and Micronutrient	0	49.84 e	57.58 a	40.01 f	49.14 c	
	200	48.81 e	56.55 ab	49.52 e	51.63 b	
	400	53.87 c	51.61 d	55.65 b	53.71 a	
Effect of Micronutrient		50.84 b	55.25 a	48.39 c		

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT.

Table 4. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on the weight of harvested bulbs (gm) of *P. tuberosa.*

Bulb diameter (mm)	GA_3 Conc. (mg.l^{-1})	Micronutrient conc. (g.l^{-1}) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	33.62 fg	39.94 cd	46.68 b	40.08 b	
	200	43.02 c	52.77 a	38.75 de	44.84 a	39.30 a
	400	22.83 j	41.54 cd	34.54 fg	32.97 d	
Medium (23-17)	0	28.67 hi	55.51 a	39.39 d	41.19 b	
	200	35.45 ef	47.37 b	35.51 ef	39.44 b	38.84 a
	400	26.58 i	47.58 b	33.52 fg	35.89 c	
Small (16-9)	0	28.03 i	31.44 gh	35.65 ef	31.70 d	
	200	25.38 ij	17.56 k	34.54 fg	25.82 e	26.17 b
	400	14.14 l	25.75 ij	23.03 j	20.97 f	
Inter. Bulb diameter and Micronutrient	Lage	33.16 e	44.75 b	39.99 c		
	Medium	30.23 f	50.15 a	36.14 d	Effect of GA_3	
	small	22.51 h	24.91 g	31.07 f		
Inter. GA_3 and	0	30.11 e	42.29 a	40.57 ab	37.66 a	

Micronutrient	200	34.61 d	39.23 bc	36.26 d	36.70 a	
	400	21.18 f	38.29 c	30.36 e	29.94 b	
Effect of Micronutrient		28.63 c	39.94 a	35.73 b		

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT

The largest significant values of bulb weight were recorded at 44.84 g when interact between large bulbs with treatment at a concentration of 200 mg.l^{-1} of GA_3. The results also indicate that the largest significant values of 50.15 g were recorded when planting medium bulbs with spraying at 0.75 g.l^{-1}. In general, the largest significant values of the harvested bulb weight 55.51 g when planting medium diameter bulbs interact with no treatment with GA_3 and treated with micro-elements at 0.75 g.l^{-1}.

Bulb diameter (mm): The data in Table (5) indicate that the largest significant diameter of the bulbs is 39.70 mm could be obtained when growing large and medium bulbs. The largest significant values 37.89 mm were recorded when planting bulbs treated with a concentration of 200 mg.l^{-1} of GA_3. It is noted also from the results of the interaction that the largest significant values of 41.15 mm were recorded when planting large bulbs after treating them with 400 mg.l^{-1} of GA_3. Planting the medium bulbs recorded the largest values of 40.90 mm after spraying them with micro-elements at 0.75 g.l^{-1}. The treatment with gibberellic acid at a concentration of 200 mg.l^{-1} interact with the lack of treatment with micro-elements or the use of a concentration of 0.75 g.l^{-1} resulted in the largest significant values of bulbs diameter being 40.75 and 40.19 mm, respectively. The largest significant values were recorded at the triple interaction of medium diameter bulbs that were not treated with GA_3 or treated with concentration 200 mg.l^{-1} and spraying with micro-elements at a concentration of 0.75 g.l^{-1}.

Table 5. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on bulb diameter (mm) of *P. tuberosa.*

Bulb diameter (mm)	GA_3 Conc. (mg.l^{-1})	Micronutrient conc. (g.l^{-1}) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	35.17 c-f	35.50 c-e	41.82 ab	37.49 b	
	200	41.19 b	43.63 ab	36.52 cd	40.44 a	39.70 a
	400	43.55 ab	37.60 c	42.31 ab	41.15 a	
Medium (23-17)	0	34.00 d-g	44.53 a	42.13 ab	40.22 a	
	200	43.93 ab	44.43 a	32.42 fg	40.26 a	39.26 a
	400	34.21 d-g	33.75 d-g	43.97 ab	37.31 b	
Small (16-9)	0	33.18 e-g	25.04 i	35.99 cd	31.40 d	
	200	37.14 c	32.51 fg	29.27 h	32.97 c	30.57 b
	400	24.40 i	32.09 g	25.55 i	27.35 e	
Inter. Bulb diameter and Micronutrient	Lage	39.97 ab	38.91 b	40.21 ab		
	Medium	37.38 c	40.90 a	39.51 ab	Effect of GA_3	
	small	31.57 d	29.88 e	30.27 de		
Inter. GA_3 and Micronutrient	0	34.11 cd	35.02 c	39.98 a	36.37 b	
	200	40.75 a	40.19 a	32.74 d	37.89 a	
	400	34.05 cd	34.48 c	37.28 b	35.27 c	
Effect of Micronutrient		36.30 a	36.56 a	36.66 a		

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT

Bulb volume (cm^3): It is noted from the results in Table (6) that the largest significant volume of harvested bulbs is 34.96 cm^3 when planting large bulbs. Spraying with micro-elements at both concentrations of 0.75 and 1.50 g.l^{-1} led to a significant increase in the volume of bulbs. The results of the interaction indicated that the largest values of 37.83 cm^3 for the volume of the bulbs were recorded from the large bulbs treated with GA_3 at a concentration of 200 mg.l^{-1}. The largest significant values were recorded for large bulbs sprayed with a concentration of 0.75 and 1.50 g.l^{-1} of micro-elements. The non-treatment with GA_3 interact with spraying at 1.50 g.l^{-1} of the micro-elements led to the recording of the largest significant values of 32.70 cm^3. In general, the use of large bulbs interacted with treatment with GA_3 at 200 mg.l^{-1} with spraying with micro-elements at 0.75 g.l^{-1} led to recording the largest significant values of bulb volume 45.00 cm^3.

Bulblet weight (gm): It is noted from Table (7) that the diameter of the planted bulb has a significant effect on the bulblet weight, reaching its maximum for large bulbs. When treated with GA_3 at a concentration of 200 and 400 mg.l^{-1} caused to reduce the values significantly to the lowest. The largest significant values were recorded at 22.56

gm when spraying with a concentration of 1.50 g.l^{-1} of micro-elements.

Table 6. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on bulb volume (cm^3) of *P. tuberosa.*

Bulb diameter (mm)	GA_3 Conc. ($mg.l^{-1}$)	Micronutrient conc. ($g.l^{-1}$) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	28.75 e-g	24.72 g-j	42.50 a	31.99 c	
	200	35.00 b-d	45.00 a	33.50 cd	37.83 a	34.96 a
	400	35.83 bc	38.56 b	30.83 d-f	35.07 b	
Medium (23-17)	0	23.33 h-j	27.50 f-h	32.50 c-e	27.77 de	
	200	25.62 g-j	28.35 e-g	25.62 g-j	26.53 e	27.82 b
	400	26.25 g-i	32.49 c-e	28.75 e-g	29.16 d	
Small (16-9)	0	24.37 g-j	24.85 g-j	23.12 h-j	24.11 f	
	200	22.91 ij	16.25 k	21.66 ij	20.27 g	22.42 c
	400	21.56 j	22.08 ij	25.00 g-j	22.88 f	
Inter. Bulb diameter and Micronutrient	Lage	33.19 b	36.09 a	35.61 a		
	Medium	25.06 d	29.44 c	28.95 c	Effect of GA_3	
	small	22.95 de	21.06 e	23.26 de		
Inter. GA_3 and Micronutrient	0	25.48 e	25.69 e	32.70 a	27.96 a	
	200	27.84 c-e	29.86 bc	26.92 de	28.21 a	
	400	27.88 c-e	31.04 ab	28.19 cd	29.03 a	
Effect of Micronutrient		27.07 b	28.86 a	29.27 a		

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT.

Table 7. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on bulblet weight (gm) of *P. tuberosa.*

Bulb diameter (mm)	GA_3 Conc. ($mg.l^{-1}$)	Micronutrient conc. ($g.l^{-1}$) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	12.32 ij	50.45 a	24.61 e	29.12 a	
	200	14.10 g-j	18.16 f	42.82 b	25.03 b	23.96 a
	400	18.57 f	16.51 f-h	18.07 f	17.72 d	
Medium (23-17)	0	12.77 h-j	22.55 e	28.07 d	21.13 c	
	200	14.11 g-j	18.77 f	15.16 f-j	16.01 d	21.13 b
	400	28.41 d	17.94 f	32.45 c	26.26 b	
Small (16-9)	0	11.47 jk	8.49 kl	15.79 f-i	11.91 e	
	200	13.57 h-j	6.43 l	17.73 fg	12.57 e	11.82 c
	400	12.49 ij	12.04 ij	8.38 kl	10.97 e	
Inter. Bulb diameter and Micronutrient	Lage	14.99 d	28.37 a	28.50 a		
	Medium	18.43 c	19.75 c	25.22 b	Effect of GA_3	
	small	12.51 e	8.98 f	13.97 de		
Inter. GA_3 and Micronutrient	0	12.18 f	27.16 a	22.82 c	20.72 a	
	200	13.92 ef	14.45 e	25.24 b	17.87 b	
	400	19.82 d	15.49 e	19.63 d	18.32 b	
Effect of Micronutrient		15.31 c	19.04 b	22.56 a		

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT.

The results indicate that the largest significant values of 29.12 g were recorded when planting large bulbs without treatment with GA_3. When planting large bulbs interact with spraying at a concentration of 1.50 and 0.75 g.l^{-1} of the micro-elements it caused to recorded the largest significant values of 28.50 and 28.37 g, respectively. The best significantly results were recorded at 27.16 gm when not treated with GA_3 with spraying at 0.75 g.l^{-1} of micro-elements. It appeared from the results of the triple interaction of studied factors that the best significant results of 50.45 g were recorded when planting large bulbs and not being treated with GA_3 and spraying with 0.75 g.l^{-1} of micro-elements.

Bulblet diameter (mm): The results in Table (8) indicate that the planting of large bulbs gave the largest significant values of bulblet diameter. When the bulb treated with GA_3 at 400 mg.l^{-1} it record the largest significant values 11.28 mm. Spraying plants with micro-nutrients a concentration of 0.75 g.l^{-1} gave the largest significant values of 11.60 mm. When planting large bulbs treated with 400 mg.l^{-1} of GA_3 recorded the largest significant values of 12.59 mm.

Table 8. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on bulblet diameter (mm) of *P. tuberosa.*

Bulb diameter (mm)	GA_3 Conc. (mg.l^{-1})	Micronutrient conc. (g.l^{-1}) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	11.88 c-e	13.09 b	10.71 ij	11.89 b	
	200	11.56 d-g	12.07 cd	12.27 c	11.96 b	12.15 a
	400	11.20 g-i	14.44 a	12.13 c	12.59 a	
Medium (23-17)	0	10.82 hi	12.22 c	11.55 d-g	11.53 c	
	200	11.73 c-g	11.42 e-g	10.05 k-m	11.06 d	11.30 b
	400	10.86 hi	11.31 f-h	11.80 d-f	11.32 cd	
Small (16-9)	0	9.77 k-m	10.26 jk	8.84 n	9.62 f	
	200	10.19 k	9.56 lm	9.72 k-m	9.82 ef	9.79 c
	400	9.54 m	10.09 kl	10.21 jk	9.94 e	
Inter. Bulb diameter and Micronutrient	Lage	11.54 b	13.20 a	11.70 b		
	Medium	11.13 c	11.65 b	11.13 c	Effect of GA_3	
	small	9.83 de	9.97 d	9.59 e		
Inter. GA_3 and Micronutrient	0	10.82 de	11.86 a	10.37 f	11.01 b	
	200	11.16 bc	11.01 cd	10.68 e	10.95 b	
	400	10.53 ef	11.94 a	11.38 b	11.28 a	
Effect of Micronutrient		10.84 b	11.60 a	10.81 b		

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT.

Planting large bulbs with spraying at a concentration of 0.75 g.l^{-1} of the micro-elements caused to recorded the largest significant values of 13.20 mm. The results also indicate that the largest significant values of 11.94 mm were recorded by using GA_3 at 400 mg.l^{-1} mixed with a 0.75 g.l^{-1} of micro-elements. It can be said, that the largest significant values of the bulblet diameter 14.44 mm were recorded at the interaction between the planting of large bulbs treated with a 400 mg.l^{-1} of GA_3 and sprayed at 0.75 g.l^{-1}.

Number of bulblet (bulblet. plant^{-1}): The results indicate that the diameter of the bulb had a significant effect on the values of this trait, reaching a maximum value 18.18 bulblet.pl^{-1} when planting large bulbs (Table 9). Spraying micro-element with a high concentration of 1.50 g.l^{-1} resulted to recorded the largest values of 16.66 bulblet.pl^{-1}. It is noted that the largest significant values of the number of bulblets were recorded when planting large bulbs treated with any of the three concentrations of GA_3 studied. The results indicate that the largest significant values 20.38 bulblet.pl^{-1} were recorded when planting large bulbs interact with spraying with micro-elements at 1.50 g.l^{-1}. The largest significant values 18.23 bulblet.pl^{-1} were recorded when the bulb not treated with GA_3 and interact with a concentration of 1.50 g.l^{-1} of micro-elements. In general, it can be said that the largest significant values of the number of bulblets are 22.75 bulblet.pl^{-1} was recorded from the planting of large diameter bulbs interact with treated at 200 mg.l^{-1} of GA_3 and spraying with 0.75 g.l^{-1} of micro-elements.

Table 9. Effect of bulb diameter, gibberellic acid and micro-nutrients and their interactions on number of bulblets (bulblet. plant^{-1}) of *P. tuberosa.*

Bulb diameter (mm)	GA_3 Conc. (mg.l^{-1})	Micronutrient conc. (g.l^{-1}) 0	0.75	1.50	Inter. Bulb diameter and GA_3	Effect of bulb diameter
Large (31-24)	0	15.00 c-f	17.63 bc	21.45 a	18.03 a	
	200	14.97 c-f	22.75 a	18.25 f	18.65 a	18.18 a
	400	16.99 b-d	15.16 c-f	21.45 a	17.87 ab	
Medium (23-17)	0	15.12 c-f	14.77 c-f	18.25 b	16.05 cd	
	200	15.55 b-e	14.25 d-f	13.80 d-f	14.53 de	15.66 b
	400	16.75 b-d	13.91 d-f	18.55 b	16.40 bc	
Small (16-9)	0	12.41 e-g	13.24 ef	15.00 c-f	13.55 ef	
	200	13.83 d-f	12.07 fg	10.12 g	12.01 f	12.87 c
	400	13.97 d-f	12.11 fg	13.12 ef	13.06 ef	
Inter. Bulb diameter and Micronutrient	Lage	15.65 cd	18.51 b	20.38 a		
	Medium	15.80 cd	14.31 de	16.86 c	Effect of GA_3	
	small	13.40 ef	12.47 f	12.74 ef		
Inter. GA_3 and Micronutrient	0	14.18 d	15.21 cd	18.23 a	15.87 a	
	200	14.78 cd	16.35 bc	14.05 d	15.06 a	

400	15.90 c	13.73 d	17.71 ab	15.78 a
Effect of Micronutrient	14.95 b	15.10 b	16.66 a	

Means with same letter for each factor and interaction are not significantly different at 5% level based on DMRT.

The results obtained from the research indicated the success of its cultivation in the Mosul area for the production of bulbs and bulbs. The diameter of the bulbs used in planting plays an important role in the growth and formation of bulbs and bulblets (Dhua, 1987). It appeared from the results in Tables (1 and 2) that the largest significant values for the number of leaves and leaf area were recorded when planting large bulbs, this result is consistent with Shampa 2013)) and Singh *et al.* (2017) and Zamin *et al.* (2020) on tuberose, this may explain, according to Dhua (1987) and Ahmad *et al.* (2009) that large diameter bulbs are a larger storage container for nutrients necessary for growth, this supports the results obtained for Chlorophyll intensity (Table, 3), which was maximum in large bulb plants, which may support the vegetative growth. On the other hand, Pathak *et al.* (1978) mentioned that the large bulbs are rich in gibberellin content, which may explain the reason for the increase in leaf area compared with leaves on medium and small bulbs. It is noted from the results that the largest significant values of the traits of the produced bulbs were recorded when planting large bulbs compared to medium and small bulbs (Tables 4 and 5), and this was confirmed (Vishwakarma and Kumar, 2018 and Khan *et al.*, 2019), this may be attributed to the higher nutritional stock of mother bulbs (Pathak, 1978).

The largest significant values of bulbs weight, diameter and number (Tables 7, 8 and 9) were recorded when planting large bulbs compared to medium and small bulbs, this result agrees with Ahmad *et al.* (2009) and Shampa (2013) on tuberose, this result is explained according to Yadav *et al*. (1984) and Raja and Palanisamy (2000) that the large bulbs have a larger food stock, which supports the formation of a larger number of leaves, which in turn absorb large amounts of water and nutrients then lead to stimulating the growth of a larger number of bulblets, Hartmann *et al.* (2014) mentioned that the large bulbs which rich in the nutrients are balanced in their hormonal content, which supports the stimulation of meristems on the bulb basal disc for the formation and growth f bulblets.

It is noted from the results that treatment with GA_3 led to a significant increase in leaf area at 400 mg.l^{-1} and the leaves number at 200 mg.l^{-1} (Tables, 2 and 1), respectively. These results are in agreement with what was found by Ali *et al.* (2019), and Maheswari and Sivasanjeevi (2019) on tuberoses, that explain the increase in leaf number according to Hopkins (1999), the effect of gibberellins may be due to their regulation of enzymatic activity similar to that of auxins, despite the difference in the enzymes involved, and that a lot of evidence indicates that gibberellins stimulate growth by increasing metabolism by increasing soluble carbohydrates due to their activation of the enzyme α-amylase, as well as increasing the accumulation of a number of other enzymes, or that its effect may be due to its role in activating the transfer of photosynthetic products from the leaf to the developing apex and thus increases the number of leaves. The increase in leaf area may explain according to Naggar *et al.* (2009) and Kashif *et al.* (2014) that one of the effects of GA_3 in plants is to change the concentration of solutes in the cell that causes a change in osmotic pressure, as well as softening the cell wall, which leads to an increase in cell size and expansion. On other hand, GA_3 increases the proteins and RNA synthesis in the cell, which not only leads to cell elongation, but also encourages cell division, thus increase in the number, length and width of leaves.

The results showed that the largest significant values of chlorophyll intensity were recorded when the bulbs were treated with 400 mg.l^{-1} (Table, 3). This result may be explained according to Taiz and Zeiger (2002) that gibberellins promote chlorophyll retention in leaves, and the study of Faraji *et al.*, (2011) who mentioned on the gladiolus that GA_3 delay the breakdown of chlorophyll, helps to retain it in the leaves, and activates cytokinin that delay the aging of leaves and thus an increase in the total chlorophyll content in it (Sajid *et al.* 2015).

It appeared from the obtained results that spraying with a solution of micro-elements at 0.75 g.l^{-1} resulted in a significant increase in the number of leaves and leaf area for each plant (Tables, 1 and 2). These results on tuberose agree with Jain (2014) and Sudhagar *et al.* (2019), these results may be explained according to the positive role of boron on plant height, which It may be due to the increase in nitrogen uptake and its role in transferring the products of photosynthesis in the plant (Nath and Biswas, 2002). The addition of micro-elements also activates many enzymes and physiological activities, which leads to increase the plant growth and development, the increase in leaf area is explained according to the important role of zinc in stimulating the synthesis of the amino acid tryptophan, which is important in plant growth, which helps cell division and thus leads to an increase in leaf area (Saleh, 2012 and Devi, 2017), The results showed that chlorophyll intensity was maximum at 0.75 g.l^{-1} of micro-nutrient (Table, 3), which may mean an increase in photosynthetic products, especially as it was associated with the largest values for leaf area.

The results showed that the largest significant values of bulbs weight, size and bulb diameter were recorded when plants were sprayed with micro-elements at 0.75 g.l^{-1} (Tables 4, 6 and 8), and the best values were recorded when spraying with a 1.50 g.l^{-1} for the characteristics of bulb size, bulblets weight and number (Tables 6, 7 and 9). These results are consistent with what was obtained (Devi *et al.*, 2017). This may be due to the role of zinc in transferring metabolites from one site to another, thus increasing the number of bulblets (Naik *et al.* 2009). Jat *et al.* (2007) showed that zinc increases vegetative growth and thus led to the production of more photosynthetic products, which in turn increases the yield of bulbs and bulblets.

References

[1] AL-Dawoody,D.M (1979) Classification of forest trees. Dar al-Kutub for printing and publishing, University of Al Mosul,Iraq.

[2] Ahmad, I., T. Ahmad., M. Asif., M. Saleem and A. Akram (2009) Effect of bulb size on growth, flowering and bulbils production of tuberose. Sarhad J. Agric 25(3): 391-397.

[3] Ali, H., M. Arshad., I. U. Jan., M. Zamin., J. Khan., I. Ullah and M. Ali (2019) Influence of various concentrations of gibberellic acid and micronutrients for enhancing growth and flowering of tuberose (*Polianthes tuberosa*). Sarhad Journal of Agriculture, 35(2): 550-556.

[4] Al-Rawi, K. M. and A. M. Khalaf Allah (1980) Design and analysis of agricultural experiments. Ministry of Higher Education and Scientific Research, University of Mosul, Republic of Iraq, (in Arabic).

[5] Atal, H. L., M. Meena and K. P. Kumar (2021) Soil and nutrient management in flower crops. In book: Rese. trends in Hort. Sci., (18).

[6] Bahadoran M., H. Salehi and S. Eshghi (2012) Growth and flowering of tuberosa as affected by adding natural zeolite to the culture medium. J. of Plant Nutrition, 35(10):1491-1496 ·

[7] Davies, P. J. (1995) Plant hormones: Physio., biochemistry and molecular biology. Kluwer Academic Publishers, Dordrecht, the Netherlands.

[8] Desai, S. A., B. B. Patel., S. A. Aklade and C. S. Desai (2020) Performance of tuberose cv. Prajwal as influenced by different plant growth enhancers. Ind. J. Pure App. Biosci., 8(5): 472-477.

[9] Devi, S. R., R. Thokchom and U. C. Singh (2017) Growth, flowering and yield of tuberose (*Polianthes tuberosa* L.) cv. single as influenced by foliar application of $ZnSO_4$ and $CuSO_4$. Inter. J. Current Microbiology and Appl. Sci., 6(10): 735-743.

[10] Dhua, R. S., S. K. Gosh., S. K. Mitra., L. P. Yadav and T. K. Bose (1987) Effect of bulb size, temperature treatment of bulbs and chemicals on growth and flower production in tuberose (*Polianthes tuberose*). Acta horticulturae., 205: 121-128.

[11] Dole, J. M. and H. F. Wilkins (2005) Floriculture Principles and Species. Second Edition, Pearson Education, Inc. Saddle River New Jersey.

[12] Faraji, S., R. Naderi., O. V. Ibadle., T. Basaki., S. N. Gasimov and S. Hosseinova (2011) Effects of post harvesting on biochemical changes in gladiolus cut flowers cultivars white prosperity. Middle-East Journal of Scientific Research, 9(5): 572-577.

[13] Gawai, Y. R., S. Bayaskar and P. N. Davhale. (2020) Effect of plant growth regulators on flowering and quality of tuberose (*polianthes tuberosa* L.), Inter. J. of Current Microbiology and Appl. Sci., 9(1): 989-993.

[14] Hartmann, H. T., D. E. Kester., F. T. Davies and R. I. Geneve (2014) Hartmann & Kester's Plant propagation principles and practices. 8th Edition, Pearson Education, Inc., Published by Pearson Prentice Hall, USA.

[15] Hassan, A. A. and M. M. Abd El-Azeim (2019) Gibberellic acid usage relieving salinity adverse effects on growth, flowering and bulb production of tuberose plants (*Polianthes tuberosa* L.). J. Plant Production Mansoura Univ., 10(12):1051-1058.

[16] Hopkins, W.G. (1999) Introduction to plant physiology. 2nd edition. John John Wiley and Sons, Inc. New York, USA.

[17] Jain, P. (2014) Effect of micronutrients on growth and flowering of tuberose (*Polianthes tuberosa* L.). M.Sc. Thesis, College of Horticulture, Mandsaur, India.

[18] Jat, R. N., S. K. Khandelwal and K. N. Gupta (2007) Effect of foliar application of Urea and Zinc sulphate on growth and flowering parameters in African Marigold (*Tagetes erecta* L.). Journal of Ornamental Horticulture. 10 (4): 271-273.

[19] Kashif, M., K. Rizwan., M.A. Khan and A. Younis (2014) Efficy of macro and micro-nutrients as foliar application on growth and yield of *Dahlia hybrida* L. (Fresco). Int. J. Agric. Bio., 5: 6-10.

[20] Khan, F. N., A. Naznin., K. Ambia and M. M. R. Bhuyin (2020) Effect of varieties and planting materials on growth, flowering and bulb production in tuberose. J. of Ornamental Plants, 10(3): 135-143.

[21] Khan, F. N., A. Naznin., K. Ambia and M. M. R. Bhuyin (2020) Effect of varieties and planting materials on growth, flowering and bulb production in tuberose. Journal of Ornamental Plants, 10(3): 135-143.

[22] Khan, F.N and N. K. Dadlani. (2014) Tuberose (in Bangla). In: Flower production technology and postharvest management. Published by Second Crop Diversification Project, Dept. of Agric. Ext., Khamarbari, Dhaka.: 9-16.

[23] Lakshmi, R. N., M. L. Reddy., B. V. K. Bhagavan., A. V. D. D. Rao., P. Subbaramamma and K. U. Krishna (2020) Response of tuberose (*Polianthes tuberosa* L.) cv. Pajwal to flower inducing chemicals. Inter. J. Current Microbiology and App. Sci., 9(1): 253-262.

[24] Maheswari, T. U. and K. Sivasanjeevi (2019) Response of tuberose (*Polianthes tuberosa* L.) cv. Single to plant

growth regulators. Annals of Plant and Soil Research, 21(1): 48–50.

[25] Mandal, M., S. Maitra and D. Mahata (2018) Production technology of tuberose (*Polianthes tuberosa* L.) cultivation. J. of pharmacognosy and phytochemistry, 7(6): 2360-2364.

[26] Naggar, E. H. A., A. A. M. El–Naggar and M. I. Naglaa (2009) Effct of phosphorus application and gibberellic acid (GA3) on the growth and flwer quality of *Dianthus caryophyllus* L. J. Agric Environ. Sci., 6(4): 400-410.

[27] Naik, D. V., Dhaduk., S. S. Jhambal and D. B. Kapadia (2009) Effect of different micronutrients in gladiolus cv. American Beauty. The Horti. j., 12(4) :274-277.

[28] Nath, M. R. and J. Biswas (2002) Studies on effect of boron on vegetative and reproductive growth in tuberose (*Polianthes tuberosa*) cv. Single. Orissa J. Hort., 30(2): 39-42.

[29] Pathak, S., M. A. Choudhuri and S.K. Chatterjee (1978) Germination and flowering in different-sized bulbs of tuberose (*Polianthes tuberosa* L.). Indian Journal of plant physiology, 23: 47-54.

[30] Raja, K. and V. Palanisamy (2000) Effect of bulb size on growth, flowering and bulb yield in tuberose (*Polianthes tuberosa* L.) cv. Single. South Indian Hort, 50(2): 122-124.

[31] Safeena, S.A., D. S. Priya., A.R. Desai and N.P. Singh. (2015) Ready reckoner on cultivation of tuberose. technical bulletin No: 50. ICAR-Central Coastal Agric. Rese. Inst., Goa, India.

[32] Sajid, M., M. A. Anjum and S. Hussain (2015) Foliar application of plant growth regulators effects growth, flowering, vase life and corm production of *gladiolus grandiflorus* L. under calcareous soil. Bulgarian J Agril. Sci., 21(5):982-989.

[33] Saleh, G. Y. Q. (2012) Spray effect with benzyl adenine gibberellic acid and some micronutrients on growth and seed yield of fungreek plant *Trigonella foenum-graecum* L. Ph. D. Thesis, College of Agriculture and Forestry, University of Mosul, Iraq.

[34] Shampa, U. K. (2013) Influence of bulb size and boron on growth and yield of tuberose. M.Sc. Thesis, Sher-E-Bangla Agricultural University, Dhaka, Bangladesh.

[35] Sheela, V. L. (2008) Flowers for Trade. New India Publishing Agency.

[36] Singh, K. P., T. N. Saha and P. Hollajer (2017) Response of bulb size vegetative growth, flowering and bulb production in tuberose (*Polianthes tuberosa* L.) cv. Phule Rajani. HortFlora Research Spectrum, 6(2): 128-130.

[37] Sudhagar, R., I. Karthikeyan., S. Kamalakannan., S. Kumar and S. Venkatesan (2019) Effect of spacing and zinc application on growth parameters of tuberose (*Polianthes tuberosa* L.) cv. Single. Plant Archives, 19(2): 3620-3622.

[38] Sudhagar, R., I. Karthikeyan., S. Kamalakannan., S. Kumar and S. Venkatesan (2019) Effect of spacing and zinc application on growth parameters of tuberose (*Polianthes tuberosa* L.) cv. Single. Plant Archives, 19(2): 3620-3622.

[39] Taiz, L. and E. Zeiger (2002) Plant Physiology. 3rd ed., Sinauer Associates Publishing, California, USA.

[40] Usman, M. and M. Ashfaq. (2013) Economics analysis of tuberose production in punjab. Pakistan. Sarhad J. Agric., 29(2): 279-284.

[41] Vishwakarma, SH. K. and A. Kumar (2018) Effect of nitrogen, planting distance and bulb size on bulb and bulblets production of tuberose (*polianthes tuberosa* L.) cv. Hyderabad double. Plant Archives, 18(1): 271-274.

[42] Yadav L.P., T. K. Bose and R. G. Maiti (1984) Response of tuberose (*Polianthes tuberosa* L.) to nitrogen and phosphorus fertilization. Indian Agric., 28(1): 53-62.

[43] Zamin, M., A. Muhammad., I. Jan., H. Ullah., S. Shah., M. Amin and H. U. Rashid (2020) Production of Tuberose (*Polianthes tuberosa* L.) as affected by bulb size and planting medium. Sarhad Journal of Agriculture, 36(4): 1156-1161.