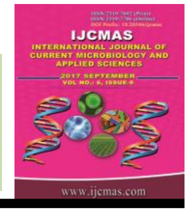
Int.J.Curr.Microbiol.App.Sci (2017) *6*(9): 1639-1652

EXCELLENT PUBLISHERS

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 9 (2017) pp. 1639-1652**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2017.609.202

Response of Growth, Flowering, Concrete Oil and its Component of *Polianthes tuberosa* L. cv. Double to Phosphorus Fertilizer and Gibberellic Acid

S.M. Selim, F.M. Matter, M.A. Hassanain and Samah M. Youssef*

Horticulture Department, Faculty of Agriculture Fayoum University, Egypt
**Corresponding author*

Keywords

Tuberose, Phosphorus fertilizer, Gibberellic acid, Vegetative growth, Flowering production and essential oil.

Article Info

Accepted:
19 July 2017
Available Online:
10 September 2017

A B S T R A C T

The present experiment was performed throughout two successive seasons of 2014/2015 and 2015/2016 at a Private Farm in Fayoum Governorate - Egypt. It intended to find out the individual and the combined effects of phosphorus fertilizer at four levels (20 "is considered as control", 40, 60 and 80 –unit/fed.) and gibberellic acid at four concentrations (control, 75, 150 and 300 ppm) on growth, flower quality, corms production, chemical composition and concrete oil percentage of tuberose (*Polianthes tuberosa*, L.) cv. Double. The results emphasized that using phosphorus fertilizer or gibberellic acid treatments had significant response on all parameters in this study. Likewise, resulted in supported vegetative growth parameters and improved flowers quality, as well as, increased concrete oil percentage and chemical constituents of essential oil, especially using the medium and high levels. Additionally, the interactive between various levels of phosphorus fertilizer and different concentrations of gibberellic acid improved all the studied parameters, particularly using the combinations between phosphorus fertilizers at 60 –unit/fed and together with gibberellic acid at 150 ppm.

Introduction

Tuberose (*Polianthes tuberosa*) is one of the popular and commercially important bulbous flower crops and occupies a prime position in the domestic and international market. Tuberose belongs to family Amaryllidaceae and is a perennial flowering plant popular worldwide as cut flower (Singh and Shanker 2011).The tuberose produces attractive, elegant and fragrant white flowers. It occupies very selective and special position among the ornamental bulbous plants to flower loving people because of its prettiness elegance and pleasantly sweet fragrance (Sood and Nagar 2005). The flowers emit a delightful fragrance and are the source of tuberose oil. The natural flower oil of tuberose is one of the most expensive perfumer's raw materials (Kabir *et al.*, 2011)

Phosphorus and gibberellic acid have been successfully used to modify the assimilate partitioning pattern in tuberose resulting in higher growth, flowering, concrete oil and yield.

Phosphorus is one of the most important nutritional elements for plants and is essential for all biological processes that occur in plant and primary life. Phosphorus is a vital component of DNA, the genetic "memory unit" of all living things. It is also a component of RNA, the compound that reads the DNA genetic code to build proteins and other compounds essential for plant structure, seed yield and genetic transfer. The structures of both DNA and RNA are linked together by phosphorus bonds. The obtained results of Khan *et al.,* (2016) reported that various phosphorus levels significantly affected plant height, number of leaves per plant, number of florets per spike and yield on tuberose. Sabastian *et al.,* (2017) devoted that application of phosphorus at 200 kg ha^{-1} show significant effect on tallest plant (79.63 cm), largest leaf area (113.63 cm^2), longest rachis (43.08 cm), maximum number of florets per spike (15.48), longest spike length (111.57 cm) and maximum vase life (12.65 days) on gladiolus.

GA_3 has the capability of modifying the growth pattern of treated plants by affecting the DNA and RNA levels, cell division and expansion, biosynthesis of enzymes, protein, carbohydrates and photosynthetic pigments (Ibrahim *et al.,* 2010). Sajid *et al.,* (2016) indicated that vegetative growth and flowering attributes were significantly affected by GA_3 treatments on *Chrysanthemum morifolium* (Amin *et al.,* 2017). They reported that a rise in vegetative growth and flowering parameters of tuberose were linearly correlated with the increase of concentration of gibberellic acid.

Therefore, the present investigation was undertaken with the following objectives: to determine the optimum dose of phosphorus, appropriate concentration of GA_3 and the suitable combination of phosphorus and GA_3 on vegetative growth, flowering, concrete oil percentage and chemical constitute of tuberose oil.

Materials and Methods

This trail was conducted to study the effects of different doses of phosphorus (P_2O_5) and spraying with various concentrations of gibberellic acid (GA_3) as well as their complex interactions on growth, flower quality, vase life, corms production, chemical composition and concrete oil percentage of tuberose (*Polianthes tuberosa*, L.) cv. Double. To achieve the mentioned investigation, a field experiment was carried out during two successive seasons 2014/2015 and 2015/2016 in a Private Farm in Fayoum Governorate, Egypt.

Experimental procedures

The corms of tuberose were sown on 15^{th} Marsh 2014 for the first season and 13^{th} Marsh 2015 in the second season. The experimental layout was laid out under split - plot system based on randomized complete blocks design with three replications. The investigation including 16 treatments was divided into four levels of phosphorus (P_2O_5) fertilizer in the main plot and four concentrations of gibberellic acid (GA_3) in the sub-plots. The phosphorus levels and gibberellic acid concentrations were randomly allocated within the main and sub-plots orderly. Before planting the corms were dipped in rizolex fungicide 1 g/ liter of water for 10 minutes. The corms were planted on ridges keeping the distance between ridge to ridge 75 cm and corm to corm 30 cm. The experimental unit consists of 3 lines in each line 10 plants, thus accommodating 30 corms per plot unit. Plot area was 2 × 3.20 = 6.40 m^2. Soil samples of the experimental site were collected prior to the initiation of each experiment and analyzed, results of the analyses as shown in table 1.

Treatments

Phosphorus treatment used as calcium super phosphate (15.5 % P_2O_5) at four levels, corresponding to (20 "is considered as control", 40, 60 and 80 –unit/fed). The full dose of phosphorus was applied at the time of sowing. All treatments in this experiment were fertilized identical doses of nitrogen and potassium at the rate of 163 kg/fed. and 50 Kg/fed., in the form of ammonium sulphate (20.5 % N) and potassium sulphate (48.5 % K_2O), respectively. A nitrogen and potassium fertilizer was added at three equal doses; One third of the fertilizer was applied 45 days after planting of the corms, the second dose was conducted at 60 days after planting of the corms, and remaining 1/3 was applied after 75 days from planting of the corms. Plants were fertilized according to the recommendation of (Selim *et al.*, 2006) on tuberose plant.

Gibberellic acid (GA_3) at four concentrations, corresponding to (control, 75, 150 and 300 ppm). "Tween 20" as a sticking agent was used at the rate of 1 cm /L. Application of GA_3 was carried out as foliar spray twice. The first spray was done after 45 days from planting and the second spray was given 15 days after the first spray. While the control was sprayed with distilled water only. Spraying was done in the latest hours of the day.

Data recorded

Vegetative growth attributes

Plant height, leaf length, number of leaves/plant, leaf area, fresh and dry weights of leaves/plant.

Flowering attributes

Number of days from planting to flowering, the length of spike and rachis, No. of florets/spike, fresh weight of inflorescence/plant and vase life.

Extraction of concrete oil

A concrete is extracted by solvent extraction from the fresh flowers. Freshly picked blossoms, before they open full were collected every day, and weighed and subjected to solvent Hexane. Erlenmeyer flask capacity 500 ml is filled with tuberose blossoms (150 g) and a solvent hexane, the solvent and flower petals were soaked with ratio of 1: 2. After that, tuberose blossoms and solvent were stirred together, in a manner that allows the solvent to be readily and continually in contact with each blossom. Next, the flask was covered with aluminium foil and left it in room temperature for change the color of the petals (Nugrahini *et al.*, 2017). After the extraction, solvent is evaporated. Remainder of evaporation yields waxes, fats, pigments and essential oil called the concrete. Tuberose absolute oils were extracted from concrete with high – proof ethyl alcohol (ethanol absolute) in three successive washings (Guenther 1987). The chemical composition of the tuberose absolutes was analyzed by gas chromatography-mass spectrometry (GC-MS).

GC-MS conditions for tuberose samples

Gas chromatography–mass spectrometry analysis (GC-MS) was carried out using Agilent auto system 7890B GC-MS equipped with HB-5MS capillary column (5% phenyl–95% dimethyl polysiloxane, 30 m × 0.25 mm × 0.25 μm). Carrier gas was helium with flowrate of 1 ml/min. Oven temperature was kept at 50 °C for 5 min, and programmed to 250 °C at a rate of 5°C/min, then fixed at 250 °C for 10 min. The injector, GC–MS interface, ion source and mass detector temperature were maintained at 230, 270, 200 and 150°C, respectively. Mass spectra were taken at 70 eV. Emission current and photomultiplier were 200 μA and 870 V. Scan duration was 0.25 sec. and mass rang was 50–500 Da. 1μl of extract was injected at a split ratio of 1: 50. The ionization of the sample was performed in the EI ion source (70 eV) and the acquisition mass range was set at 35 -

500 amu. Identification of components was based on comparison of their mass spectra (using molecular ion (M+) peak and the m/z values) with those provided in mass spectra library NIST (2007), (Adams 2007) and literature review. The relative peak area percentages were used to report the abundance of a compound in the extracts.

Statistical analysis

All collected data were statistically analyzed according to technique of analysis of variance for split-plot design by Info Stat computer software package (version 2012). The differences among treatment means were compared by Duncan's multiple range as a post hoc test at $P \leq 0.05$ (Snedecor and Cochran, 1994).

Results and Discussion

Vegetative growth attributes

The general and interaction effects of the two examined variables which phosphorus fertilizer doses and gibberellic acid concentrations on growth parameters i.e. plant height, leaf length, number of leaves/plant, leaf area, fresh and dry weights of leaves/plant of tuberose plant are presented in tables 2 and 3.

Comparisons among the various phosphorus rates displayed that, phosphorus fertilizer with any level led to a significant increase in all growth parameters comparing to control. Otherwise, the application of phosphorus fertilizer at rate of 80 -unit/fed. was pioneer and significantly increased plant height (86.31 and 86.90 cm), number of leaves/plant (80.43 and 80.51 leaf/plant) and leaf area (61.35 and 63.07 cm^2) in the first and second seasons, respectively. Whilst, increasing phosphorus fertilizer levels to 80 –unit/fed. did not differ significantly than 60 –unit/fed. on leaf length and fresh weight of leaves/plant the trend was the same in both seasons. Whereas, application of the highest rate of phosphorus (80 –unit/fed.) gave the largest leaves dry weight/plant (27.80 gm) in the first season, on the contrary, in the second season the highest significant value of leaves dry weight/plant was detected for 60 –unit/fed.

Concerning the gibberellic acid concentrations obviously, results collectively devoted that gibberellic acid exerted a positive effect on vegetative growth parameters. Likewise, spraying high concentrate (300 ppm) of gibberellic acid gave the highest values of number of leaves/plant, leaf area, as well as, fresh and dry weights of leaves/plant. Nevertheless, the highest significant values of plant height and leaf length were detected by 150 ppm of gibberellic acid the trend was the same in both seasons.

The combined influence of phosphorus fertilizer levels and gibberellic acid concentrations seemed to be more significant influence on all parameters in this study. Furthermore, the highest mean values of vegetative growth characteristics such as plant height, leaf length, number of leaves/plant, as well as, fresh and dry weights of leaves/plant were recorded when phosphorus fertilizer level at 60 –unit/fed. and gibberellic acid concentration at 150 ppm combined together in both seasons. While, the highest mean values of leaf area were detected by application of phosphorus fertilizer at high rate with gibberellic acid at high concentration.

In conclusion, utilizing phosphorus increased all vegetative growth parameters of tuberose plant i.e. plant height, leaf length… etc. This effect may be attributed to that phosphorus considered an important constituent in energy rich compounds and thus an indispensable element in energy metabolism. This is involved in the synthesis of growth stimulating compound absorption of nutrients, cell division and cell growth (Chandana and Dorajeerao, 2014), consequently contributes in vigorous growth. These observations and findings in the present investigation are in conformity with those reported earlier by (Alkurdi ,2014) on *Helichrysum bractum* and (Negahban *et al.*, 2014) on Mexican marigold.

On the other hand, plants spraying with gibberellin also caused as increase in plant vegetative growth characters. This effect may be interpreted efficiency of the gibberellic acid to increase in level of auxin causing increasing cell division and cell elongation (Taiz and Zeiger, 1998), consequently promotes growth. These results are in close conformity with the findings of Wagh *et al.*, (2012) and Singh *et al.*, (2013) on tuberose.

Flowering attributes

Results of the impact of phosphorus fertilizer at various rates, gibberellic acid at different concentrations and their interaction on flowering characters are shown in tables 4 and 5.

As for the effect of phosphorus fertilizer on number of days from planting to flowering, the length of spike and rachis, No. of florets/spike, fresh weight of inflorescence /plant and vase life, data recorded that phosphorus fertilizer treatments significantly affected on flowering characters in both seasons. Furthermore, phosphorus fertilizer at 40, 60 and 80 –unit/fed. caused a decrement in the time required from planting to flowering comparing with that scored from plants which received 20 –unit/fed. (Control) in the two seasons. Otherwise, 60 –unit/fed. application with phosphorus fertilizer occupied the first rank for early flowering, gave highest values of length of spike and rachis, fresh weight of inflorescences in both seasons and number of florets /spike in the second season only. However, further increase of phosphorus fertilizer rate to 80 –unit/fed. did not promote these parameters to go forward. on the contrary, the increment in vase life in both seasons and number of florets /spike in the first season between 60 and 80 –unit/fed. Did not reach the level of significance.

Regarding the effect of gibberellic acid concentrations, results reflected that the flowering parameters were significantly affected by any concentrations of gibberellic acid comparing to control. Likewise, foliar application of gibberellic acid at 150 ppm resulted in significantly decreased in number of days from planting to flowering, the highest mean values of length of spike and rachis, number of florets /spike and fresh weight of inflorescence. Whereas, the highest values of vase life were observed by 300 ppm of gibberellic acid and the trend was the same in both seasons.

The impact of interaction between the two studied factors (phosphorus fertilizer and gibberellic acid) on flowering parameters was significant in the two experimental seasons. Furthermore, the combined soil application of phosphorus fertilizer at 60 –unit/fed. together with foliar application of gibberellic acid at 150 ppm significantly achieved the increase in length of spike and rachis, number of florets /spike and fresh weight of inflorescence in both seasons. However, the decrease in number of days from planting to flowering was achieved when application of phosphorus fertilizer at 80 –unit/fed. With gibberellic acid at 150 ppm. In addition the longest vase life was recorded by treatment of phosphorus fertilizer at 60 –unit/fed. or 80 –unit/fed. together with 300 ppm gibberellic acid, whereas, the difference in vase life between two treatments was at par.

Table.1 Analysis of the soil sample of the experimental filed before sowing

Seasons	Texture	Soluble cations (meq/L)				Soluble anions (meq/L)				pH	Ec (ds/m)	N %	P %	K %
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	Co_3^{--}					
2014/15	Sandy clay Loam	8.10	7.71	14.31	0.52	16.42	0.88	16.77	0.07	7.9	3.51	0.20	0.22	0.37
2015/16		7.93	6.77	13.33	0.51	16.70	0.89	17.10	0.02	7.79	3.46	0.19	0.24	0.38

Table.2 Mean values of plant height, leaf length in (cm) and number of leaves/plant as affected by phosphorus fertilizer and gibberellic acid, as well as, their interactions during 2014/15 and 2015/16 growing seasons

Treatment \ Character		Plant height		Leaf length		No. of leaves/plant	
Phosphorus (P)		2014/15	2015/16	2014/15	2015/16	2014/15	2015/16
P1 (20)		65.72^{D}	66.56^{D}	46.06 ^{C}	46.70^{C}	71.11^{D}	72.14 ^{D}
P2 (40)		69.04^{C}	69.89^{C}	48.06 ^{B}	48.93^{B}	72.85^{C}	73.60 ^{C}
P3 (60)		78.60^{B}	79.63^{B}	53.16 ^{A}	53.82^{A}	78.50 ^{B}	79.11 ^{B}
P4 (80)		86.31^{A}	86.90 ^{A}	52.63 ^{A}	53.64^{A}	80.43 ^{A}	80.51 ^{A}
Gibberellin (G)							
G1 (0)		64.54^{D}	65.41^{D}	43.61 ^{D}	44.53^{D}	69.10^{D}	69.94^{D}
G2 (75)		72.71^{C}	73.51^{C}	47.55 $_{C}$	48.49^{C}	73.58^{C}	72.19 ^{C}
G3 (150)		81.75^{A}	82.52^{A}	54.83 ^{A}	55.49^{A}	79.67^{B}	80.26^{B}
G4 (300)		80.67^{B}	81.53^{B}	53.93 ^{B}	54.57^{B}	80.54^{A}	80.97^{A}
(P x G) interaction							
P1	G1	58.55 ^{M}	59.38 ^{M}	41.15 ^{K}	41.94 ^{J}	66.11^{H}	66.95^{K}
	G2	63.93^{K}	64.31^{K}	44.11 ^{I}	44.80^{I}	70.31 ^{G}	70.92 ^{I}
	G3	66.98^{I}	67.80$_{I}$	48.09 ^{G}	48.43^{G}	72.92 ^{F}	73.96 ^{G}
	G4	73.44^{G}	74.73^{G}	50.89 ^{E}	51.63^{EF}	75.11 ^{E}	76.74 ^{E}
P2	G1	61.57 ^{L}	62.14 ^{L}	42.71 ^{J}	43.44^{I}	66.93 ^{H}	68.01 ^{J}
	G2	67.17 ^{I}	68.03^{I}	45.99 ^{H}	46.95^{H}	71.42 ^{G}	72.44 ^{H}
	G3	71.38^{H}	72.40^{H}	49.73 ^{F}	50.78^{EF}	74.86 ^{E}	75.50 ^{F}
	G4	76.03^{F}	76.97 ^{F}	53.80 ^{D}	54.53^{D}	78.21 ^{D}	78.47 ^{D}
P3	G1	65.16^{J}	66.23^{J}	43.80 ^{IJ}	44.77^{I}	70.35 ^{G}	71.37 ^{I}
	G2	71.89 ^{H}	72.71 ^{H}	49.66 ^{F}	50.33^{F}	74.77 ^{E}	75.40 ^{F}
	G3	95.07^{A}	96.23 ^{A}	63.51 ^{A}	64.08^{A}	86.14 ^{A}	86.77 ^{A}
	G4	82.27^{E}	83.35 ^{E}	55.67 ^{C}	56.09 ^{C}	82.72 ^{C}	82.88 ^{C}
P4	G1	72.86^{G}	73.89 ^{G}	46.77 ^{H}	47.98^{GH}	73.01 ^{F}	73.45 ^{GH}
	G2	87.87^{D}	89.00^{D}	50.42 ^{EF}	51.87^{E}	77.82 ^{D}	77.99 ^{D}
	G3	93.56^{B}	93.66^{B}	57.97 ^{B}	58.67 ^{B}	84.78 ^{B}	84.81 ^{B}
	G4	90.94^{C}	91.07 ^{C}	55.37 ^{C}	56.04 ^{C}	86.13^{A}	85.80 ^{AB}

Means in the same column with a common capital letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's multiple range test.

Table.3 Mean values of leaf area (cm^2), fresh and dry weight of leaves/plant (gm) as affected by phosphorus fertilizer and gibberellic acid, as well as, their interactions during 2014/15 and 2015/16 growing seasons

Character / Treatment		F.W. of leaves/plant		D.W. of leaves/plant		leaf area	
		2014/15	2015/16	2014/15	2015/16	2014/15	2015/16
Phosphorus (P)							
P1 (20)		241.97 C	246.41 C	19.96 D	22.22 D	52.71 D	54.55 D
P2 (40)		257.41 B	263.63 B	22.78 C	24.65 C	56.12 C	57.24 C
P3 (60)		283.39 A	290.22 A	27.40 B	29.17 A	60.08 B	61.49 B
P4 (80)		284.90 A	289.28 A	27.80 A	28.21 B	61.35 A	63.07 A
Gibberellin (G)							
G1 (0)		237.73 D	229.86 D	19.75 D	21.35 C	51.09 D	54.09 D
G2 (75)		237.73 C	243.66 C	21.57 C	23.26 B	55.31 C	57.14 C
G3 (150)		300.03 B	305.52 B	28.15 B	29.60 A	58.82 B	60.20 B
G4 (300)		303.38 A	310.48 A	28.46 A	30.05 A	65.04 A	64.91 A
(P x G) interaction							
P1	G1	220.52 J	223.09 J	17.66 L	19.50 H	48.13 J	50.83 M
	G2	227.24 IJ	228.55 IJ	18.55 K	20.57 G	50.90 HI	53.00 L
	G3	250.98 G	256.89 F	20.84 HI	23.11 F	54.84 G	55.30 K
	G4	269.14 F	277.10 E	22.78 G	25.69 E	56.96 F	59.05 G
P2	G1	224.53 J	229.38 IJ	19.32 J	21.06 G	49.57 IJ	52.79 L
	G2	231.85 I	238.26 GH	20.31 I	23.06 F	52.80 GH	55.13 K
	G3	273.60 F	279.33 E	24.35 F	26.17 E	57.40 F	58.02 H
	G4	299.66 E	307.53 D	27.13 E	28.32 D	64.72 B	63.00 D
P3	G1	227.58 IJ	232.92 HI	21.01 H	23.73 F	52.81 GH	55.67 J
	G2	241.68 H	244.66 G	22.64 G	23.04 F	57.81 EF	59.68 F
	G3	352.84 A	359.72 A	35.29 A	37.14 A	61.02 CD	62.69 D
	G4	311.44 D	323.56 C	30.67 D	32.77 BC	68.70 A	67.92 B
P4	G1	233.47 I	234.06 HI	21.01 H	21.09 G	53.85 G	57.07 I
	G2	250.16 G	263.17 F	24.77 F	26.36 E	59.74 DE	60.75 E
	G3	322.67 C	326.13 C	32.12 C	31.99 C	62.03 C	64.80 C
	G4	333.27 B	333.74 B	33.28 B	33.42 B	69.79 A	69.66 A

Means in the same column with a common capital letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's multiple range test.

Table.4 Mean values of No. of days from planting to flowering (day), vase life (day) and length of spike (cm) as affected by phosphorus fertilizer and gibberellic acid, as well as, their interactions during 2014/15 and 2015/16 growing seasons

Treatment \ Character		No. of days from planting to flowering		Vase life		length of spike	
		2014/15	2015/16	2014/15	2015/16	2014/15	2015/16
Phosphorus (P)							
P1 (20)		125.76 D	128.03 D	12.87 C	14.15 C	56.78 D	57.36 D
P2 (40)		123.32 C	125.38 C	14.22 B	14.76 B	59.07 C	59.77 C
P3 (60)		94.67 A	98.53 A	20.10 A	20.58 A	63.94 A	64.67 A
P4 (80)		111.57 B	113.34 B	20.07 A	20.55 A	60.31 B	61.40 B
Gibberellin (G)							
G1 (0)		120.76 D	122.96 D	12.04 D	12.63 D	52.87 C	53.64 D
G2 (75)		116.98 C	118.96 C	16.21 C	16.92 C	58.08 B	58.98 C
G3 (150)		104.36 A	108.34 A	16.21 B	19.47 B	64.53 A	65.60 A
G4 (300)		113.22 B	115.03 B	20.34 A	21.02 A	64.62 A	64.98 B
(P x G) interaction							
P1	G1	129.48 H	131.40 I	11.35 L	12.10 K	51.78 K	51.29 J
	G2	126.80 GH	128.98 HI	12.22 JK	13.49 I	55.99 H	56.79 G
	G3	122.99 F	125.50 G	13.57 H	14.99 G	58.93 F	59.97 F
	G4	123.76 FG	126.24 GH	14.34 G	16.03 F	60.42 E	61.40 E
P2	G1	126.82 GH	129.36 HI	12.00 KL	12.36 JK	52.74 J	53.38 I
	G2	125.60 FG	127.05 GH	13.06 HI	14.35 H	57.59 G	57.94 G
	G3	118.45 E	120.79 F	15.07 F	15.25 G	60.39 E	61.75 E
	G4	122.43 F	124.35 G	16.73 E	17.08 E	65.57 C	66.01 C
P3	G1	99.39 C	101.78 D	12.06 JK	12.74 J	54.19 I	55.33 H
	G2	97.39 C	99.27 CD	20.19 C	20.63 C	63.37 D	64.53 D
	G3	88.00 A	97.25 BC	22.91 B	23.60 B	71.10 A	72.34 A
	G4	93.91 B	95.83 B	25.24 A	25.35 A	67.11 B	66.49 C
P4	G1	127.36 GH	129.30 HI	12.74 IJ	13.31 I	52.76 J	54.58 HI
	G2	118.12 E	120.54 F	19.39 D	19.20 D	55.39 H	56.66 G
	G3	88.01 A	89.83 A	23.07 B	24.05 B	67.70 B	68.34 B
	G4	112.77 D	113.70 E	25.06 A	25.63 A	65.37 C	66.03 C

Means in the same column with a common capital letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's multiple range test.

Table.5 Mean values of length of rachis (cm), No. of florets /spike and F.W. of inflorescences(gm) as affected by phosphorus fertilizer and gibberellic acid, as well as, their interactions during 2014/15 and 2015/16 growing seasons

Character / Treatment		length of rachis		No. of florets /spike		F.W. of inflorescences	
Phosphorus (P)		2014/15	2015/16	2014/15	2015/16	2014/15	2015/16
P1 (20)		67.89 D	68.47D	43.71 C	44.69 D	85.71 D	86.18 D
P2 (40)		70.13 C	70.98 C	44.69 B	45.77 C	89.58 C	90.61 C
P3 (60)		75.05 A	75.78 A	50.97 A	51.75 A	111.13 A	112.27 A
P4 (80)		71.42 B	72.52 B	50.40 A	51.16 B	108.11 B	109.07 B
Gibberellin (G)							
G1 (0)		63.99 C	64.82 D	39.93 D	41.03 D	86.89 D	87.66 D
G2 (75)		69.13 B	70.14 C	46.75 C	47.52 C	93.70 C	94.54 C
G3 (150)		75.65 A	76.71 A	51.92 A	52.66 A	110.38 A	111.44 A
G4 (300)		75.73 A	76.08 B	51.17 B	52.16 B	103.57 B	104.49 B
(P x G) interaction							
P1	G1	62.88 K	62.39 K	38.70 K	39.85 J	82.63 L	82.87 L
	G2	67.10 H	67.94 H	41.85 I	42.45 HI	84.78 K	85.06 K
	G3	70.04 F	71.08 F	46.01 G	47.14 F	88.40 I	88.90 I
	G4	71.54 E	72.48 E	48.26 F	49.32 E	87.02 IJ	87.91 IJ
P2	G1	63.88 J	64.76 J	38.55 K	39.48 J	82.87 L	84.18 K
	G2	68.44 G	69.19 G	43.86 H	45.00 G	86.39 JK	87.50 J
	G3	71.53 E	72.86 E	47.92 F	49.08 E	93.05 H	94.08 H
	G4	76.68 C	77.12 C	48.42 F	49.54 E	96.02 G	96.69 G
P3	G1	65.31 I	66.44 I	40.62 J	41.76 I	95.58 G	96.55 G
	G2	74.48 D	75.63 D	50.83 E	51.66 D	99.29 F	99.92 F
	G3	82.20 A	83.45 A	57.84 A	58.26 A	135.82 A	137.50 A
	G4	78.22 B	77.60 C	54.59 C	55.30 C	113.84 D	115.09 D
P4	G1	63.88 J	65.69 IJ	41.86 I	43.02 H	86.46 JK	87.02 J
	G2	66.50 H	67.81 H	50.44 E	50.96 D	104.34 E	105.70 E
	G3	78.81 B	79.44 B	55.91 B	56.17 B	124.25 B	125.27 B
	G4	76.49 C	77.13 C	53.42 D	54.48 C	117.39 C	118.29 C

Means in the same column with a common capital letter (s) are not significantly different ($p \leq 0.05$) according to Duncan's multiple range test.

Table.6 GC–MS data of some major constituents detected in tuberose oil as affected by soil application of phosphorus fertilizer combined with gibberellic acid spraying during 2014/15 and 2015/16 growing seasons

R.T. (min)	Identified compounds	Relative peak area %							
		2014/15				2014/15			
		P1×G 1	P3×G 4	P4×G 3	P3×G 3	P1×G 1	P3×G 4	P4×G 3	P3×G 3
29.33	Geraniol	1.30	4.73	5.27	5.28	1.21	4.94	5.53	5.41
30.47	Methyl benzoate	12.88	13.20	12.90	14.92	12.80	12.93	12.71	15.36
30.60	Farnesol	2.64	4.46	1.78	2.68	2.44	4.51	1.65	2.49
31.95	Benzyl benzoate	8.92	12.10	12.34	12.54	9.15	11.77	12.65	12.92
36.58	Methyl anthranilate	4.40	6.94	8.65	6.64	5.90	7.41	7.19	6.87
38.43	Indole	3.88	4.09	4.36	1.35	3.16	5.63	4.57	1.79
39.19	Benzaldehyde	2.12	1.07	1.09	1.98	2.13	1.02	1.44	1.80
40.20	Cineol	3.53	4.42	4.46	4.22	3.63	4.26	4.63	4.40
41.90	Eugenol	2.32	2.86	2.91	2.83	2.35	2.41	2.25	2.85
44.18	β -Pinene	0.94	1.07	0.82	2.20	1.32	1.05	0.67	2.19
45.11	Benzoic acid	1.97	2.58	2.48	2.15	2.04	2.41	2.18	2.09
45.96	Benzyl salicylate	2.26	3.44	3.21	4.66	2.56	3.29	3.29	4.50
48.92	Nerol	1.04	1.72	1.09	1.15	1.34	1.21	1.31	1.16

Identifications were carried out using NIST library (2007), Adams (2007) and literature review.
R.T. (min): Retention time. (Minute).
P1 × G1 = 20 –unit/fed. With distillate water (Control).
P3 × G4 = 60 –unit/fed. With 300 ppm.
P4 × G3 = 80 –unit/fed. With 150 ppm.
P3 × G3 = 60 –unit/fed. With 150 ppm.

Fig.1 Effect of soil application of phosphorus fertilizer combined with gibberellic acid spraying on concrete oil % of tuberose flowers in 2014/15 season

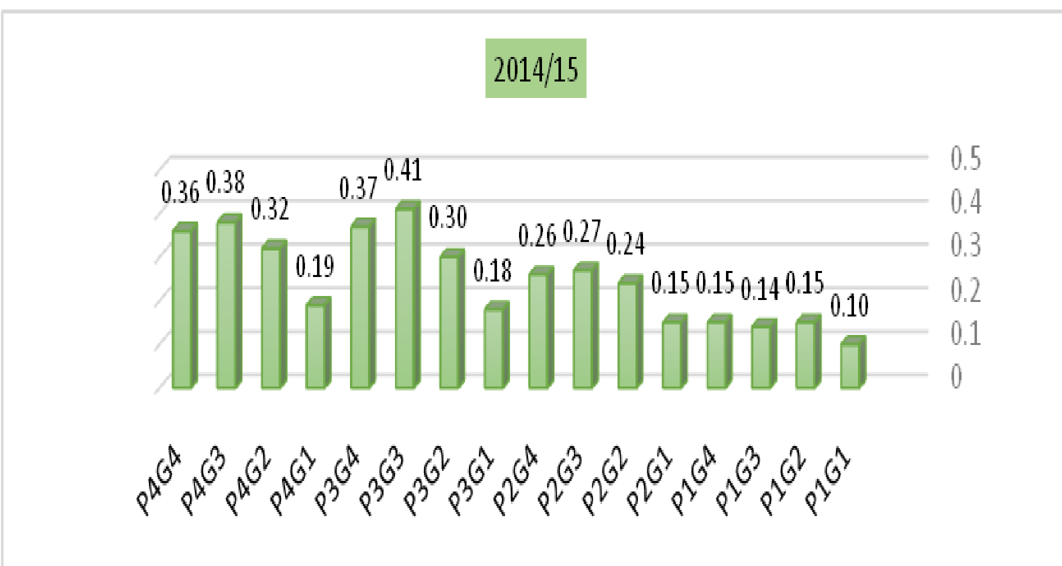
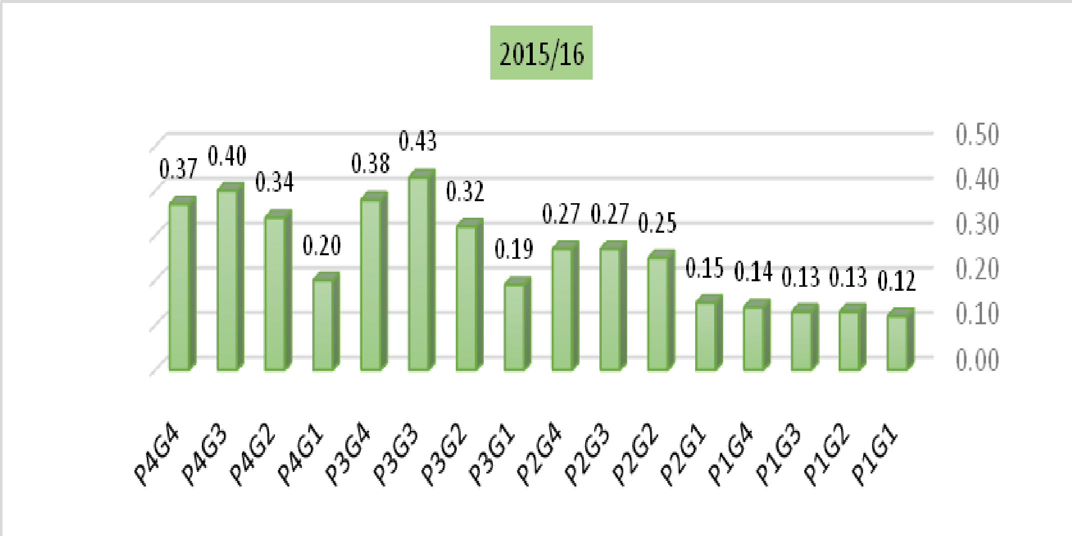


Fig.2 Effect of soil application of phosphorus fertilizer combined with gibberellic acid spraying on concrete oil % of tuberose flowers in 2015/16 season



In conclusion, soil application with phosphorus markedly enhanced all flowering quality of tuberose plant like length of spike, length of rachis ……etc. This influence might be due to the fact that sulphur in the single super phosphate which might have participated in higher protein synthesis and thus improved the vegetative growth responsible for more dry matter accumulation and partitioning of nutrient toward the developing flowering attributes (Kumar and Misra 2003). Similar reports were earlier published by Shaukat *et al.,* (2012) on gladiolus and Gangwar *et al.,* (2013) on tuberose.

On the other hand, plants sprayed with gibberellin also promoted in flowering quality. Whereas, reduction of days from planting to flowering this reduction may be due to early flower primordial development, cell differentiation and early utilization of nutrients. Furthermore, GA_3 reduced the vegetative period and higher capacity of cell division and elongation, resulting in induction of early flower development. Favorable effect of application of gibberellins on increase the other parameters might be due to improved physiological efficiency, selective ion uptake, sufficient water uptake causing high rate of accumulate deposition (Iqbal *et al.,* 2011), consequently contributes in vigorous flower. Our results are also in agreement with those by Kumar *et al.,* (2013) on tulip and Jamil *et al.,* (2015) on hippeastrum.

Concrete oil

Concrete oil percentage

Figures 1 and 2 illustrate the results of concrete oil as affected by phosphorus fertilizer levels combined with gibberellic acid concentrations during the two experimental seasons.

Comparisons among the mean values of the interaction between phosphorus fertilizer levels and gibberellic acid concentrations, generally results indicated that whole collection between the two studied factors marked increases in concrete oil percentage, as compared to the control treatment.

Likewise, utilize of phosphorus fertilizer at 60 –unit/fed. Together with gibberellic acid at

150 ppm gave the considerable percentage of concrete oil, followed by phosphorus fertilizer at 80 –unit/fed. with gibberellic acid at 150 ppm then phosphorus fertilizer at 60 – unit/fed. With gibberellic acid at 300 ppm in both seasons.

The greatest increase in the concrete oil percentage was observed with the tuberose plants applied with phosphorus fertilizer, this is because utilize phosphor might have been due to the increase in the synthesis of tricycle-glycerol from glycerol-3- phosphate – the precursor to the syntheses of mevalonic acid and isoprene (C_5H_8) that constituted the building blocks of the main components of essential oil (terpenoids). In addition, now that phosphorus makes up the building blocks of the phosphoenolpyruvate (PEP) molecule it plays a significant role in the formation of aromatic compounds (Qadry 2010).These results are in harmony with those obtained by Erbas *et al*., (2017) on lavandin and Jeshni *et al.*, (2017) on german chamomile.

Gibberellic acid resulted in higher concrete oil percentage compared to control, this is because the application of GA3 may affect essential oils due to their effects on enzymatic pathways of terpenoids biosynthesis (Prins *et al.*, 2010).Furthermore, gibberellic acid can influence essential oil production through effects on plant growth, metabolic activity within pathways leading to accumulation of secondary metabolites, essential oil biosynthesis and the number of oil storage structures (Sharafzadeh and Zare, 2011). These results are in close conformity with the findings by Metwally *et al.*, (2016) on *Lathyrus odoratus* and Ibrahim (2017) on carnation.

Chemical composition of essential oil

The data presented in table 6 illustrate the influence of adding various rates of phosphorus fertilizer combined with different concentrations of gibberellic acid on several constituents of essential oil during 1st and 2nd seasons.

It is obvious from the GC/MS analyses that, the scent in all interactions was strongly dominated by the benzenoid compounds like this methyl benzoate, benzyl benzoate, methyl anthranilate, indole, benzaldehyde, eugenol, benzoic acid and benzyl salicylate followed in descending order by monoterpene hydrocarbons such as geraniol, cineol, β – pinene and nerol then sesquiterpene hydrocarbons as farnesol during the two successive seasons.

In this concern, the results described above confirmed that, the impact of interactions between P3×G3, P4×G3 and P3×G4 gave a pronounced increase of the benzenoid compounds, monoterpenes and sesquiterpenes hydrocarbons over the control treatment in both seasons.

In the study, the main components of the essential oil of tuberose consisted of the benzenoid compounds like this methyl benzoate > benzyl benzoate > methyl anthranilate > indole > benzyl salicylate were identified as major components. Furthermore, the fact that tuberose oil comprised the benzenoid compounds was also reported by (Maiti *et al.*, 2014).

References

Adams, R.P., 2007. Identification of essential oil components by gas chromatography/mass spectroscopy, 3rd edition, IL, USA: Allured Publishing Corporation.

Alkurdi, M.I.S., 2014. Impact of nitrogen and phosphorus efficiency on the growth and flowering of *Helichrysum bractum*. Journal of Agriculture and Veterinary Science, 7 (2): 7 – 12.

Amin, M.R., Pervin, N., Nusrat, A., Mehraj, H. and Jamal Uddin, A.F.M. 2017. Effect of plant growth regulators on growth and flowering of tuberose (*Polianthes tuberosa* L.) cv. single. Journal of Bioscience and Agriculture Research, 12 (01): 1016 - 1020.

Chandana, K., and Dorajeerao, A.V.D. 2014. Effect of graded levels of nitrogen and phosphorus on growth and yield of gladiolus (*Gladiolus grandifloras* L.) cv. White prosperityincoastala. P., India. Plant Archives 14 (1): 143 – 150.

Erbas, S., Kucukyumuk, Z., Baydar, H., Erdal, I. and Sanl, A. 2017. Effect of different phosphorus doses on nutrient concentrations as well as yield and quality characteristics of lavandin (Lavandula × intermedia Emeric ex Loisel. Var. Super). Turk J. Field Crops, 22 (1): 32 – 38.

Gangwar, A.P.S., Singh, J.P. and Singh, I.P. 2013. Influence of nitrogen and phosphorus fertilizers with nitrogen sources on floral parameters of tuberose (*Polianthes tuberosa* L.). Hort. Flora. Research Spectrum, 2 (1): 40 - 44.

Guenther, E., 1987. The essential oils. Universitas Indonesia Press. Jakarta. Part I, pages 695 - 709.

Ibrahim, M.E., 2017. Trials on the application of fertilization combined with plant hormone spraying for improving the production of carnation (*Dianthus caryophyllus* L.) absolute oil. Journal of Materials and Environmental Sciences, 8 (4): 1284 – 1290.

Ibrahim, S.M.M., Taha, L.S. and Farahat, M.M. 2010. Vegetative growth and chemical constituents of croton plants as affected by foliar application of benzyl adenine and gibberellic acid. Journal of American Science, 6 (7): 126 – 130.

Iqbal, N., Nazar, R., Iqbal, M., Khan, R., Masood, A. and Khan, N.A. 2011. Role of gibberellins in regulation of source–sink relations under optimal and limiting environmental conditions. Curr. Sci., 100 (7): 998 – 1007.

Jamil, M.K., Rahman, M.M., Hossain, M.M., Hossain, M.T. and Karim, A.J.M. 2015. Effect of plant growth regulators on flower and bulb production of hippeastrum (*Hippeastrum hybridum*). Bangladesh J. Agril. Res., 40 (4): 591 – 600.

Jeshni, M.G., Mousavinik, M., Khammari, I. and Rahimi, M. (2017). The changes of yield and essential oil components of german chamomile (*Matricaria recutita* L.) under application of phosphorus and zinc fertilizers and drought stress conditions. Journal of the Saudi Society of Agricultural Sciences, 16: 60 – 65.

Kabir, A.K.M.R., Iman, M.H., Mondal, M.M.A. and Chowdhury, S. 2011. Response of tuberose to integrated nutrient management. J. Environ. Sci. and Natural Res., 4 (2): 55 - 59.

Khan, S., Jan, I., Iqbal, J., Iqbal, S., Shah, S.H.A. and Khan, A.A. 2016. Influence of phosphorus and bulb size on flower and bulblet production of tuberose. American-Eurasian J. Agric. and Environ. Sci., 16 (1): 191 - 197.

Kumar, R., Ahmed, N., Singh, D.B., Sharma, O.C., Lai, S. and Salmani, M.M. 2013. Enhancing blooming period and propagation coefficient of tulip (*Tulipa gesneriana* L.) using growth regulators. African Journal of Biotechnology, 12 (2): 68 – 74.

Kumar, R., and Misra, R. L. 2003. Response of gladiolus to nitrogen, phosphorus and potassium fertilization. Journal of Ornamental Horticulture, 6: 95 – 99.

Maiti, S., Moon, U.R., Bera, P., Samanta, T. and Mitra, A. 2014. The in vitro antioxidant capacities of *Polianthes tuberosa* L. flower extracts. Acta Physiol. Plant., 36 (10): 2597 – 2605.

Metwally, S.A., Ibrahim, G.E., Abo-Leila, B.H. and Hussein, A.M.S. 2016. Effect of gibberellic acid and progesterone on growth, vase life and volatile component of *Lathyrus odoratus* plant. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 7 (3): 2307 – 2317.

Negahban, M., Aboutalebi, A. and Zakerin, A.

2014. The effect of phosphorus on the growth and productivity of mexican marigold (*Tagetes minuta* L.). Russian Journal of Biological Research, 2 (2): 93 – 99.

Nugrahini, A.D., Ristanti, A.L. and Jumeri, M.W. 2017. Characterization of essential oils from tuberose flowers waste (*Polianthes tuberosa* L.). Journal of Advanced Agricultural Technologies, 4 (1): 53 – 56.

Prins, C.I., Vieira, J.C. and Freitas, S.P. 2010. Growth regulators and essential oil production. Braz. J. Plant Physiol., 22 (2): 91 – 102.

Qadry, J.S., 2010. Pharmacognosy text book, 16th Ed., Somya Printers. Delhi- India, 5.

Sabastian, K.S., Keditsu, R., Moyon, N.N., Dakho, J. and Hemanta, L. 2017. Graded level of phosphorus on growth and flowering of gladiolus cv. White (*Gladiolus grandifloras*). International Journal of Technical Research and Science, 2 (1): 62 – 64.

Sajid, M., Amin, N., Ahmad, H. and Khan, K. 2016. Effect of gibberellic acid on enhancing flowering time in *Chrysanthemum morifolium*. Pak. J. Bot., 48 (2): 477 – 483.

Selim, S.M., Abdella, E.M., Ahmed, Z.H. and Matter, F.M.A. 2006. Physiological effects of nitrogen soil application and zinc foliar spray and their interaction on growth, flowering, bulbs and chemical composition of (*Polianthes tuberosa* L.) cv. Double. Annals of Agric. Sci. Moshtohor, 44 (3): 1223 – 1238.

Sharafzadeh, S., and Zare, M. 2011. Influence of growth regulators on growth and secondary metabolites of some medicinal plants from Lamiaceae family. Advances in Environmental Biology, 5 (8): 2296 – 2302.

Shaukat, S.A., Ali Shah, S.Z., Ishaq, Y., Ahmed, M., Shaukat, S.K. and Shoukat, S.W. 2012. Influence of phosphorus fertilization on gladiolus corm and flower production. Scientific Journal of Agricultural, 1 (5): 105 – 111.

Singh, A.K., and Shankar, K. 2011. Effect of plant growth regulators on vegetative growth and flowering behavior of tuberose (*Polianthes tuberosa* L.) cv. Double. Plant Arch., 11 (2): 919 - 921.

Singh, P.K., Singh, D.B. and Singh, S.N. 2013. Effect of GA3 and NAA on plant growth, flowering, bulb production and vase life of tuberose (*Pollianthes tuberosa* L.) cv. Single. Research in Environment and Life Sciences, 6 (4): 137 – 140.

Snedecor, G.W., and Cochran, W.G. 1994. Statistical methods 8th edition. Affiliated East - West press and Iowa State University press.

Sood, S., and Nagar, P.K. 2005. Alteration in endogenous polyamines in bulbous of tuberose (*Polianthes tuberose* L.) during dormancy. Sci. Hort., 105 (4): 483 - 490.

Taiz, L., and Zeiger, E. 1998. Plant Physiology. Sinauer Associate Inc. Publishers. 2nd. Ed. p. 792.

Wagh, V.K., Chawla, S.L., Gaikwad, A.R. and Parolekar, S.S. 2012. Effect of bulb size and GA3 on vegetative and floral characters of tuberose (*Polianthes tuberosa* L.) cvs. Prajwal and Calcutta single. Progressive Horticulture, 44 (1): 27 – 31.

How to cite this article:

Selim, S.M., F.M. Matter, M.A. Hassanain and Samah M. Youssef. 2017. Response of Growth, Flowering, Concrete Oil and Its Component of *Polianthes tuberosa* L. cv. Double to Phosphorus Fertilizer and Gibberellic Acid. *Int.J.Curr.Microbiol.App.Sci.* 6(9): 1639-1652.
doi: https://doi.org/10.20546/ijcmas.2017.609.202