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Effect of Phosphorus Application and Gibberellic Acid (GA_3) on the Growth and Flower Quality of *Dianthus caryophyllus* L.

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Abstract: This work was carried out during two successive seasons of 2007 and 2008, at the new reclaimed lands of Noubaria region Alexandria, Egypt under greenhouse conditions to investigate the effect of different concentrations of GA_3 (0. 0, 25, 50 and 100 ppm) with the Orthophosphoric acid (H_3PO_3) rates (0. 0, 50,100 and 200 ppm of P_2O_5) on the growth and flower quality of *Dianthus caryophyllus* cv. "Red Sim" plants. The results showed that spraying the plants with GA_3 solely or in combination with the different rates of P-fertilizer stimulated the growth and flower production and quality, compared to the control plants. The highest values of vegetative growth and flowering parameters were obtained by application of 50 ppm GA_3 in combination with 100 ppm P_2O_5. Moreover, total chlorophyll, carotenoides, total carbohydrates and phosphorus contents in the leaves were significantly increased as a result of spraying GA_3 and P- fertilizer, compared to the untreated plants (control).

Key words: Carnation · Flower production · Gibberellic acid (GA3) · Phosphorus · Greenhouse conditions

INTRODUCTION

Ancestors of the greenhouse carnation (*Dianthus caryophyllus* L. Caryophyllaceae) originally were native to the Mediterranean region; however it can be production over the entire world in greenhouse. The commercial production of carnation plants is very important to the florist industry of Egypt. A commercial carnation plant is capable to produce 10 to 20 flowers per year. Each flowering stem originates from a "break" or "shoot" that emerged from a one side of lower stem node. A typical flowering stem would develop at 15 to18 nodes with two opposite leaves at each node. The leaf pairs on the nodes alternated at 180° up the stem, so that leaves extend in two planes [1]. It has been reported that P delayed plant growth and the young leaves become very dark green in color. In some cases, purpling was noted especially of the underside of the older leaves. When the phosphorus was applied to the soils, to prevent phosphorus deficiency, there were possibilities of reacting with soil active calcium and magnesium to form of precipitated phosphate salts which were unavailable to plant. In chrysanthemum plants, the chlorosis of the middle and upper leaves was suggested to be due to reducing the concentration of active Fe in the leaves by high phosphorus, which also caused root browning, rotting and reduced the root activity [2].

Some growth regulators such as Gibberellic acid (GA_3) and phosphorus fertilizer have an effective role on the production potentiality of carnation plant (*Dianthus caryophyllus* L.). Jana and Jahangir Kabir [3], Amitabha Mukhopadhyay [4], Saks and Van Staden [5], Neelofar lolapori and Arora [6] and Verma *et al.* [7] found that spraying the carnation plants with GA_3 at different concentrations produced more flowers and improved flowering stem characteristics. In addition, the effective role of GA_3 application on the growth and flowering was assured with rose by El-Shafie *et al.* [8], Mazrou [9] and Eraki *et al.* [10]. Furthermore, several investigators such as Farina *et al.* [11] and Hosni and El-Shoura [12] recommended phosphorus fertilization to improve the growth and flowering of carnation. The effect of hormonal and mineral nutrients on various physiological process and growth are fairly well understood but no information

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exists concerning the interactive of hormonal concentration for mineral levels on each other. Therefore, this study was conducted to determine the suitable rate of P- fertilizer and its synergistic effect with GA_3 on the growth and flowering of carnation plants cv. "Red Sim".

MATERIALS AND METHODS

Two experiments was carried out on carnation plant "*Dianthus caryophyllus* cv. "Red Sim" during seasons of 2007/2008 in the greenhouse conditions at the new reclaimed lands of Noubaria region, West of Alexandria City, Egypt. The stem-tip cuttings of standard carnation "Red Sim" were taken from certified mother plants on 27th June, 2007 and 26th June, 2008, respectively. These uniform cuttings, with an average length of 10 cm, 6 visible leaf pairs and average weight of 10g, were directly rooted under mist propagation for three weeks (giving 10 second bursts every 5 minutes). The propagation bed composted using a mixture of peat-moss and sand (1:3, v/v). The chemical and physical properties of the used soil are shown in Table 1. Two kilograms of farmyard manure / m^2 (moisture 18 %) of the surface soil was added, few days before planting and well mixed with the soil during preparing the greenhouse soil. The chemical composition of the used manure was 0. 83 % N, 0. 26 % P_2O_5 and 0. 19% K_2O.

The rooted cutting were planted on 18th and 17th July in the first and second seasons, respectively. The plants were planted in rows, at 20 cm between rows and 20 cm between plants within the row [13] and drip irrigated with 1. 87 liters m^{-2} day^{-1} divided to three irrigation times druing a day [14, 15]. After three weeks, on 9th August and 8th August 2007 and 2008, single pinching was carried out by leaving 5 pairs of leaves on each plant. After that the plants were supported with plastic grids at suitable heights. The disbudding was practiced to allow one terminal bud to develop per branch.

Four foliar treatments of Gibberellic acid (GA_3) at concentrations of 0. 0, 25, 50 and 100 ppm were applied till run off point at 25, 50 and 75 days after the planting. Also, four foliar treatments of P_2O_5 at 0. 0, 50, 100 and 200 ppm, each divided into six equal doses applied during the growth period starting two weeks after planting, were sprayed three weeks intervals till run off point. The Orthophosphoric acid (H_3PO_3) was used as sources of P element (purity of H_3PO_3 was 98%, P_2O_5 = 70%), whereas control plants were sprayed with distilled water. The experimental unit was 5 rows width (spacing was 20 cm between rows) and 1. 2 m length. Each experimental unit received the foliar applications by using two liters of GA_3 and two liters of P solution per spray.

Nitrogen and Potassium fertilizers were added as ammonium nitrate (33. 0% N) and potassium sulfate (48% K_2O) at rates of 20 and 50 g per plot, as N and K_2O, respectively [13]. These amounts were divided into six equal doses which were added at three weeks intervals, starting two weeks after the final transplanting in greenhouse. All other agricultural practices were performed as usual.

The layout of the experiment was complete randomized blocks in a factorial trial containing three replicates. The experiment contained 16 different treatments (4 GA_3 x 4 P-fertilization). The experimental unit contained twenty-five plants, which were used as an experimental plot, for each treatment. The data on the vegetative growth characteristics and chemical analyses were subjected to statistical analysis of variance and the means were compared using the "Least Significant Difference (L. S. D.)" test at the 5% level [16]. The vegetative growth parameters including stem length (cm), stem diameter (cm), stem fresh and dry weights, number of leaves per branch, leaves fresh and dry weight (g) as well as the flowering characteristics including the time taken to showing color stage from planting date (day), number of flowers per plant, flower diameter (cm) at full-opining

Table 1: Chemical and physical analysis of experimental soil before planting in 2007 and 2008 seasons

Soil chemical analysis													
EC* (dSm^{-1})		pH**		Available N ($mg\ kg^{-1}$ soil)		Available P ($mg\ kg^{-1}$ soil)		Available K ($mg\ kg^{-1}$ soil)		Total carbonate (%)		Organic matter (%)	
2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008	2007	2008
1. 15	1. 00	8	7. 9	32. 22	28. 45	2. 84	2. 34	1. 19	1. 11	20. 21	19. 15	8%	17%

Soil physical analysis					
Particle size distribution				Soil texture	Water holding capacity (%)
Coarse sand %	Fine sand %	Silt %	Clay %	Loamy sand	15
16. 1	62. 9	13. 7	7. 3		

* In water saturated soil paste extract.

** In 1:2. 5 soil water ratio.

stage and dry weight of flowers per plant (g) were recorded. In addition chemical analyses of fresh leaf samples in the two leaves beneath of the terminal bud at showing coloring stage was conducted to determine their total content of chlorophyll (a and b) and total carotenoids (mg/100g fresh weight of leaves) as described by Moran and Porath [17]. Also, phosphorus % was determined in the leaves according to methods described by Chapman and Partt [18] and Bingham [19] while total carbohydrate content in dried leaf samples was determined according to Herbert *et al.* [20].

RESULTS AND DISCUSSION

Vegetative Growth

Stem Length (cm): The data in Table 2 showed that foliar application of carnation cv. "Red Sim" with each of GA_3, P_2O_5 or combination of GA_3 and P_2O_5 produced significant increases in stem length compared with the control plants, in the two growing seasons. The highest values of stem length were obtained by addition of 50 ppm GA_3 in combination with 100 ppm P_2O_5 compared to the other treatments, in the two seasons. This treatment leads to an increase of the stem length by 66. 00 and 73. 34 % as average of relative increase, over the control in the first and second seasons, respectively. These increases may be due to the effect of Gibberellic acid (GA_3), on stimulating the division and elongation of new growth cells formed on the carnation plants [21]. In addition, P-fertilizer acts to regulate many enzymatic reactions which are leading to enhancement of plant metabolism and formation of new cells and consequently increasing stem length [22]. Similar results were obtained by Kato and Takei [23] on chrysanthemum.

Stem Diameter (cm): Data presented in Table 2 showed that the stem diameter of carnation "*Dianthus caryophyllus* cv. "Red Sim" was significantly affected by the combination treatments of GA_3 and P_2O_5. The highest values of stem diameter (0. 94 cm) were obtained by using 50 ppm GA_3 in combination with 100 ppm P_2O_5 in the first and second seasons, respectively. These increases may be due to the role of GA_3 and /or phosphorus, in the energetic metabolism and biosynthetic reactions. These results are in agreement with El-Naggar and El-Naggar [24] on carnation plants.

Total Stems Fresh and Dry Weights (g): The obtained results indicated that application of 50 ppm GA_3 in combination with 100 ppm P_2O_5 produced the maximum stem fresh and dry weights, compared to the other treatments treatment in the two successive seasons (Table 2), giving values of 75. 93 and 4. 17 g, respectively, in the first season and 77. 53 and 4. 19 g, respectively, in the second season. These increases may be due to the favorable effects of GA_3 and P- fertilizer on the vegetative growth, which lead to an increase in the photosynthesis efficiency and accumulation of dry matter in the stem. Similar results were obtained by El-Baky [25] on carnation.

Leaves Number/ Branch: Data in Table 3 showed that foliage spray by Gibberellic acid (GA_3) and/or P-fertilizer, significantly increased leaves number/branch compared with the control plants in the two growing seasons. Generally, the highest number of leaves was produced by application of 50 ppm GA_3 in combination with 100 ppm P_2O_5. Such increases estimated by the relative increase were 27. 15% and 22. 49% over the control in the first and second seasons, respectively. The stimulating effects of both Gibberellic acid (GA_3) and P-fertilizer may be due to activating apical meristems, enhancing the biosynthesis of proteins and carbohydrates and leads to an enhancing for the initiation of leaves primordial and consequently produced more leaves. Similar results were found by Conny *et al.* [26] on chrysanthemum.

Total Leaf Fresh and Dry Weights (g): Data in Table 3 showed that foliar application of 50 ppm GA_3 in combination with 100 ppm P_2O_5 treatment gave the highest values of leaves fresh and dry weights compared with the other treatments in the two growing seasons. These increases may be due to the accumulation of the biosynthetic compounds, which have positive roles for the formation and division of cells and leading to produce thicker and heavier leaves. Also, the increase in leaves dry matter may be related to the increase in the number of leaves. Similar results were obtained by Ateeque *et al.* [27] on sunflower plant.

Flower Characteristics

Flowering Time (day): The results in Table 4 indicated that the flowering time from a planting date was significantly decreased as a result of spraying GA_3 solely or in combination with the gradually increase rates of P-fertilizer from 0 to 100 ppm in the two growing seasons. The highest reduction in number of days from planting date until appearance of flower color was obtained by application of 50 or 100 ppm GA_3 in combination with 100 ppm P_2O_5, as compared with the control in the first and second seasons, respectively. The same trend was reported by El-Naggar [28] on gladiolus and El-Naggar and Sharaf [29] on tuberose.

Table 2: Effect of GA_3 concentrations, P-fertilization and their interaction on stem length (cm), stem diameter (cm), stem fresh and dry weights (g) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2007 and 2008

Stem length (cm)

	First season						Second season				
	P_2O_5 Rates (ppm)						P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	52.75	68.93	72.55	67.59	65.45	0.0	50.97	69.15	71.87	67.42	64.85
25	58.34	73.54	77.32	75.97	71.29	25	58.98	72.65	76.18	75.26	70.77
50	68.72	75.61	87.57	80.41	78.08	50	66.20	74.81	88.35	79.45	77.20
100	64.97	74.65	78.53	72.75	72.72	100	65.76	74.96	77.95	72.38	72.76
Mean	61.19	73.18	78.99	74.18		Mean	60.48	72.89	78.58	73.63	
$L.S.D_{0.05}$	GA_3 = 1.67	P_2O_5 = 2.24		Inter.= 2.57		$L.S.D_{0.05}$	GA_3 = 1.87	P_2O_5 = 2.29		Inter.= 2.63	

Stem diameter (cm)

	First season						Second season				
	P_2O_5 Rates (ppm)						P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	0.48	0.59	0.65	0.62	0.58	0.0	0.49	0.59	0.67	0.62	0.59
25	0.57	0.66	0.74	0.71	0.67	25	0.58	0.67	0.74	0.70	0.67
50	0.68	0.78	0.94	0.85	0.81	50	0.65	0.76	0.94	0.86	0.80
100	0. 69	0. 77	0. 90	0. 80	0. 79	100	0. 67	0. 75	0. 91	0. 78	0. 78
Mean	0. 61	0. 70	0. 91	0. 75		Mean	0. 59	0. 69	0. 82	0. 74	
$L. S. D_{0.05}$	GA_3 = 0.03	P_2O_5 = 0.04		Inter. = 0.07		$L.S.D_{(0.05)}$	GA_3 = 0.03	P_2O_5 = 0.04		Inter. = 0.07	

Stem fresh weight (g)

	First season						Second season				
	P_2O_5 Rates (ppm)						P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	39.87	48.76	54.12	49.43	48.04	0.0	38.97	46.42	54.21	47.65	46.81
25	43.57	53.84	60.47	59.49	54.34	25	44.00	53.95	62.25	58.53	54.68
50	49.29	67.98	75.93	73.54	66.68	50	48.95	69.85	77.53	71.97	67.07
100	47.56	65.87	71.00	64.83	62.31	100	46.66	65.49	70.81	63.69	61.66
Mean	45.07	59.11	65.38	61.82		Mean	44.64	58.93	66.20	60.45	
$L.S.D_{0.05}$	GA_3 =1.45	P_2O_5 = 1.289		Inter.= 2.12		$L.S.D_{0.05}$	GA_3 = 1.39	P_2O_5 = 1.23		Inter.= 2.09	

Stem dry weight (g)

	First season						Second season				
	P_2O_5 Rates (ppm)						P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	3.25	3.37	3.54	3.46	3.40	0.0	3.23	3.34	3.54	3.44	3.39
25	3.31	3.56	3.59	3.53	3.50	25	3.30	3.54	3.59	3.52	3.49
50	3.47	3.67	4.17	4.11	3.85	50	3.46	3.66	4.19	4.09	3.85
100	3.47	3.76	4.13	3.97	3.83	100	3.47	3.75	4.12	3.96	3.82
Mean	3.37	3.59	3.86	3.76		Mean	3.36	3.57	3.86	3.75	
$L.S.D_{0.05}$	GA_3 =0.13	P_2O_5 = 0.16		Inter.= 0.20		$L.S.D_{0.05}$	GA_3 =0.13	P_2O_5 = 0.16		Inter.= 0.20	

Table 3: Effect of GA_3 concentrations, P-fertilization and their interaction on leaves number/ branch as well as total leaf fresh and dry weights (g)/of *Dianthus caryophyllus* cv."Red Sim" during the two seasons of 2007 and 2008

Leaves number/ branch

	First season P_2O_5 Rates (ppm)						Second season P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	18.10	20.89	23.75	23.00	21.43	0.0	18.22	21.00	23.79	23.50	21.73
25	20.51	23.57	24.89	24.13	23.27	25	20.36	23.76	25.31	24.29	23.43
50	20.59	24.90	26.18	24.11	23.94	50	21.21	24.94	25.98	24.20	24.08
100	20.35	23.19	24.57	22.13	22.56	100	20.51	23.08	24.29	22.15	22.51
Mean	19.88	23.14	24.84	23.34		Mean	20.07	23.19	24.84	23.53	22.93
$L.S.D_{0.05}$	GA_3=0.25	P_2O_5 = 0.33		Inter.= 0.60		$L.S.D_{0.05}$	GA_3=0.22	P_2O_5 = 0.35		Inter.= 0.64	

Total leaf fresh weight (g)

	First season P_2O_5 Rates (ppm)						Second season P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	23.79	24.22	27.20	26.19	25.35	0.0	23.81	24.43	27.22	26.29	25.41
25	24.97	25.89	29.57	29.07	27.37	25	24.89	25.88	30.00	29.16	27.48
50	25.08	35.96	44.98	39.64	36.41	50	25.21	35.87	43.59	39.77	36.11
100	24.33	34.36	41.94	36.17	34.20	100	24.41	34.29	41.87	35.93	34.12
Mean	24.54	30.11	35.92	32.76		Mean	24.58	30.09	35.67	32.78	
$L.S.D_{0.05}$	GA_3 = 1.16	P_2O_5 = 1.22		Inter.= 1.43		$L.S.D_{0.05}$	GA_3 = 1.13	P_2O_5 = 1.18		Inter.= 1.37	

Total leaf dry weight (g)

	First season P_2O_5 Rates (ppm)						Second season P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	2.15	2.32	2.41	2.39	2.32	0.0	2.17	2.43	2.42	2.39	2.33
25	2.43	2.57	2.71	2.63	2.58	25	2.42	2.59	2.71	2.62	2.58
50	2.57	2.78	3.19	2.98	2.88	50	2.60	2.77	3.13	3.05	2.87
100	2.50	2.68	3.10	2.70	2.74	100	2.52	2.65	3.08	2.69	2.73
Mean	2.41	2.58	2.85	2.67		Mean	2.43	2.58	2.83	2.68	
$L.S.D_{0.05}$	GA_3 = 0.09	P_2O_5 = 0.07		Inter.= 0.13		$L.S.D_{0.05}$	GA_3 = 0.09	P_2O_5 = 0.07		Inter.= 0.13	

Table 4: Effect of GA_3 concentrations, P- fertilization and their interaction on flowering time (day), flowers number/plant, flowers size (cm) and flower dry weight (g) of *Dianthus caryophyllus* cv."Red Sim" during the two seasons of 2007 and 2008

Flowering time (day)

	First season P_2O_5 Rates (ppm)						Second season P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	131.79	126.36	122.42	122.97	125.88	0.0	131.76	125.93	121.86	122.17	125.43
25	125.34	117.48	115.30	117.59	118.93	25	126.00	117.57	114.79	121.29	119.91
50	123.86	111.42	107.30	115.52	114.65	50	123.00	110.86	109.01	116.29	114.75
100	122.86	117.95	109.15	118.97	117.23	100	122.70	116.85	108.39	119.51	116.86
Mean	125.77	117.05	113.66	119.93		Mean	125.86	117.80	113.51	119.77	
$L.S.D_{0.05}$	GA_3 = 1.15	P_2O_5 = 1.42		Inter.= 2.17		$L.S.D_{0.05}$	GA_3 = 1.32	P_2O_5 = 1.64		Inter.= 2.23	

Table 4: Continued

Flowers number/ plant											
	First season						Second season				
	P_2O_5 Rates (ppm)						P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	3.57	4.32	5.18	4.32	4.35	0.0	3.49	4.36	5.21	4.29	4.34
25	4.52	6.75	8.63	7.00	6.72	25	5.59	6.58	8.73	7.00	6.72
50	5.28	9.89	12.87	9.70	9.43	50	5.30	9.50	12.90	9.29	9.28
100	5.10	10.23	11.67	9.13	9.03	100	5.12	9.95	10.63	9.10	8.70
Mean	4.62	7.79	9.58	7.53		Mean	4.87	7.59	9.36	7.42	
$L.S.D_{0.05}$	GA_3 = 0.29	P_2O_5 = 0.38		Inter.= 0.57		$L.S.D_{(0.05)}$	GA_3 = 0.29	P_2O_5 = 0..38		Inter.= 0.57	

Flowers diameter (cm)											
	First season						Second season				
	P_2O_5 Rates (ppm)						P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	3.50	3.99	4.48	4.32	4.07	0.0	3.58	3.99	4.50	4.36	4.1
25	4.19	5.89	7.72	7.47	6.32	25	4.20	5.73	7.56	7.39	6.22
50	5.69	9.78	13.85	11.39	10.18	50	5.73	9.65	13.50	11.54	10.10
100	5.31	10.23	12.00	10.76	9.57	100	5.40	10.15	11.78	10.56	9.47
Mean	4.67	7.47	9.51	8.48		Mean	4.72	7.38	9.33	8.46	
$L.S.D_{0.05}$	GA_3 = 0.12	P_2O_5 = 0.21		Inter.= 0.35		$L.S.D_{0.05}$	GA_3 = 0.12	P_2O_5 = 0.21		Inter.= 0.35	

Flower dry weight (g)											
	First season						Second season				
	P_2O_5 Rates (ppm)						P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	2.00	2.18	2.35	2.27	2.20	0.0	2.03	2.15	2.39	2.28	2.21
25	2.27	2.47	2.75	2.62	2.53	25	2.26	2.45	2.71	2.59	2.50
50	2.51	2.78	3.13	3.02	2.86	50	2.51	2.73	3.13	2.95	2.83
100	2.43	2.83	2.99	2.82	2.77	100	2.40	2.85	2.98	2.80	2.76
Mean	2.30	2.56	2.80	2.68		Mean	2.30	2.54	2.80	2.65	
$L.S.D_{0.05}$	GA_3 = 0.06	P_2O_5 = 0.07		Inter.= 0.10		$L.S.D_{(0.05)}$	GA_3 = 0.06	P_2O_5 = 0.07		Inter.= 0.10	

Flowers Number/plant: Data in Table 4 showed that foliar application of carnation cv. "Red Sim" with each of GA_3, P_2O_5 or combination of GA_3 and P_2O_5 significantly increased flowers number per plant during the two seasons. Generally, the greatest number of flowers/plant was obtained by application of 50 ppm GA_3 in combination with 100 ppm P_2O_5. The recorded average values reached to 12. 87 and 12. 90 flowers/plant compared with 3. 57 and 3. 49 flowers recorded at the untreated plants in the first and second seasons, respectively. These results were similar to those obtained by Kirilov *et al.* [30] and on chrysanthemum plants.

Flower Diameter (cm): Data in Table 4 revealed that the flower diameter (size) was significantly increased due to all foliar application treatments as compared with the control. Generally, the largest diameter of flower was found with plants sprayed with 50 ppm GA_3 in combination with 100 ppm P_2O_5 as compared with the other treatments in both growing seasons. The increment in the flowers size may be due to the role of Gibberellic acid (GA_3) and/or the phosphorus at suitable concentrations which lead to increases in the petals number, their expansion or both of them, consequently, the diameter of flowers could be increased. The results are in agreement with those obtained by Ramesh *et al.* [31] on carnation plants.

Table 5: Effect of GA_3 concentrations, P- fertilization and their interaction on total chlorophyll, total carotenoids (mg/100g FW), total carbohydrates and phosphorus (% DW) of *Dianthus caryophyllus* cv."Red Sim" during the two seasons of 2007 and 2008

Total chlorophyll (mg/100 g FW)

	First season P_2O_5 Rates (ppm)						Second season P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	175.97	188.59	198.35	193.87	189.19	0.0	176.29	188.48	197.90	193.94	189.15
25	180.53	200.12	220.17	216.49	204.33	25	182.70	203.26	223.17	219.00	207.03
50	185.49	212.17	248.65	242.54	222.21	50	185.00	213.32	247.46	243.10	222.22
100	183.39	217.90	250.59	238.68	222.64	100	182.70	216.85	250.76	239.70	222.50
Mean	181.34	150.22	229.44	222.89		Mean	181.67	152.14	229.82	223.93	
$L.S.D_{0.05}$	GA_3 = 2.19	P_2O_5 = 2.51		Inter.= 3.50		$L.S.D_{0.05}$	GA_3 = 1.98	P_2O_5 = 2.20		Inter.= 3.39	

Total carotenoids (mg/100 g FW)

	First season P_2O_5 Rates (ppm)						Second season P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	26.97	27.90	30.88	30.32	29.08	0.0	28.26	29.21	31.01	29.38	29.46
25	27.54	33.87	39.76	40.72	35.47	25	28.19	32.96	39.45	41.21	35.45
50	30.56	38.53	51.42	46.21	41.73	50	30.13	39.20	51.00	47.90	42.06
100	30.11	37.56	50.84	46.39	41.22	100	31.00	37.77	51.90	46.32	41.22
Mean	28.79	34.46	43.22	40.91		Mean	29.39	34.78	43.34	41.20	
$L.S.D_{0.05}$	GA_3 = 1.77	P_2O_5 = 2.21		Inter.= 3.36		$L.S.D_{0.05}$	GA_3 = 1.52	P_2O_5 = 2.10		Inter.= 2.50	

Total carbohydrates (%)

	First season P_2O_5 Rates (ppm)						Second season P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	13.50	15.00	16.89	16.00	15.35	0.0	13.68	15.13	16.46	15.87	15.28
25	14.96	17.59	22.10	21.32	18.99	25	15.05	18.00	22.65	20.76	19.11
50	16.94	24.37	27.15	26.46	23.73	50	16.35	24.87	28.59	11.54	20.34
100	15.48	26.89	28.00	26.79	24.26	100	15.40	25.96	28.82	26.18	24.09
Mean	15.22	20.93	23.53	22.64		Mean	15.12	20.99	24.13	18.58	
$L.S.D_{0.05}$	GA_3 = 0.14	P_2O_5 = 0.19		Inter.= 0.24		$L.S.D_{0.05}$	GA_3 = 0.14	P_2O_5 = 0.19		Inter.= 0.24	

Phosphorus (%)

	First season P_2O_5 Rates (ppm)						Second season P_2O_5 Rates (ppm)				
GA_3 Conc. (ppm)	0. 0	50	100	200	Mean	GA_3 Conc. (ppm)	0. 0	50	100	200	Mean
0.0	0.16	0.21	0.27	0.31	0.24	0.0	0.19	0.22	0.28	0.32	0.25
25	0.18	0.22	0.33	0.38	0.28	25	0.22	0.24	0.33	0.39	0.29
50	0.23	0.27	0.39	0.49	0.34	50	0.23	029	0.39	0.47	0.34
100	0.27	0.38	0.43	0.50	0.39	100	0.31	0.40	0.48	0.52	0.43
Mean	0.21	0.27	0.35	0.42		Mean	0.23	0.28	0.37	0.43	
$L.S.D_{0.05}$	GA_3 = 0.05	P_2O_5 = 0.06		Inter. = 0.08		$L.S.D_{0.05}$	GA_3 = 0.05	P_2O_5 = 0.06		Inter. = 0.08	

Flowers Dry Weight (g): As shown in Table 4 it is obvious that, foliar application treatments significantly affected the flower dry weight. Applying 50 or 100 ppm GA_3 in combination with 100 ppm P_2O_5 produced the highest flower dry weight compared with the other treatment, in the two growing seasons. These increases may be due to the effect of GA_3 and/or phosphorus in increasing the biosynthesis and accumulation of materials, as well as, GA_3 and P are important for cell division activity, leading to the increase of flower dry weight ([32] and [33]). Similar results were found by El-Shafie [34] on carnation

Chemical Constituents

Total Chlorophyll and Carotenoids (mg/100 g FW): The results in Table 5 indicated that the highest significant increases in the total chlorophyll and carotenoides contents were recorded in plants sprayed with 50 or 100 ppm GA_3 in combination with 100 ppm P_2O_5. These increases may be due to the role of phosphorus in synthesis of phospholipids of membranes, sugar phosphates, various nucleotides and co-enzymes. Moreover, this could be also attributing to the physiological role of phosphorus in enhancing the plastid pigments content. Furthermore, using GA_3 + P might lead to increase the green pigments in the plants by stimulating the production of chlorophyll in leaves [21]. Similar trend of results was obtained by EL-Naggar [28] on gladiolus and Mostafa [35] on *Dendranthema grandiflorum.*

Total Carbohydrate in the Dried Leaves (%): Results in Table 5 indicated that foliar application of carnation cv. "Red Sim" with each of GA_3, P_2O_5 or combination of GA_3 and P_2O_5 significantly increased the total carbohydrate percentages in the dried leaves of "Red Sim" carnation plants as compared with the untreated plants through the two growth seasons. The highest significant increase in the total carbohydrates (%) was found with plants sprayed with 100 ppm GA_3 in combination with 100 ppm P in both experimental trails. The recorded average values of the total carbohydrate content reached to 28. 00 and 28. 82 % whereas those values were 15. 48 and 15. 40 % in the control plants in both seasons, respectively. This increase may be due to the effects of GA_3 and P-fertilizer on stimulating the growth and enhancing leaf production which probably had higher chlorophyll content and consequently more carbohydrate production. These results are in agreement with those obtained by Eraki *et al.* [10] and Al-Humaid [36] on rose plants.

Phosphorus Content: Data in Table 5 showed that increasing the dose of P- fertilizer alone or in combination with GA_3 significantly increased the phosphorus content in carnation leaves, in most cases. The highest significant increase of phosphorus (%) was obtained by applying the 200 ppm P_2O_5 in combination with 100 ppm GA_3 as compared with the control in the two growing seasons. This result may be related to the effect of spraying phosphoric acid on the increase of phosphorus absorption by the plant surface, especially leaves and hence its accumulation in leaves [22]. Similar results were obtained by Khattab and Hassan [37] on chrysanthemum and Mahgoub *et al.* [38] on Iris plants.

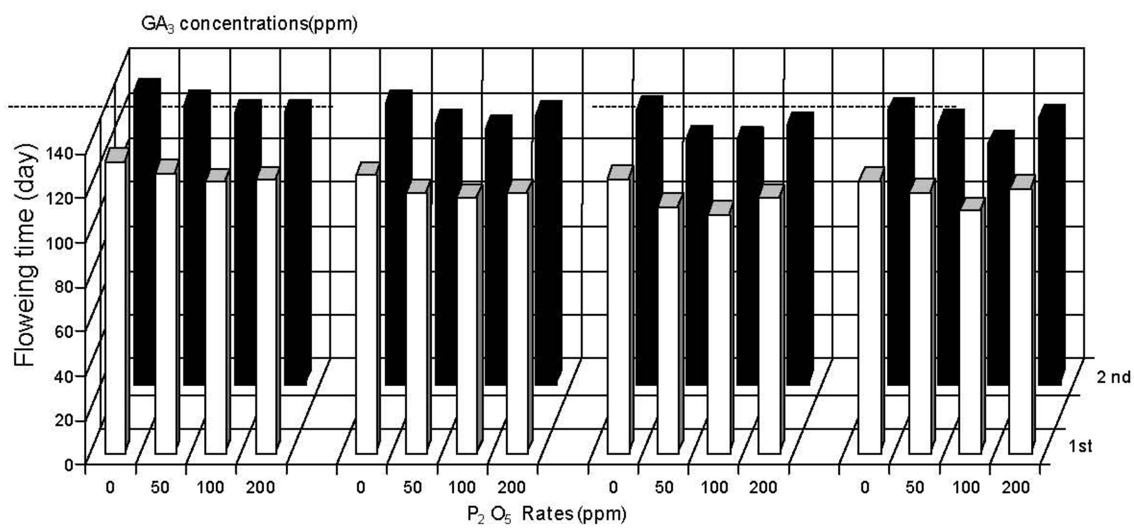

Fig. 1: Effect of GA_3 concentrations, P- fertilization and their interaction on flowering time (day) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2007 and 2008.

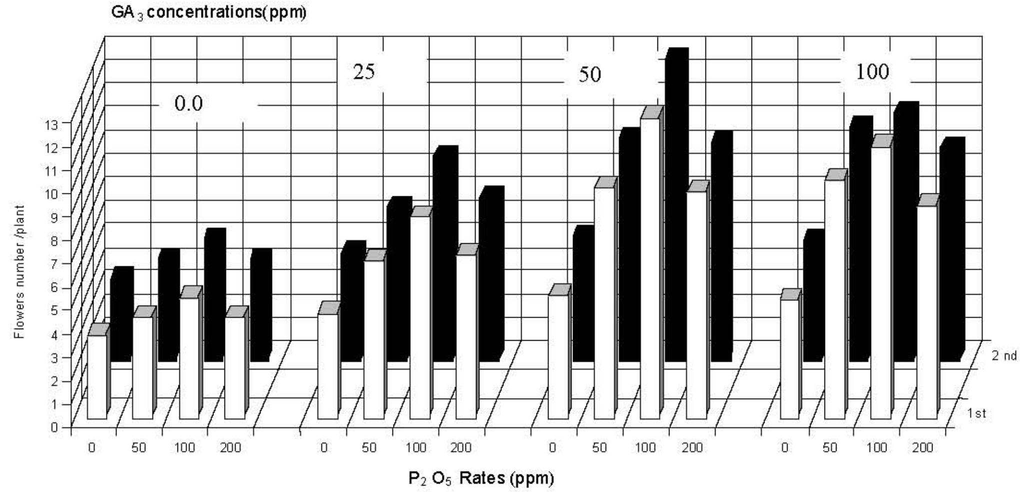

Fig. 2: Effect of GA_3 concentrations, P- fertilization and their interaction on flowers number/plant, of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2007 and 2008.

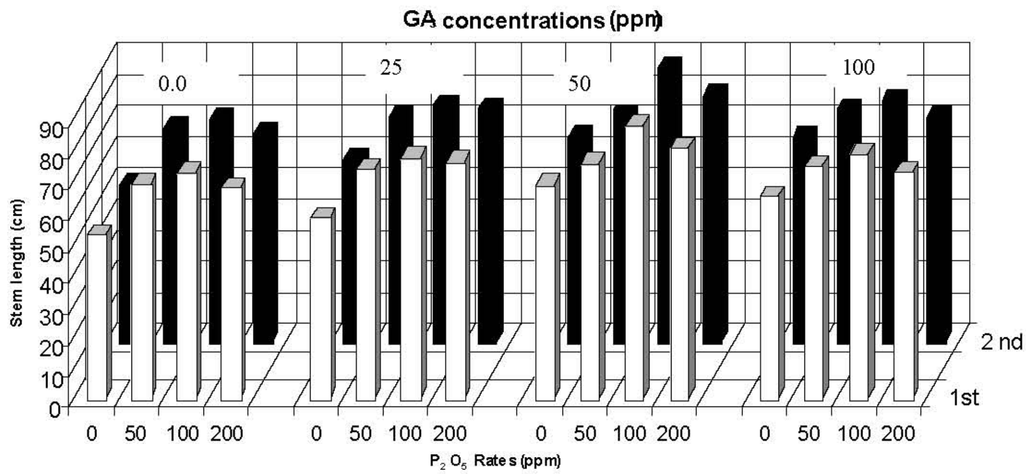

Fig. 3: Effect of GA_3 concentrations, P-fertilization and their interaction on stem length (cm) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2007and 2008.

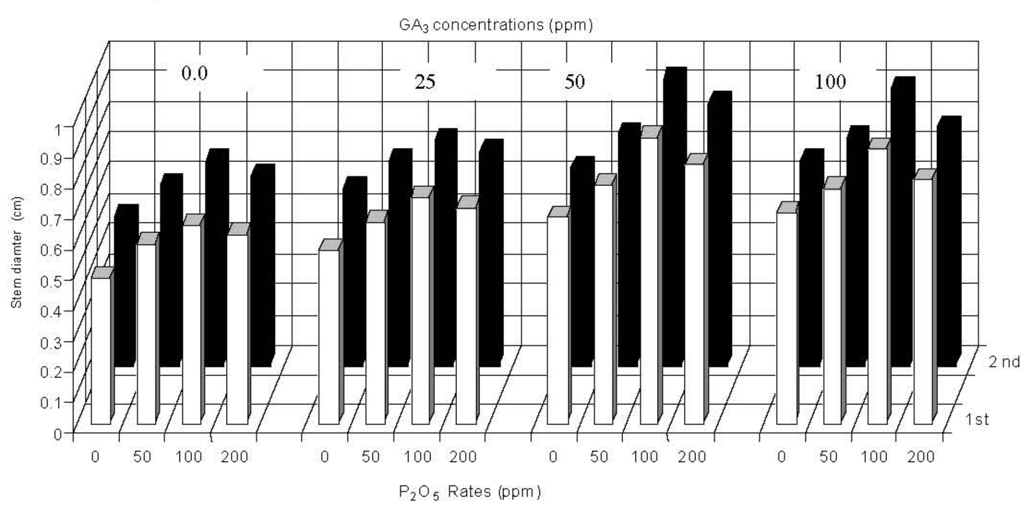

Fig. 4: Effect of GA_3 concentrations, P-fertilization and their interaction on stem diameter (cm) of *Dianthus caryophyllus* cv. "Red Sim" during the two seasons of 2007and 2008.

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